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Analysis of the Synergistic Evolution Characteristics of the Logistics Industry and the High-Quality Development of Modern Manufacturing in the GBA①

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Abstract

The Greater Bay Area (GBA) is one of the most open and economically vibrant regions in China, and promoting high-quality development of modern manufacturing is one of the critical strategic tasks for the GBA. Practical experience has shown that the synergistic development of the logistics industry and the manufacturing industry are of immense significance for promoting the high-quality development of modern manufacturing. This study aimed to reveal the Synergistic Evolution Characteristics of the logistics industry and the high-quality development of modern manufacturing in the GBA, offering methodological and decision-making insights for further exploration. It should be noted that the manufacturing industry in the GBA is mainly concentrated in 9 cities in the Pearl River Delta (PRD), so this paper selects only 9 cities in the PRD for the manufacturing industry panel data and 11 cities in the GBA for the logistics industry data. Using the above data from 2008-2022, three coupling coordination models were built in this study, the coupling coordination model for the logistics industry and the manufacturing industry of cities in the PRD, the coupling coordination model for the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong and Macau and the coupling coordination model for the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong. The comprehensive index of the high-quality development of the modern manufacturing industry in GBA and the coupling coordination degrees (CCDs) of three coupling coordination models were calculated in this study. Furthermore, this study analyzed the characteristics of the spatial and temporal characteristics of the CCDs of cities in the PRD. The results showed that: (1) The comprehensive index of manufacturing has been improving in the past 15 years, and it has already achieved some development results. (2) Notable achievements have been made in the synergistic development of manufacturing and logistics in the GBA. (3) The CCDs of high-quality development of the logistics industry and modern manufacturing industry of cities in the PRD featured obvious regional heterogeneity. In 2022, the CCDs of the eastern regions were higher than that of the western regions, and the CCDs of the southern regions were higher than that of the northern regions.

Keywords: GBA, Coupling coordination degree, Spatiotemporal evolution, High-quality development

1. Instruction

With the steady development of the social economy, the manufacturing industry, as the main body of the real economy, its high-quality development contributes to the comprehensive strength[1]. Over the past few years, the

Chinese government has been committed to promoting the high-quality development of the manufacturing industry through industrial integration. It was mentioned in the “Made in China 2025” that China should accelerate the synergistic development of the manufacturing and service industries and transform production-based manufacturing into service-based manufacturing. In 2019, the outline development plan for the GBA also focused on promoting the integration of the manufacturing industry with the productive service industry to build a modern industrial system with international competitiveness, as unveiled by the Chinese authorities. As an important part of the productive service industry, the logistics industry has a close relationship with the manufacturing industry in the value chain[2]. The logistics industry itself is divested from the manufacturing industry and has a natural industrial correlation with the manufacturing industry, which indicates that the balanced development of the integration of the logistics industry and the manufacturing industry is the key to the high-quality development of the manufacturing industry. In 2020, the National Development and Reform Commission issued the "Implementation Plan for Promoting Deep Integration and Innovative Development of the Manufacturing Industry of the Logistics Sector", which proposed to strengthen the role of the logistics industry in promoting the high-quality development of the traditional manufacturing industry, etc.

Against the background of promoting high-quality development of the modern manufacturing in the GBA, this study aimed to explore the comprehensive index of manufacturing from 2008-2022. Besides, this paper focused on the development of the coupling between the logistics industry and the manufacturing industry in the GBA from 2008-2022. Taking 11 cities in the GBA as case studies, adopting the modified entropy model, and the coupling coordination degree model, this study measured the comprehensive index of manufacturing of cities in the GBA from 2008 to 2022 and analyzed the characteristics of the spatial and temporal characteristics of the CCDs of cities in the PRD. By examining these issues, this paper hopes to help provide theoretical references for government decision-making.

2. Literature Review

The relevant literature on the industrial integration of manufacturing and logistics has focused on their interrelationships and the measurement and evaluation of their degree of coordination. Discussion on their interrelationships began in the 1970s, and research to date has mainly formed three perspectives: hypothesis of demand-following, hypothesis of supply-leading, and hypothesis of interaction. The hypothesis of demand-following holds that manufacturing holds a dominant position in the relationship between the producer services industry and the manufacturing industry.

Guerrieri and Meliciani emphasized that the productive service sectors are in a demand-following position and act as an adjunct and complement to manufacturing[3]. Wang suggested that the coordinated development between manufacturing and logistics is a form of collaboration based on logistics outsourcing, serving as a service procurement activity for manufacturing enterprises[4]. Conversely, the hypothesis of supply-leading argues that the logistics industry is a prerequisite for the development of manufacturing. Productive service sectors have a significant positive impact on the production efficiency of manufacturing. The productive service sectors can enhance the internal division of labor in manufacturing, thus improving productivity[5]. Scholars like Daniels and Coffey, who advocated the hypothesis of interaction, viewed manufacturing and logistics as having a complementary relationship characterized by interconnected development and interactive effects[6][7]. Lundvall argued that the integration of the two industries strengthens their development and promotes economic growth[8]. Deng noted a strong industrial correlation between the two sectors, arguing that their coordinated development is an effective pathway to mutual benefit and an effective industrial strategy during economic transition, while also

pointing out the inadequacies in their coordination[9]. When it comes to the measurement and evaluation of their degree of coordination., there are few direct studies abroad on the relationship between manufacturing and logistics. More often, studies focus on the interaction between manufacturing and the productive service sectors. For instance, Czarnitzki and Ebersberger applied the input-output method to analyze the intermediate inputs of manufacturing in different countries, finding that increases in high-tech inputs in manufacturing promote the development of productive services[10].

Chinese research in this area was more abundant. Xu and Ran have used the coupling coordination degree model to test factors related to the coordinated development of these two industries[11][12]. Shi et al. used the DEA (Data Envelopment Analysis) method to measure the coordination between the logistics and manufacturing industries in Jiangsu Province from 1998 to 2007[13]. Gu studied the degree of coordination development between manufacturing and logistics in the PRD region, focusing primarily on the development trends of the gross production values of manufacturing and logistics, and then used stationarity tests, cointegration tests, and Granger causality tests to comprehensively examine the interaction between the two industries[14]. Gong et al. used Chinese data from 2003-2013 to develop a GRNN model, selecting indicators such as industrial input levels, development scale, and output efficiency to analyze the development trends and coordination between state-owned manufacturing and logistics[15]. Du et al. employed the Haken model in an empirical analysis that showed a high overall coordination level between logistics and manufacturing in the Yangtze River Economic Belt, and that the development of manufacturing could effectively promote the coordinated evolution of logistics and manufacturing[16]. Gong et al. used the data from 30 provinces in China (excluding Tibet, Hong Kong, Macau, and Taiwan) from 2009 to 2022 and employed fixed-effects and random-effects regression models to investigate the impact of the "two industries" coupling and coordination on the level of high-quality development in manufacturing[17].

For the study of industrial coordination between the logistics industry and the manufacturing industry, scholars' empirical research has become more and more diversified in terms of measurement, and the perspectives of exploring the relationship between the two industries have also been evolving. In a comprehensive view, research on high-quality industrial development and the CCD have been gradually enriched, but there are still some shortcomings that need to be addressed. Few scholars have analyzed the industry connections between the industries in Hong Kong and Macau and those in the mainland. Scholars usually exclude Hong Kong and Macau in their research. Therefore, this study focused on the Greater Bay Area as its research region. Based on actual statistical data, this study constructed three coupling coordination models for evaluating the coordination between industries, aiming to fill a gap in regional empirical research.

3. Research Methods, Data Sources, and the Indication System

3.1 Research Methods

In this context, the different years are denoted as y_j $(j = 1,2,3 \ldots m)$ and the selected indicators are denoted as y_i $(i = 1,2,3 \ldots n)$. The attribute value of the ith indicator in the jth year is then denoted as y_{ij}. Because different dimensions that exist among different indicators are not comparable with each other. Standardization of the indicator data is required.

The Modified Entropy Method

Step 1:

Conduct the data normalization process

if y_{ij} is a positive indicator:

$$y_{ij} = \frac{x_{ij} - x_{\min}'}{x_{\max}' - x_{\min}'} \quad (1)$$

if y_{ij} is a negative indicator:

$$y_{ij} = \frac{x_{\max}' - x_{ij}}{x_{\max}' - x_{\min}'} \quad (2)$$

Where x_{max}' and x_{min}' are the maximum and minimum values treated as 1% reduction and 1% expansion, respectively, of indicator y_i in all years.

Step 2:

P_{ij} is calculated by the following equation:

$$p_{ij} = y_{ij} \Big/ \sum_{j=1}^{m} y_{ij} \quad (3)$$

Where P_{ij} is the specific gravity value for each y_{ij}.

Step 3:

The equation for calculating the index entropy is expressed as follows:

$$e_j = -\frac{1}{\ln n} \sum_{i=1}^{n} p_{ij} \ln(p_{ij}) \quad (4)$$

Step 4:

g_j is calculated by the following equation:

$$g_j = 1 - e_j \quad (5)$$

Step 5:

The equation for calculating the weight of indexes is expressed as follows:

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \quad (6)$$

The range of w_j is [0,1].

Step 6:

A comprehensive index U_i to assess the level of development of an industry is calculated as follows:

$$U_i = \sum_{j=1}^{m} w_j y_{ij} \quad (7)$$

The range of U_i is [0,1]. The larger the index is, the higher the development level of the industry.

Coupling Coordination Degree Model

Coupling is a physics concept that refers to the phenomenon of synergy between two or more systems through mutual movement, interaction, and mutual influence on each other to ultimately realize synergy[18]. Reference relevant studies[19], the following coupled coordination model is used in this paper:

$$C = \frac{2\sqrt{U_1 U_2}}{U_1 + U_2} \quad (8)$$

$$T = \alpha U_1 + \beta U_2 \quad (9)$$

$$D = \sqrt{C \times T} \quad (10)$$

Where C is the coupling degree, whilst U_1 and U_2 are the comprehensive index of the high-quality development of modern manufacturing and logistics systems, respectively. T represents the comprehensive coordination index. α and β is the coefficient to be determined, $\alpha = \beta = 0.5$. D represents the coupling coordination degree.

Referring to previous studies[20], we divided D into ten different levels. (Table 1)

Table 1 Division of the Coupling Coordination Degree Levels

Value of D	Level	Value of D	Level
[0.0,0.10)	Extreme maladjustment recession	[0.50,0.60)	Critical coordinated development
[0.10,0.20)	Severe maladjustment recession	[0.60,0.70)	Primary coordinated development
[0.20,0.30)	Moderate maladjustment recession	[0.70,0.80)	Intermediate coordinated development
[0.30,0.40)	Mild maladjustment recession	[0.80,0.90)	Good coordinated development
[0.40,0.50)	Near maladjustment recession	[0.90,1.00]	High-quality coordinated development

3.2 Data Sources

The data in this study came from the Guangdong Statistical Yearbook, Guangdong Statistical Yearbook of Industry, Hong Kong Annual Digest of Statistics, Macau Yearbook of Statistics, as well as the yearbook data of

the nine cities in the PRD. The time series of data was from 2008 to 2022, and this study adopted data interpolation to address missing values that exist in the data.

3.3 The Indicator System

The selection of industry evaluation indexes usually includes economic, scale, development capacity, and other dimensions[21]. This study, based on scientific, availability, and comprehensiveness, selected indicators that can significantly reflect the characteristics and evolution process of the high-quality development of modern manufacturing industry system and logistics industry system. Scale, business capability, development capacity, and green energy saving were chosen to reflect the characteristics of systems. Indicators of the three systems are shown in Table 2, Table 3, and Table 4, respectively.

Table 2 Evaluation Index System for High-Quality Development of Modern Manufacturing Industry of Cities in the PRD

Dimension	Indicator (Influence)	Unit	Weight
Scale	Number of Corporate Units (+)	Number	0.249
	Gross manufacturing output value (+)	Yuan	0.132
Business Capability	Average Wage of Staff and Workers (+)	Yuan	0.172
	Labor Productivity (+)	Yuan/ Person	0.125
Development Capacity	Share of Manufacturing Fixed-Asset Investment in Total Fixed-Asset Investment in Society (+)	%	0.131
	Growth rate of manufacturing GDP (+)	%	0.078
Green Energy Saving	Electricity Consumption per Unit of Manufacturing GDP (-)	Kilowatt-hour /10 thousand yuan	0.113

Table 3 Evaluation Index System for Logistics Industry Development of Cities in the PRD

Dimension	Indicator (Influence)	Unit	Weight
Scale	Freight transport volume (+)	Tons	0.094
	Volume of Freight Handled in Ports (+)	Tons	0.111
	Number of Corporate Units in the Logistics Industry (+)	Number	0.193
Business Capability	Freight turnover (+)	100 million ton-km	0.126
	Number of Employed Persons (+)	Number	0.111
Development Capacity	Total Investment in Fixed Assets (+)	Yuan	0.138
	Formation Growth Rate of Logistics GDP (+)	Yuan	0.144
Green Energy Saving	Energy Consumption per Unit of Logistics GDP (-)	Tons of SCE /10 thousand yuan	0.083

Table 4 Evaluation Index System for Logistics Industry Development in Hong Kong and Macau

Dimension	Indicator (Influence)	Unit	Weight
Scale	Port container throughput (+)	TEUs	0.125
	Number of Corporate Units (+)	Number	0.132
Business Capability	Value of Imports and Exports of Goods (+)	Dollar	0.099
	Number of Employed Persons (+)	Number	0.076
Development Capacity	Total Investment in Fixed Assets (+)	Hong Kong Dollar	0.160
	Formation Growth Rate of Logistics GDP (+)	Hong Kong Dollar	0.165
Green Energy Saving	Greenhouse Gas Emissions by the Logistics Industry (-)	Kilotonnes CO_2-e	0.243

4. Results and Analysis

4.1 Analysis of the Comprehensive Index of Manufacturing

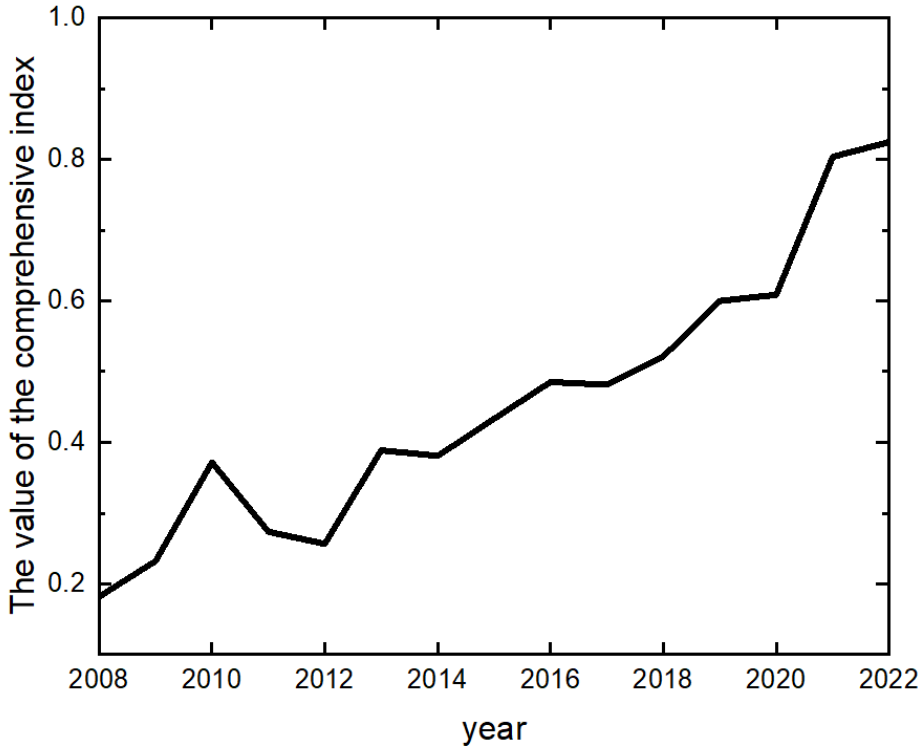


Fig.1 Time-series diagram of the comprehensive index of manufacturing

The comprehensive index of manufacturing was calculated based on equation (1)-(7), as shown in Fig.1.From 2008 to 2022, the comprehensive index of manufacturing has shown a fluctuating upward trend. The development of the comprehensive index of manufacturing has gone through the following stages. For 2008-2012, the comprehensive index of manufacturing jumped from the initial 0.18 to the stage high of 0.37 in 2010, and then

showed a downward trend in the following two years, with the comprehensive index of manufacturing dropping back to 0.26 in 2012. For 2012-2013, the comprehensive index of manufacturing stopped declining and rebounded, exceeding the stage high of 0.39 in 2010. Subsequently, the comprehensive index of manufacturing oscillated upward, and the index reached 0.82 as of 2022. It indicates that the high-quality development of the modern manufacturing industry has been improving in the past 15 years, and it has already achieved some development results.

4.2 Spatial and Temporal Characteristics of the Coupling Coordination Degrees

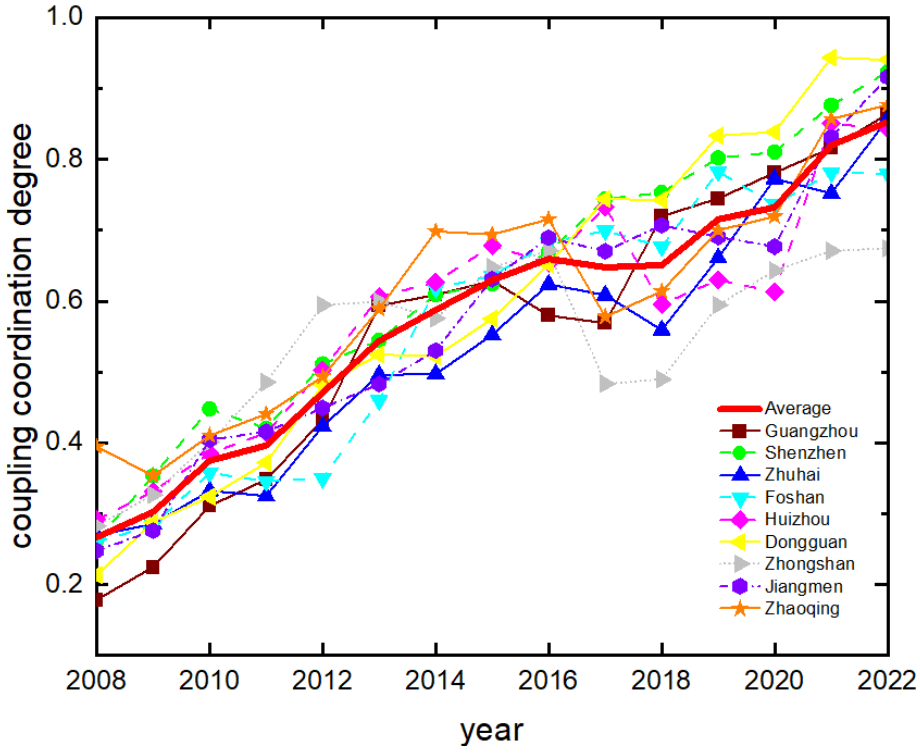


Fig.2 Time-series diagram of the CCDs between the logistics industry and the manufacturing industry of cities in the PRD

As can be seen in Fig.2, the CCDs between the logistics industry and the manufacturing industry of cities in the PRD in the period 2008-2022 show a slow upward trend. In the past 15 years, important progress has been made in addressing and promoting the synergy between the logistics industry and the manufacturing industry in this period.

From a broad perspective, there were three distinct phases in the temporal pattern of the average value of the CCDes between the logistics industry and the manufacturing industry of cities in the PRD. For 2008-2016, the average value of the CCDs has shown an obvious upward trend, and the average coupling of the two industries in the 9 cities rose from 0.27 in 2008 to 0.66 in 2016, with an average annual increase of 30.6%. In this phase, there were differences in the CCDs between different cities, the difference was always fluctuating within a relatively stable interval. For 2016-2018, changes in the average value of the CCDs have gradually leveled off, with the average value of the CCDs fluctuating from 0.65 to 0.66. At this phase, the development trend of the CCDs between different cities has diverged. The CCDs of Guangzhou, Shenzhen. Dongguan and Jiangmen continued to rise trend, but the rest of the cities saw varying degrees of decline in their CCD, Zhongshan had the greatest degree

of decline in its CCD. For 2018-2022, the average value of the CCDs has shown again trending upward, with the average value eventually rising to 0.85 in 2022. The CCD in each of the nine cities has once again shown an upward trend, but at this time, the degree of coupling varies greatly between different cities. The difference in CCD between Dongguan, the city with the highest CCD of the two industries, and Zhongshan, the city with the lowest CCD of the two industries, was 0.27 in 2022. It can be seen that 9 cities in the PRD have shown an obvious upward trend in the past 15 years, and notable achievements have been made in the synergistic development of manufacturing and logistics.

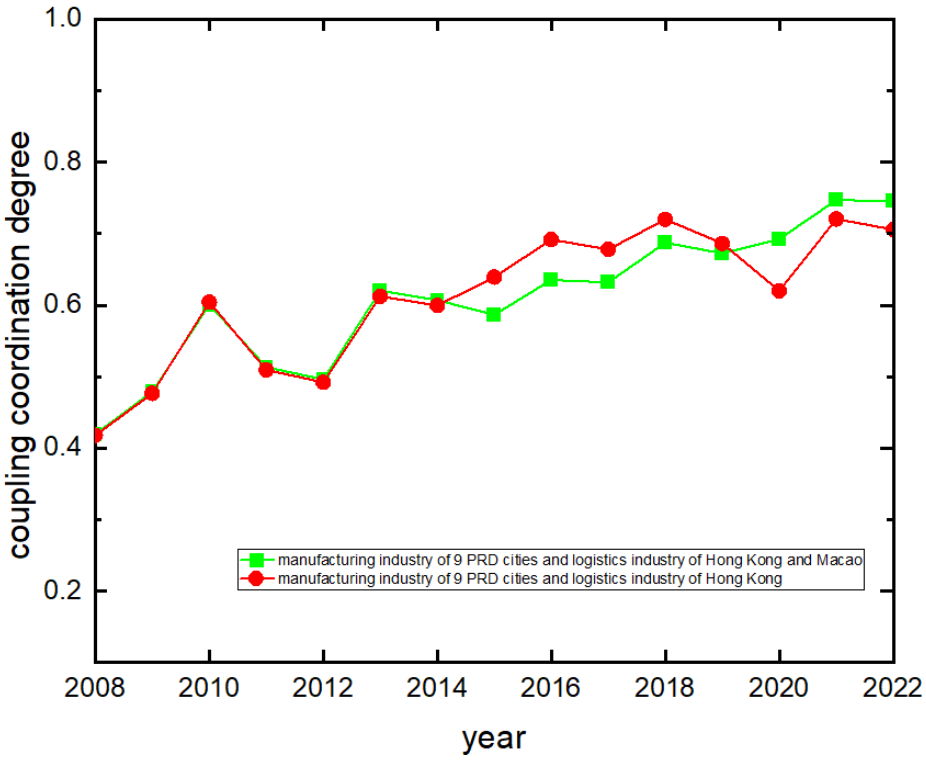


Fig. 3 Time-series diagram of the CCDs

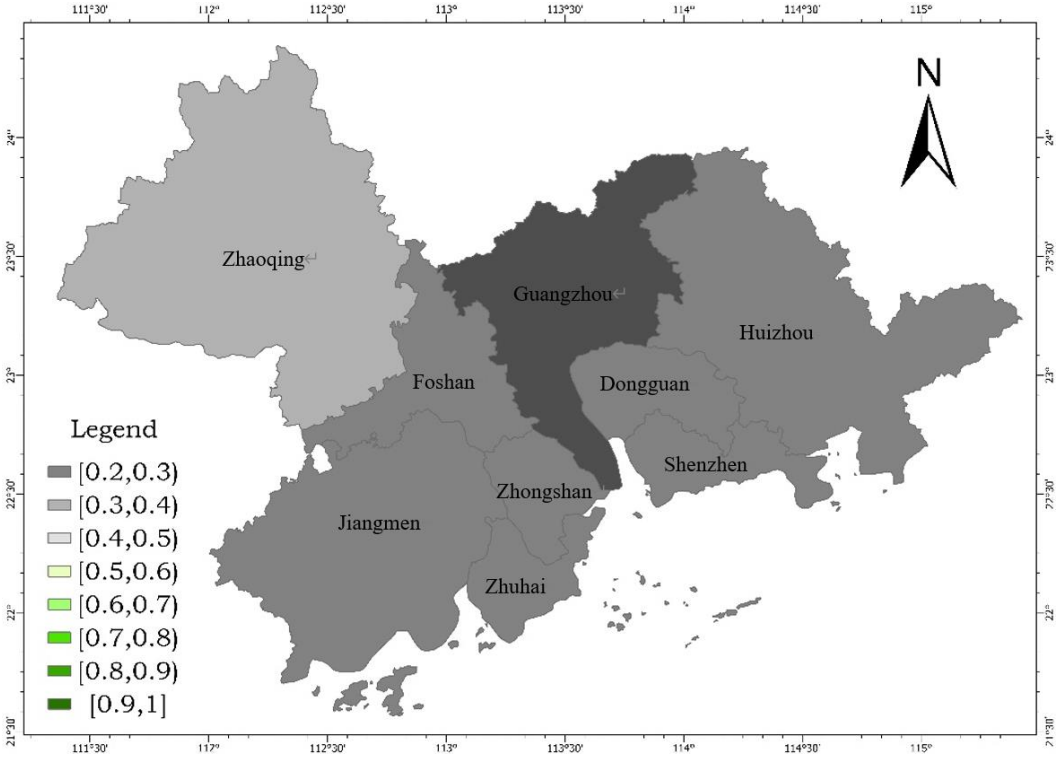
Figure 3 shows the CCDs from 2008 to 2022. As shown in the figure, the value of the CCDs generally shows an oscillating upward growth trend.

For 2008-2012, the trend of the CCDs between the two has shown in line with each other. After that period, the trend of the CCDs of the two diverged, and the trend of the CCDs between the manufacturing industry of the 9 cities in the PRD and Hong Kong's logistics industry fluctuated a lot.

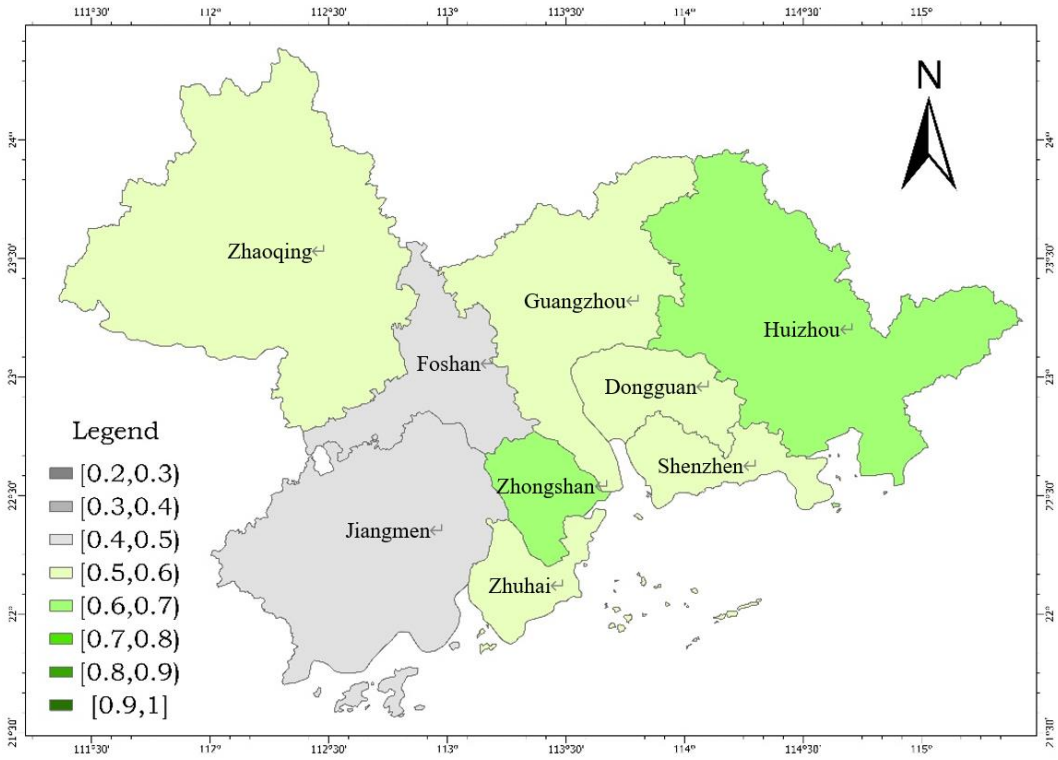
The CCDs of the two were continuously high in 2008-2010, both of them exceeding 0.6 in 2010, hitting a stage high. The CCDs of the two subsequently took a sharp turn for the worse. The CCDs of the two oscillated downward from 2010 to 2012, and fell to a stage low in 2012, with the CCD between the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong and Macau at 0.5; and the CCD between the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong at 0.49. The trends of the two have also diverged from this year。

In 2015, the CCD between the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong exceeded the CCD between the manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong and Macau for the first time. Until 2020, the value of the manufacturing industry of the cities in the PRD and logistics industry in Hong Kong and Macau once again surpassed the value of the

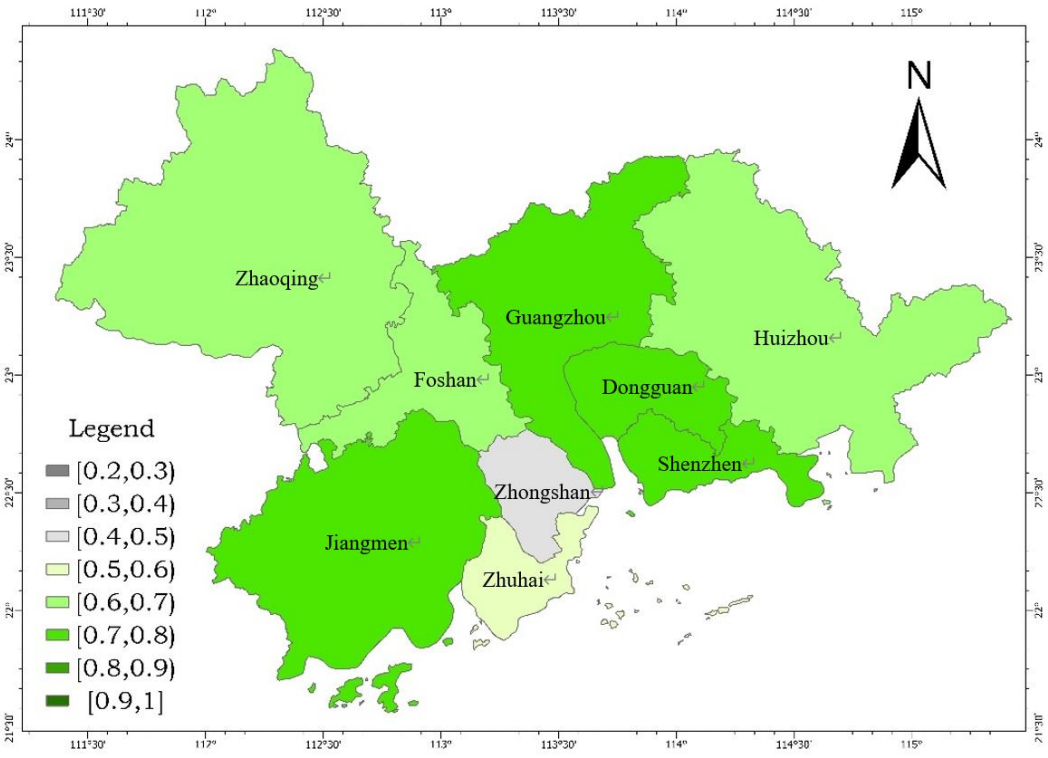
manufacturing industry of the cities in the PRD and the logistics industry in Hong Kong and remained so until 2022. As of 2022, the CCDs of both were above 0.70.



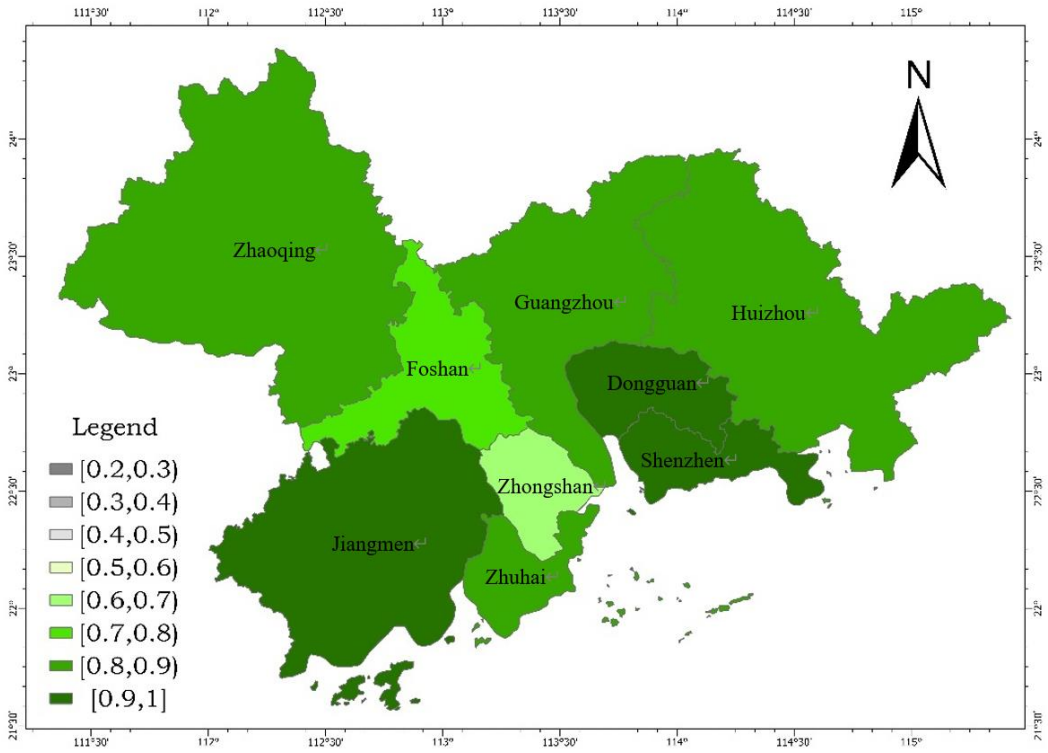
(a)2008



(b)2013



(c)2018



(d)2022

Figure 4. Spatial evolution trend of CCDs of cities in the PRD

To better describe the spatial evolution pattern of cities in the PRD from 2008 to 2022, ArcGIS Pro was used

to draw the spatial distribution of the CCDs between the logistics industry and the manufacturing industry of cities in the PRD in 2008, 2013, 2018, and 2022, as a representative of the change of CCDs of cities in the PRD. See (a)–(d) in Fig. 4 above for details.

Influenced by economic development, industrial linkage development, and policy drive, the CCDs of high-quality development of the logistics industry and modern manufacturing industry in all the nine PRD cities in the past 15 years has changed from more low-value and fewer high-value to fewer low-value and more high-value. The characteristics of spatial evolution were obvious. The CCDs of cities in the GBA showed a spatial evolution characteristic of increasing from north to south and from west to east.

In 2008, the city with the highest CCD was Zhaoqing, with the coupling coordination degree level in the mild maladjustment recession. The city with the worst CCD was Guangzhou, with the coupling coordination degree level in the moderate maladjustment recession. The levels of the rest cities were moderate maladjustment recession. At that time, the synergistic development of the two industries in GBA was relatively balanced, and the CCDs of various cities did not show obvious spatial differentiation. Until 2022, the cities with the highest coupling coordination degree level were Shenzhen, Dongguan, and Jiangmen, which have reached high-quality coordinated development. The city with the worst coupling coordination degree level was Zhongshan, which has only reached the primary coordinated development. It was easy to notice that the three cities with the highest coupling coordination degree levels in 2022 were located in the southern part of the GBA, showing the south was stronger than the north. In 2022, the CCDs of the three cities on the east bank of the Pearl River, Shenzhen, Dongguan, and Huizhou, were 0.92, 0.94, and 0.84, respectively, while the CCDs of the three cities on the west bank of the Pearl River, Zhongshan, Zhuhai and Jiangmen, were 0.67, 0.86 and 0.92, respectively. The difference in the CCDs of the cities on both sides of the river was obvious, with the cities on the east bank of the river having a higher degree of coupling coordination. The coupling coordination degree level showed a more pronounced regional imbalance among the cities in the Greater Bay Area.

It is worth mentioning that the growth rate of the average value of the CCDs of the cities on the east coast was relatively consistent. However, the growth rate of the average value of the CCDs of the cities on the west coast varies, and the coupling coordination levels of the three cities generally showed a stepwise distribution.

5. Conclusions

Based on the evaluation index system for high-quality development of the modern manufacturing industry of cities in the PRD, evaluation index system for logistics industry development of cities in the PRD, and evaluation index system for logistics industry development in Hong Kong and Macau, the comprehensive index of manufacturing of cities in the PRD and the CCDs of coupling coordination models were respectively measured in this study. The main conclusions are as follows:

(1) The comprehensive index of manufacturing has shown an upward trend in the past 15 years, indicating that the improvement in the level of high-quality development has been effective.
(2) The CCDs of different coupling coordination models have shown an overall upward trend from 2008 to 2022. In 2022, the CCDs of different coupling coordination models were all at a high level.
(3) The CCDs of high-quality development of the logistics industry and modern manufacturing industry of cities in the PRD features obvious regional heterogeneity, which is indicated by the fact that the CCDs of the eastern regions were greater than that of the western regions, while that of the southern regions were higher than that of the north regions.

These analyses are believed to be helpful to the government in further planning for the GBA. Finally, there are a few limitations that should be improved in future research. Due to the limitations of data availability, this study inevitably has limitations that need to categorize the CCDs of logistics and modern manufacturing industries in the GBA into three coupling coordination models to be calculated. Besides, this study only described the CCD between the logistics industry and the modern manufacturing industry in the GBA but did not analyze the mechanism of its influence.

Appendix

Table 5 Coupling Coordination Degrees of Different coupling coordination model

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Guangzhou	0.18	0.22	0.31	0.35	0.43	0.59	0.61	0.63	0.58	0.57	0.72	0.74	0.78	0.82	0.86
Shenzhen	0.26	0.35	0.45	0.42	0.51	0.54	0.61	0.62	0.67	0.74	0.75	0.80	0.81	0.88	0.92
Zhuhai	0.27	0.29	0.33	0.32	0.42	0.50	0.50	0.55	0.62	0.61	0.56	0.66	0.77	0.75	0.86
Foshan	0.26	0.28	0.36	0.35	0.35	0.46	0.62	0.64	0.68	0.70	0.68	0.78	0.74	0.78	0.78
Huizhou	0.29	0.33	0.38	0.41	0.50	0.61	0.63	0.68	0.65	0.73	0.60	0.63	0.61	0.85	0.84
Dongguan	0.21	0.29	0.32	0.37	0.48	0.52	0.52	0.57	0.65	0.74	0.74	0.83	0.84	0.94	0.94
Zhongshan	0.28	0.33	0.40	0.49	0.59	0.60	0.58	0.65	0.67	0.48	0.49	0.59	0.64	0.67	0.67
Jiangmen	0.25	0.28	0.40	0.42	0.45	0.48	0.53	0.63	0.69	0.67	0.71	0.69	0.68	0.83	0.92
Zhaoqing	0.39	0.35	0.41	0.44	0.49	0.59	0.70	0.69	0.72	0.58	0.61	0.70	0.72	0.86	0.88
Average	0.27	0.30	0.37	0.40	0.47	0.54	0.59	0.63	0.66	0.65	0.65	0.72	0.73	0.82	0.85

Year	Manufacturing Industry of the Cities in the PRD and the Logistics Industry of Hong Kong and Macau	Manufacturing Industry of the Cities in the PRD and the Logistics Industry of Hong Kong
2008	0.42	0.42
2009	0.48	0.48
2010	0.60	0.60
2011	0.51	0.51
2012	0.50	0.49
2013	0.62	0.61
2014	0.61	0.60
2015	0.59	0.64
2016	0.63	0.69
2017	0.63	0.68
2018	0.69	0.72
2019	0.67	0.69
2020	0.69	0.62
2021	0.75	0.72
2022	0.75	0.71

Table 6 Index of the Comprehensive Index of Manufacturing of Cities in the PRD

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Value	0.18	0.23	0.37	0.27	0.26	0.39	0.38	0.43	0.49	0.48	0.52	0.60	0.61	0.80	0.82

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A study on Integrity Evaluation System of Chinese Food Enterprises amidst the COVID-19 Pandemic

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Abstract

With the global outbreak of the COVID-19 epidemic, the issue of food safety increasingly draws more attention. Accordingly, the image of corporate integrity is becoming a focus in the society. Previous research on the integrity of food companies has largely been done from the perspective of government and management. This paper takes public scrutiny into consideration and attempts to construct corporate integrity evaluation system from a consumer perspective, which complements the gap in the current research field. In this study, we collect consumers' views on corporate integrity through a questionnaire survey and analyze the questionnaire data by using SPSS25.0 and AMOS24.0. This paper finally constructs a corporate integrity evaluation system including 4 factors, 6 dimensions and 32 indicators. To be more noticeable, a newly born factor under the COVID-19 named epidemic prevention integrity clearly shows its crucial influence on corporate integrity.

Keywords: COVID-19, corporate integrity, integrity evaluation system, Chinese food enterprises, public scrutiny

1. Introduction

The outbreak of the COVID-19 has impacted China's politics, economy, culture and even integrity to a certain extent. Integrity is one of the core values of Chinese traditional culture (Sun, 2003). Since the Ming and Qing Dynasties, Chinese Confucian Merchant Culture has always been an important thought of the Confucianism (Zhan and Yang, 2022). The integrity of enterprises is essentially "faith because of honesty".

"Honesty" refers to the observance of broad rules, including laws and moral norms; "Credit" is the recognition of the public, shown as enterprise credit, and is a dynamic establishment process (Pan and Cha, 2006). In the west, Integrity is defined by Erhard et al. (2007) as “a state or condition for being whole, complete, unbroken, unimpaired, sound, perfect condition.” They distinguish between integrity for an individual as being solely a matter of that person's word, and for a group or organizational entity as being comprised solely of what is said by or on behalf of the group or organization. They argue that for these entities to have integrity, they must honor their words.

Since the outbreak of COVID-19, the root cause of frequent food safety incidents lies in the myopic business behavior caused by the lack of integrity of the production enterprises, who are directly responsible for food safety (Wang and Ma, 2016). In recent years, food safety problems occurred in some well-known brands, such as Heytea, Masterkong and Nayuki etc. These food safety problems disclosed the decline of corporate ethics and lack of integrity in the economic field has become an indisputable fact at this moment. Especially, in the current COVID-19, consumers with diversified consumption views and highly developed social media have put forward higher requirements for corporate integrity.

Under the impact of COVID-19, the positive role of corporate integrity has been well-recognized by the society, and corporate dishonesty has been widely criticized by the society. The authors of this study believe the construction of enterprise integrity should not only rely on the supervision mechanism of industry national standards, government supervision, or laws and policies, but also public supervision from market consumers as the biggest stakeholders of enterprises. This study proposes to make clear the consumer concerns about influencing factors of corporate integrity and disclose core components of corporate integrity from the perspective of consumers. A questionnaire survey has been conducted to collect information about enterprise integrity indicators from consumers, and then SPSS25.0 and AMOS24.0 are deployed to analyze the questionnaire data, and finally suggestions on construction of the enterprise integrity

system in the food industry under COVID-19 are put forward.

2. Literature review

2.1 Review of studies on corporate integrity

Western researchers relate the corporate integrity to the business ethics and corporate performance. Prior literature has examined the relationship between corporate integrity and corporate behavior. They find that corporate integrity facilitates the transmission and exchange of information and that a greater level of corporate integrity results in higher-quality financial reporting (Shu et al., 2018). Additional research in this area examines the effect s of corporate integrity on mergers and acquisitions (M&A) activities (Bargeron et al., 2015), and earnings management (Biggerstaff et al., 2015). Domestic scholars' research on enterprise integrity mainly focuses on the lack of enterprise integrity, the construction of enterprise integrity culture, enterprise integrity management, enterprise integrity marketing, as well as the construction of enterprise integrity evaluation index system. Many scholars have analyzed the reasons for the lack of enterprise integrity (Leng and Li ,2013; Song, 2011; Wang, 2011), and put forward the governance and countermeasures for the lack of enterprise integrity (Huang, 2011; Luo, 2009). Wang (2022) analyzed that the root cause of the lack of enterprise accounting integrity under COVID-19 background lay in the drive of commercial interest and the asymmetry of information, and then gave corresponding countermeasures and suggestions that are to promote enterprise innovation, promote the construction of financial sharing service platform, improve laws and regulations, and increase punishment etc. Wang and Xia (2019) disclosed that the main reasons for the lack of integrity in Chinese private enterprises are the ambiguity of Confucianism and the decline of traditional morality. Enterprise owners have a weak sense of integrity and lack of enterprise credit system, asymmetric transaction information and scattered social credit information, Imperfect laws and regulations, and ineffective supervision and punishment. Furthermore, the government credit management system is imperfect and the behaviors of a few officials needs to be

improved. Therefore, the measures to improve the integrity of China's private enterprises in the new era are to strengthen integrity education and consolidate the concept of integrity, give full play to the role of industry organizations and strengthen industry self-discipline, improve the social credit system and restrict market dishonesty behaviors, strengthen the legal system construction and ensure economic order. Many scholars have also focused on corporate integrity culture. Specific research areas included the impact of corporate integrity culture on companies' accrual and real earnings management behavior (Zuo et al., 2020), the analysis and training of corporate integrity culture (Wang, 2013), and the connotation and cultivation of corporate integrity culture (Xu, 2012). In recent years, many scholars have also carried out research on the construction of enterprise integrity (Peng and Wang, 2021; Yang and Ding, 2020; Wu and Zha, 2020). Wang (2019) proposed to improve the corporate integrity by virtue, collaboration, and law. Li (2019) based on the essence of Confucianism traditional integrity culture, proposed that the construction of enterprise integrity system should promote the integrity culture heritage, shape the integrity character of enterprise management, and play the role of social supervision at the same time. Jiang et al. (2019) study the corporate culture of integrity and find out that t firms with an integrity focused culture have lower investment–cash flow sensitivity, even after we address endogeneity concerns. Garrett et al. (2014) assess organizational culture of integrity in terms of employees’ trust in management, and conduct empirical research on the link between corporate integrity and financial reporting.

2.2 Review of studies on corporate integrity management

Integrity management is the most widely advocated approach in the management of organizational ethics within the public sector. It calls for a balance between compliance and value approaches in order to implement appropriate controls, methods, instruments, and procedures that foster ethical behavior among organizational members. However, organizations do not yet have access to a tool or method that would allow them to measure this balance (Tremblay et al. 2017). By highlighting the main

limitations of the integrity management framework, Tremblay et al. (2017) argue that such a tool has not yet been developed because it is extremely difficult to establish a balance between these two approaches and then proposes the adoption of a new pluralistic contingency approach in the management of organizational ethics, an approach that overcomes the limitations of the integrity management framework. Some scholars focus on the research on integrity management framework (IMF). It is one of the frameworks most advocated by academics and practitioners for the management of public sector ethics (e.g., Boisvert et al. 2003; Brewer et al. 2015; Heywood, 2012; Hoekstra, 2015; Hoekstra, et al., 2016; Huberts, 2014).

2.3 Review of studies on corporate integrity of food enterprises

Due to the specific research field, this study reviewed the corporate integrity in the food industry. Jiang et al. (2022) summarized the construction background, development process and development status of the integrity management system of China's food industry enterprises, analyzed the relationship between the integrity management system and other management systems in the food industry. They pointed out the problems existing in the construction process of the integrity management system and put forward development suggestions. Zhou (2021) analyzed the current situation and harm of the lack of integrity of food enterprises, and found that the lack of integrity of food enterprises, on the one hand, came from the negative guidance of the profit seeking behavior orientation of food enterprises and the market information asymmetry mechanism under the imperfect market mechanism. On the other hand, it came from the insufficient function of the integrity system and the anomie of government supervision caused by the external supervision failure environment. The author further proposed to construct the food corporate integrity system from shaping of the integrity management concept, construction of market credit management system and the formulation of laws and regulations (Zhou, 2021). Bai and Li (2019) analyzed the basic characteristics and existing problems of large-scale food production enterprises, and through the analysis of the problems, proposed to strengthen

supervision from the aspects of implementing the main responsibility of enterprises, giving full play to the demonstration and leading role of enterprises , and strengthening food safety risk management.

2.4 Review of studies on corporate integrity evaluation system

It is worth noting that in recent years, scholars' research on enterprise integrity system has shown a hot trend (Wang and Li, 2021; Jiang, 2020; Yang and Peng, 2020). These studies mainly focused on the construction of enterprise integrity index system or evaluation system. Yang and Deng (2020) based on stakeholder theory, collected a total of 479 valid questionnaires and finally formed a 4-dimensional and 8-factor enterprise integrity evaluation system from the perspective of enterprises seeking partners. Tang (2020) started with the integrity development of logistics enterprises, combined with the current development opportunities faced by logistics enterprises, and established a logistics enterprise integrity evaluation index system to provide a certain basis for the integrity construction of logistics enterprises. Zhang et al. (2020) used Analytic Hierarchy Process to build an integrity evaluation system including three-level evaluation indicators, which made an attempt for the integrity evaluation of domestic enterprises. Zhao (2022) analyzed the basic characteristics of current start-ups, introduced the method of combining Analytic Hierarchy Process and Fuzzy Comprehensive Evaluation to construct the integrity index system which explored the evaluation of the integrity level of start-ups, thus trying to solve the problems existing in the integrity management of start-ups by improving the "integrity rating - elimination" mechanism. Yang and Zhang (2011) constructed the enterprise integrity evaluation index system from the analysis of enterprise integrity ability, internal and external environment and social responsibility. They deployed the method of Analytic Hierarchy Process, and then established a two-level Fuzzy Comprehensive Evaluation model, which is conducive to making a reasonable evaluation of enterprise integrity. They further apply the system to the analysis of specific examples. An and Tian (2017) took the integrity of leading agricultural enterprises as the research object and

established corresponding integrity evaluation indicators from three aspects: basic integrity, characteristic integrity and public welfare integrity. They also quantitatively analyzed the weight of evaluation indicators in each level structure by using expert opinion method and Analytic Hierarchy Process. Finally, through the overall ranking of levels, it is concluded that product quality management indicators, service integrity indicators and integrity culture construction indicators are the key elements affecting enterprise integrity. In the west, many researchers also do research on the integrity evaluation framework or system. Ali et al. (2016) provide a discussion on the development of food SC integrity framework using triangulation of interviews' insights with literature and then propose a food supply chain (SC) integrity framework including four dimensions in the context of halal food. Chiu and Hackett (2015) construct an inductive-descriptive theory-building framework based on three interrelated streams of inquiry for evaluation of individual ethicality or moral character to yield insight concerning both formal and informal instances of assessment Ongsakul et al. (2021) explores the effect of hostile takeover exposure on corporate integrity by exploiting an innovative measure of corporate integrity based on machine learning and textual analysis. The study employs the novel text-based measure of corporate integrity.

Through combing the above literature, this study finds that: 1) in terms of research contents, the research on enterprise integrity has been carried out comprehensively covering the major aspects of corporate integrity. There have sufficient research results from the interpretation of the connotation of integrity to the interaction and extension with social economy, the lack of enterprise integrity and countermeasures, the enterprise integrity culture, integrity management and the construction of enterprise integrity index system etc. 2) From the perspective of research objects, scholars' research covers enterprises in variety of industries and enterprises of different sizes, including not only the research on integrity of the whole industry and the analysis of integrity of specific enterprise cases. 3) Concerning research methods, the vast majority of scholars have integrated qualitative and quantitative research methods to improve the scientificity of the research results. In sum, the statistics methods such as AHP and

FCE are highly deployed. 4) In the research review of enterprise integrity evaluation indicators, it is found that the construction of enterprise integrity evaluation indicator system is mainly carried out from top entities such government supervision, laws and regulations, industry norms, or expert advice and other upper authorities, which is obviously different from the perspective of this research of constructing an evaluation indicator system rated by consumers. 5) Another obvious research niche is the research background. This study is conducted during the widespread of COVID-19. We attempt to disclose some unique influence factors different from the previous studies in line with the characteristics of COVID-19 era.

3. Research methodology

3.1 Research question

In this study, there is only one research question as follows:

What is corporate integrity evaluation system from the perspective of consumers under the situation of COVID-19?

With the research progression, we in particular figure out how many integrity influencing indicators, dimensions and factors there are in this system progressively.

3.2 Design of the questionnaire

In order to answer the research question above, the study designs a customer-oriented questionnaire. The questionnaire includes two parts. The first part is demographic information which includes gender, age, and education of the surveyed participants. Part two is the main part of the questionnaire which includes 39 questions concerning the influencing factors of food corporate integrity. Each question is to examine how important one influencing factor is from the viewpoints of the customers and there are five choices of score 1 to score 5 in terms of importance. The importance is increasing from 1 to 5, 1 being the least important and 5 being the most important. And the surveyed participants are requested to choose only one score with its

corresponding importance the influencing factor based on their own understanding and recognition.

3.3 Principles of constructing the influencing factors questionnaire

As mentioned above, 39 questions incorporate 39 influencing factors of food industry enterprise integrity. These influencing factors are sorted out by abiding by the following principles.

1) Based on Credit Evaluation Norms for Food Industry Enterprises (GB/T 4112-2010), we mainly summarize the following evaluation elements: the basic situation of the enterprise, the financial situation of the enterprise, the ability to guarantee the quality and integrity of the enterprise, and corporate social responsibility. We in particular adopt the evaluation indicators of credit evaluation norms for food industry enterprises, thus forming 29 influencing factors of integrity.

2) We have fully considered the impact of the COVID-19 on the construction of corporate integrity and set up the evaluation dimension of COVID-19 control and prevention integrity. Therefore, we specifically identified 6 epidemic influencing factors, and investigated how consumers perceive the impact of the epidemic on the construction of corporate integrity.

3) Yang & Deng (2020) proposed that when evaluating integrity, we should not only measure the contractual integrity of enterprises, but also measure the moral integrity of enterprises. We should ensure integrity not only by material and other objective conditions, but also by moral and other character cultivation. Chinese traditional Confucian Merchant culture stresses moral integrity, that is, the pursuit of moral integrity of quality cultivation. This integrity stems from the pursuit of personal quality cultivation, and advocates that people in the society need not only external trust in people, but also internal honesty in the heart to achieve self-sublimation. Therefore, in the design of this questionnaire, we have added the dimension of moral integrity to investigate 4 factors, such as the moral quality of corporate legal person, management and employees, as well as corporate moral culture.

In total, 39 indicators affecting the enterprise integrity of food industry under COVID-19 have been established (see Table 1)

Table 1 Influencing factor indicators

Question items	Indicators (Measurement index)
Q1	Moral quality of enterprise legal person
Q2	Moral quality of enterprise management
Q3	Moral quality of enterprise employees
Q4	Enterprise culture that stresses moral integrity
Q5	The employees of the enterprise have a clear division of labor and match their positions
Q6	Regular training plans and records of enterprise employees
Q7	Establishment and improvement of food quality and safety assurance system
Q8	Establishment of food integrity management system
Q9	Enterprise integrity record
Q10	Enterprise financial status
Q11	Enterprise tax credit
Q12	Financing credit of financial institutions
Q13	Raw and auxiliary material management
Q14	Production environment and equipment
Q15	Quality of food products
Q16	Food product processing and packaging
Q17	Food product inspection system
Q18	Food product storage
Q19	Transportation of food products
Q20	Food product sales and after-sales service
Q21	Food related industry certification
Q22	Traceability system and recall system of food production and operation
Q23	Food safety incidents
Q24	Government regulation
Q25	Consumers' word of mouth
Q26	Industry self-discipline
Q27	Social supervision
Q28	Abiding by national labor security and employment policies and regulations
Q29	Quality commitment performance
Q30	Stakeholder contract performance

Q31	Salary and payment
Q32	Participating in social public welfare undertakings
Q33	Strong awareness of environmental protection and energy-saving and emission reduction measures
Q34	Complying with COVID-19 control and prevention requirements of units at all levels with good performance in COVID-19 control and prevention of personnel and plant area without epidemic prevention incidents
Q35	Employees of the enterprise shall be vaccinated according to COVID-19 control and prevention requirements
Q36	Employees of the enterprise should regularly carry out nucleic acid testing according to the requirements of COVID-19 control and prevention requirements
Q37	Employees of the enterprise properly wear masks to comply with daily epidemic control and prevention requirements
Q38	Food transportation and sales in accordance with epidemic control and prevention requirements to prevent novel coronavirus from polluting food
Q39	Enterprises participate in public welfare activities to fight the epidemic

3.4 Research methods and procedure

This study uses SPSS25.0 and Amos24.0 to analyze the questionnaire data, the specific steps are as follows: 1) Reliability and validity analysis. It mainly tests the validity and consistency of the preparation of the scale and the measurement results of the questionnaire. 2) Exploratory factor analysis (EFA). Exploratory factor analysis is mainly to find out the number of factors that affect the observed variables and the degree of correlation between each factor and each observed variable through the "dimension reduction" method (Guo et al., 2019). In this paper, Principal Component Analysis (PCA) and Varimax Rotation are used to extract factors with eigenvalues greater than 1, and factor loadings greater than 0.5 are selected for further data interpretation. 3) Confirmatory factor analysis (CFA). Since exploratory factor analysis

lacks the test of theoretical model fitting, confirmatory factor analysis is further carried out. CFA is to test whether the collected data works according to the predetermined structure, so as to determine the ability of the theoretical model of factors to fit the actual data.

3.5 Data collection

The questionnaire survey has done online. The APP of Questionnaire Star Network has been deployed to deliver the questionnaires and collect the result data online. 486 questionnaires are finally collected. However, only 357 questionnaires are valid after excluding the incomplete or inconsistent questionnaires. The percentage of valid questionnaires accounts for 73.46%.

4 Results and discussion

4.1 Demographic information of the surveyed consumers

The data from part one help make clear of the basic information of the surveyed participants. The following is the demographic descriptions of the surveyed consumers. The survey is on food industry which is highly relevant with daily life necessities. The gender ratio also shows that females are more concerned about the food issues and are willing to share their views. Among 357 surveyed consumers, 261 is female accounting for 73.1% and 96 is male making up 26.9%. In order to cover a wide age range of consumers, the questionnaires don’t set the age limit. All the consumers who have an access to internet and can fully read and understand the questions in the questionnaire are welcome to share their points of view. Table one shows the age distribution of the surveyed consumers. It indicates that the majority of surveyed consumers is under 30 years old. The age group of consumers are supposed to have the strongest food consumption needs.

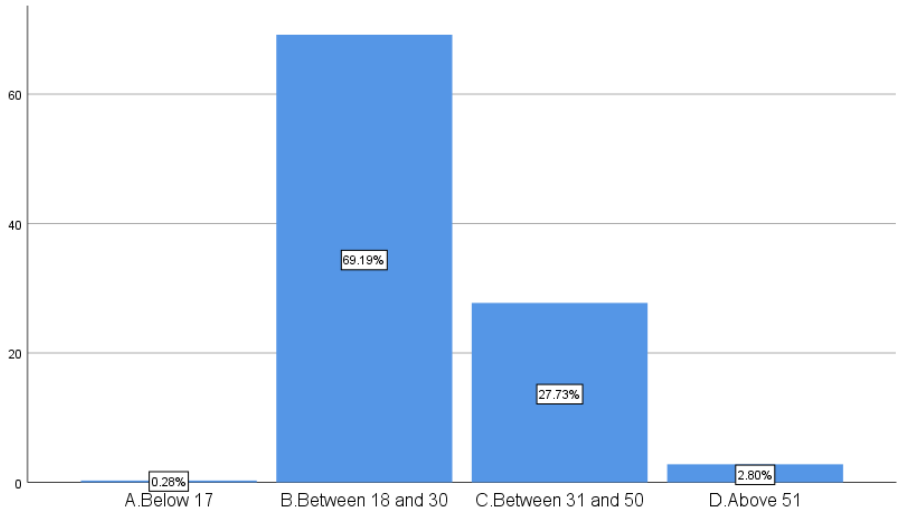

Figure 1 Age distribution of the surveyed consumers

The data collected also presents that more than 95% surveyed consumers have good education background of bachelor or above. It is well agreed that the consumers with good education may have high income that can support their consumption and are supposed to have a clear understanding and judgment of food integrity.

4.2 Constructing corporate integrity evaluation system

4.2.1 Reliability and validity analysis and EFA

Reliability is an index to test whether the questionnaire measurement results are reliable and consistent (Feng et al., 2022). In order to test the internal consistency reliability of the questionnaire structure, Cronbach's alpha is selected in this paper as the reliability test standard. The scholar devellis (1991) believes that Cronbach's alpha coefficient greater than 0.7 is acceptable, and greater than 0.8 is the best. Since this questionnaire is mainly composed of various measurement indicators, the reliability of the questionnaire as a whole is directly analyzed here. And Cronbach's alpha is obtained the coefficient is 0.961. Obviously, the reliability of the questionnaire is high, and the influencing factor index scale passed the test. The influencing factors refer to the high reliability and consistency between the title items, so the next step of validity analysis can be carried out.

Validity refers to the validity of the scale, that is, the degree of accurately

measuring the characteristics or functions it is intended to measure (Li, 2021). Validity analysis usually includes content validity and structure validity. Among them, structural validity analysis is divided into EFA and CFA. In this paper, KMO test and Bartlett's test were used to analyze the validity of the scale.

After SPSS analysis, the questionnaire data shows that the KMO value is 0.947, indicating that the questionnaire has high validity. At the same time, the significance of Bartlett's test is 0.000, and there is a strong correlation between variables, which is very suitable for factor analysis. Next, this paper first conducts EFA on the questionnaire data.

In this paper, PCA is used to study the common factor variance and extract principal components.

1) Common factor variance. The common factor variance indicates the degree to which the information contained in each index can be extracted. The results show that the extracted value of common factor variance of 39 indicators ranges from 0.426~0.847, of which Q5, Q24 and Q33 are less than 0.5, and the interpretation is poor. In general, the extent to which most indicators are interpreted is still within a reasonable range.

2) Extract principal components. The principal component extraction method used in this study is to extract components with eigenvalues greater than 1. The first eight results are shown in Table 2. Obviously, from the seventh result, the eigenvalue does not meet the extraction conditions (0.949<1), indicating that the principal component of this item has a smaller degree of interpretation of data variation than a single variable. Therefore, this paper selects six principal components, which explain 65.64% of the data variation.

Table 2 Interpretation results of total variance

	Initial eigenvalue			**Extract the sum of squares of loads**			**Sum of squares of rotating loads**		
Component	Total	Variance percentage	Cumulative%	Total	Variance percentage	Cumulative%	Total	Variance percentage	Cumulative%
1	16.766	42.99	42.99	16.766	42.99	42.99	5.587	14.326	14.326
2	3.115	7.988	50.977	3.115	7.988	50.977	5.481	14.053	28.379

3	1.859	4.766	55.743	1.859	4.766	55.743	5.219	13.382	41.761
4	1.478	3.789	59.532	1.478	3.789	59.532	3.586	9.195	50.956
5	1.241	3.182	62.714	1.241	3.182	62.714	2.937	7.53	58.486
6	1.141	2.926	65.64	1.141	2.926	65.64	2.79	7.154	65.64
7	0.949	2.435	68.075						
8	0.847	2.173	70.247						

According to the rotated component matrix, this paper eliminates the measurement items Q6, Q11, Q20, Q22, Q23, Q25, Q32, Q33 in which the factor loadings are less than 0.5 and cannot be attributed to any factor. From the perspective of consumers, "regular training plans and records of enterprise employees", "enterprise tax credit", "food product sales and after-sales service", "traceability system and recall system of food ", "food safety accidents", "consumers' word of mouth", "participating in social public welfare undertakings" and "strong awareness of environmental protection and energy-saving and emission reduction measures" have low correlation with overall evaluation of corporate integrity. At the same time, there are also situations of inclusion or intersection in the meaning of different measurement indicators, such as "participating in social public welfare undertakings"(Q32, 0.635) and "participating in public welfare activities to fight the epidemic"(Q39, 0.671). Combined with the common factor value, it is obvious that in the current social environment, consumers are more concerned about enterprises' participation in public welfare activities related to the epidemic.

After deletion, this paper finally gets 6 factors and 32 measurement indicators. According to the results of factor analysis and the characteristics of each measurement index, the following names and explanations are given to the six factors in turn.

Factor 1: Production integrity (X1). Production integrity refers to the integrity issues involved in the process of manufacturing products, including Q13-Q17 and Q19. Integrity in the production process is mainly related to food itself, and food is often the most important element for consumers to make purchase decisions, so it has also become an important part of corporate integrity.

Factor 2: Contractual integrity (X2). Contract integrity includes Q21, Q24 and Q26-Q30. It mainly asks questions about the performance of contracts, certificates or

moral standards, professional ethics and other aspects from the government, industry, society and so on. The performance record of an enterprise is a powerful proof of corporate integrity and an important reference factor for consumers to judge the level of corporate integrity. Therefore, this paper believes that enterprises should strictly perform the terms of the contract and abide by professional ethics. Facts have proved that when it comes to contract performance, corporate integrity and corporate image are often directly affected.

Factor 3: Epidemic prevention integrity (X3). Indicator Q34-Q39 mainly measures the current enterprise epidemic prevention measures and contributions. Since the virus may spread unintentionally during the purchase process, whether the epidemic prevention and control is appropriate has become an important factor for consumers to consider in the context of the epidemic era.

Factor 4: Management integrity (X4). Indicators Q4 and Q7-Q9 mainly measure the structural management problems of enterprises. As an abstract moral quality and even corporate culture, integrity cannot be cultivated without the assistance of the environment, and it also needs certain clues as evidence. Therefore, the establishment of a reasonable management system can more persuasively show all aspects of corporate integrity to consumers.

Factor 5: Moral integrity (X5). Q1-Q3 and Q5 mainly focus on the moral quality of internal personnel of the enterprise. The moral concepts of management and employees will indirectly affect the overall integrity image of the enterprise from the aspects of production, operation and communication. Therefore, this paper summarizes it as moral integrity.

Factor 6: Financial integrity (X6). This paper summarizes the three financial accounting indicators of Q10, Q12 and Q30 as financial integrity, of which the factor coefficient is the highest "enterprise financial status". It can be seen that before choosing a food enterprise, consumers will still comprehensively consider the financial situation of the enterprise. Enterprises with good financial conditions will help to improve the integrity image of the enterprise.

4.2.2 Confirmatory factor analysis

4.2.2.1 First-order factor analysis

Based on the above results of EFA, a structural equation model is established to further test the model. After importing the data, the analysis shows that the Chi-Square degree of freedom ratio of the model is 3.67, and RMR and CFI are also not up to standard, with a poor degree of fitting. Therefore, the model is further modified by combining factor loadings and Modification Indices (MI). The observed variables and their paths with factor loadings less than 0.6 or MI value greater than 20 are deleted. After repeated debugging, the observed variables Q13, Q18 and Q37 were finally removed, and the correlation of E7-E8 and E30-E31 two residual terms were established.

The correlation between "raw and auxiliary material management" (Q13) and “production environment and equipment” (Q14) is too high, which affects the overall fitting effect of the model. From the data, the respondents can't distinguish these two indicators well, so this paper deletes the Q13 with low factor loading. At the same time, "food product storage" (Q18) and "the employees of the enterprise properly wear masks to comply with daily epidemic prevention requirements" (Q37) also have semantic duplication or unclear expression with other measurement indicators. Under comprehensive consideration, this article will eventually delete it.

The correlation of residual items in Q7-Q8 and Q30-Q31 are based on the consideration of content validity. Although these two groups of indicators are different in language expression and cannot completely replace each other, the measured objects are indeed relatively close, and even affect the fitting effect of the model. Therefore, this paper adopts the establishment of relevant methods. This shows that the two groups of indicators can not only be explained by their own latent variables, but also play a role in explaining each other.

Table 3 Comparison of first-order model fitting indicators

	CMIN	CMIN/DF	RMR	GFI	RMSEA	CFI
Ideal range	-	<3	<0.05	>0.9	<0.1	>0.9

Calculation results	Before model correction	1647.886	3.67	0.42	0.768	0.087	0.853
	After model correction	874.841	2.627	0.35	0.901	0.068	0.918

According to the statistical analysis results, the Average Variance Extraction (AVE) and Combination Reliability (CR) of the modified model are calculated. And AVE range of the 6 potential factors after the model modification is 0.53~0.68, which is greater than the judgment value of 0.5. The range of CR is 0.82~0.91, which is greater than the judgment value of 0.7, indicating that the system has good convergent validity. However, in the analysis of discriminant validity, it was found that the correlation coefficient between latent factors was greater than the square root of AVE, indicating that the discriminant validity was general. After data sorting, as shown in Table 4, the bold part is the case that the square root of AVE is greater than the correlation coefficient, indicating that the correlation between factors is high, such as X1 and X4 (r=0.803), X2 and X4 (r=0.751), X2 and X6 (r=0.837) and X4 and x6 (r=0.774). Obviously, since the correlation coefficient ranges from 0.373 to 0.837, there is a medium high correlation between the 6 latent factors, so it is reasonable to speculate that there may be a second-order potential factor in the model.

Table 4 First-order latent factor correlation matrix

	X1	X2	X3	X4	X5	X6
X1	0.58					
X2	0.73**	0.57				
X3	0.463**	0.628**	0.68			
X4	**0.803****	**0.751****	0.373**	0.55		
X5	0.63**	0.701**	.487**	0.709**	0.53	
X6	0.664**	**0.837****	0.656**	**0.774****	0.67**	0.55
Ave square root	0.76	0.75	0.82	0.74	0.73	0.73

*p<0.05 **p<0.01

4.2.2.2 Second-order factor analysis

Based on the above analysis, this paper establishes 5 models for comparative analysis, and the specific construction is as follows:

Model 1: 6 first-order factors are summarized into one higher-order factor.

Model 2: X1 and X5; X2, X4 and X6 are summarized into two higher-order factors respectively.

Model 3: X1 and X2; X4 and X6 are summarized into two higher-order factors.

Model 4: X1 and X4; X2 and X6 are summarized into two higher-order factors.

Model 5: Summarize X2, X4 and X6 into a high-order factor.

Through continuous adjustment of the model, the fitting indexes of the models are shown in Table 5.

Table 5 Comparison of indicators of fitting degree of second-order model

	System 1	System 2	System 3	System 4	System 5
CMIN/DF	2.771	2.782	2.792	2.644	2.787
GFI	0.833	0.835	0.833	0.902	0.835
RMR	0.04	0.039	0.04	0.033	0.039
RMSEA	0.071	0.071	0.071	0.068	0.071
CFI	0.908	0.908	0.908	0.916	0.908

In general, the indicators of the five models have little difference, but the fitting degree of the Model 4 is obviously better than the other four, and each parameter basically meets the judgment standard. Specifically, the factor loadings in the Model 4 are higher than 0.8; CR and AVE are also greater than 0.8, indicating good reliability and convergent validity. So far, according to the characteristics of observed variables and latent variables, the second-order latent variables are defined as follows:

Factor 1: Institutional integrity. As production integrity and management integrity are mainly derived from the internal integrity management of enterprise operation, such as "food product inspection system and process", "enterprise culture", "establishment of integrity management system" and other aspects, the internal system of the enterprise as the first person responsible for production is mainly considered, and the level of integrity reflected is closely related to the enterprise's own institutional structure. Therefore, this paper names the first second-order factor as institutional integrity, and pays attention to the conventional managerial integrity in the internal processes and rules and regulations of enterprises.

Factor 2: Market integrity. Market integrity can be divided into contractual

integrity and financial integrity. Because the performance of contracts and financial transactions involve many stakeholders, the consumer of this paper is also included. The performance of these two aspects of integrity often requires communication with various stakeholders in the market, involving many enterprise information disclosure, which is also the most accessible aspect of corporate integrity for consumer groups. Therefore, this paper named the second second-order factor market integrity.

4.2.2.3 Higher-order model test

Taking the ultimate latent variable of corporate integrity into account, this paper establishes a system with institutional integrity, market integrity, epidemic prevention integrity and moral integrity as four factors to build corporate integrity for verification. See Table 6 for the summary of model reference indicators. It can be seen that there is a small gap between each index and the index of the first-order model, which has reached the basic judgment standard, indicating that the model is acceptable and the adaptability is medium. AVE (0.7>0.5) and CR (0.9>0.7) are also within a reasonable range, and convergent validity is good. However, GFI and other indicators are close to the basic judgment value, and the system can further optimize the fitting effect by increasing the sample size and modifying the model path.

Table 6 Summary of indicators of corporate integrity evaluation system from the perspective of consumers

	CMIN/DF	GFI	RMR	RMSEA	CFI	AVE	CR
Overall model	2.704	0.903	0.038	0.069	0.912	0.7	0.9

Finally, this paper obtains the corporate integrity evaluation system from the perspective of consumers, as shown in Figure 2.

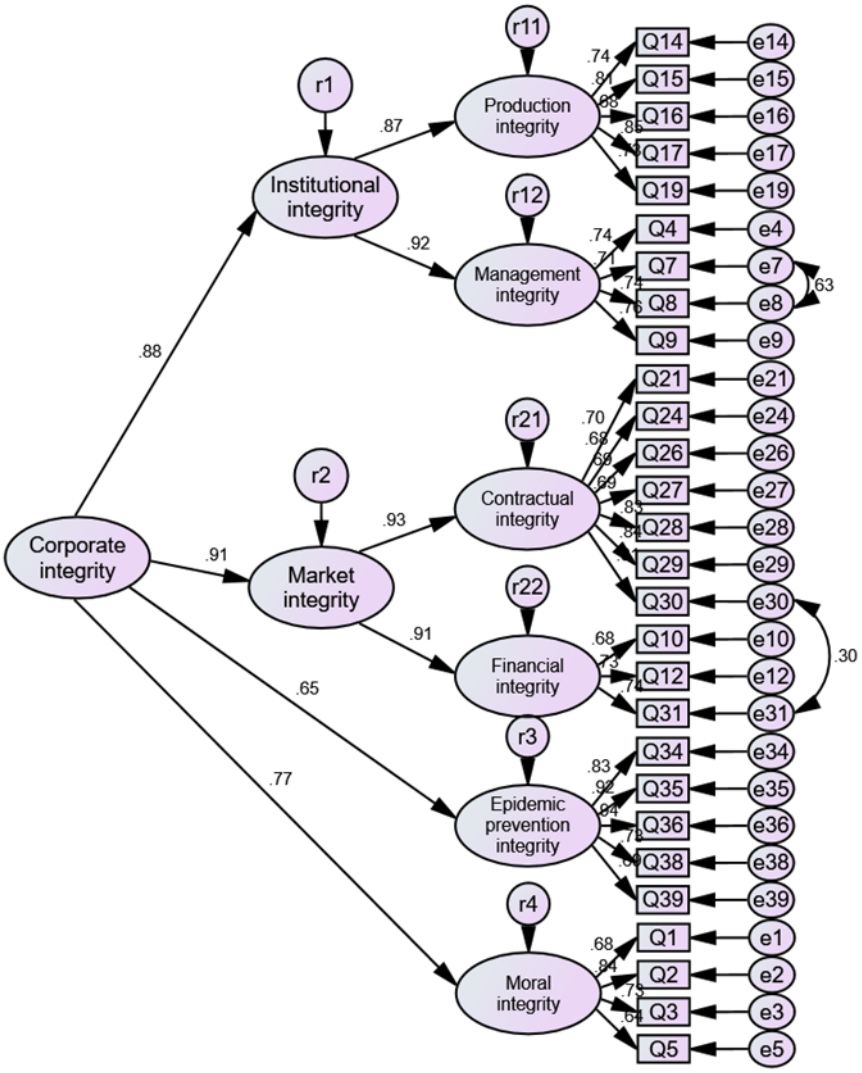

Figure 2 Corporate integrity evaluation system from the perspective of consumers

In general, the system combines national standard basis as well as the analysis of the views of consumer groups, it has good reliability and validity, and the fitting level of the system is moderate, which can more scientifically detect the influencing factors of consumer groups on corporate integrity evaluation. Although the system can still be optimized to improve the interpretation, the construction of this system has met the research purpose of this study, thus there is no further theoretical revision of the model.

5 Conclusion and implication

This paper is an attempt of bottom-up empirical research. The research data are collected through questionnaire survey, and the structural equation system is established for factor analysis. Finally, an evaluation system with 4 factors, 6 dimensions and 32 indicators is established. In the process of questionnaire data analysis and system refinement and adjustment, this paper mainly has the following three findings.

1) Market integrity has a high factor loading (0.91). It shows that among the four factors, consumers attach the most importance to market integrity, followed by institutional integrity (0.88), epidemic prevention integrity (0.65) and moral integrity (0.77). Contractual integrity and financial integrity under market factors are the most direct sources of information that consumers can contact. The market integrity formed by enterprises in different stakeholders will further generate good or bad public word-of-mouth, affecting the corporate image and the judgment of consumers.

2）In the integrity of epidemic prevention, whether employees regularly carry out nucleic acid testing (Q36) is the most important indicator. At the same time, it is also the index with the highest factor loading among all observed variables (0.94), which means that Q36 has the highest correlation with the latent variable of epidemic prevention integrity, and plays an important role in the construction of integrity of the whole enterprise. Compared with several other observation variables, such as epidemic prevention and vaccination in production areas, nucleic acid testing of enterprise employees is the most likely to cause safety risks. Since employees' daily activity areas and behaviors are difficult to predict except for going to work, regular nucleic acid testing can not only provide assurance for the epidemic prevention work of enterprises, but also enable consumers to dynamically understand the epidemic prevention situation of enterprises and enhance trust.

3）The regular training plan and records of enterprise employees, food safety accidents, and the reputation of enterprise consumers are difficult to become the basis for consumers to judge the level of corporate integrity. The common factor variance of these three indicators is less than 0.5. At the same time, in the exploratory factor analysis, their factor loadings of the 6 components is less than 0.4, indicating that they can be extracted by the corporate integrity with less information, lack of corresponding relationship, and are not suitable to be included in the evaluation system. Specifically, the employee training plan is part of the internal talent training program, and consumers usually lack access to this kind of information. And because the language expression of the "training plan" is too extensive to correspond to the theme "corporate integrity", consumers will not take it as the basis for integrity evaluation. Food safety accidents are established facts, but consumers are more concerned about the enterprise's preventive measures in advance, such as model construction or market supervision in the production process. At the same time, there are various types of safety accidents, and consumers are not easy to attribute them to integrity factors. They will take into account the impact of food safety or the production environment itself. And the public praise of consumers is too differentiated. It is greatly influenced by personal preferences and independent marketing of enterprises, and usually has exaggerated elements. Especially in the case of highly developed social media and diversified consumer demand, consumption gradually tends to view the word-of-mouth effect rationally, and consumers' judgments on corporate integrity mostly come from the behavior of enterprises themselves.

There are still some deficiencies in this study. They are now proposed to provide reference for future research in order to be improved in future research. The fitting level of the model is medium, and it can be further optimized. The system construction of this paper is mainly based on national standards and questionnaire survey data. In the future, we can also conduct in-depth interviews with consumers, improve the model, adjust the structure and improve the interpretation through qualitative research and other methods. Besides, the discriminant validity of the system was general. The

reasons may be: 1) the text description of the scale is not clear enough; 2) The respondents' understanding of the questionnaire questions deviated from the designer's idea; 3) The respondents did not think carefully when filling out the questionnaire. If you want to optimize and improve the system data, in addition to modifying the scale language, you can also try to use the way of offline questionnaire collection to fully communicate with the respondents to ensure the correct transmission of the meaning of the questionnaire questions.

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MCashew: A Chinese Venture in Mozambique's Trade

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Abstract

In an era defined by global connectivity, our group set up a startup called MCashew, a Chinese enterprise venturing into the Mozambican cashew market, epitomizes the intersection of entrepreneurship and cross-cultural commerce. This project not only presents a lucrative business opportunity but also signifies a significant contribution to social and economic development for cashew producers in Mozambique and consumers in China.

The topic of discussion is MCashew's strategic entry into Mozambique, which first analyze the market and competition analysis as well as the financial forecasts. Secondly, the study encompassed cashew production, marketing strategies and logistics management, delving deeply into the dynamics of cashew production in Mozambique, illuminating the agronomic techniques, processing methods, and nuances of the value chain, uncovering the ins and outs of the industry.

Importantly, MCashew's impact transcends mere profit motives, as it is deeply committed to driving socioeconomic development in Mozambique. By fostering local partnerships, investing in infrastructure, and promoting skill development, MCashew endeavors to empower communities and effect enduring positive change. Furthermore, MCashew's steadfast commitment to sustainable development and inclusive growth underscores its overarching vision. By adopting a holistic approach that harmonizes economic prosperity with social and environmental stewardship, MCashew aims to generate value for all stakeholders involved.

Overall, this paper will propose a business strategy for MCashew's entrepreneurial program in Mozambique, with a vision for development and cooperation over the next three to five years, with the goal of sustainable social and economic development for Mozambican producers and consumers in China and beyond.

Keywords: Mozambique, Cashew, Startup, International trade, Strategic planning

1. Instruction

In the global economy of today, entrepreneurial endeavors frequently cross national boundaries and unite disparate markets and cultures. Cross-cultural commerce and entrepreneurship meet at the junction in the case of MCashew, a Chinese company that the author created is making its way into the Mozambican cashew industry. This initiative holds great potential for promoting social and economic development among Chinese customers and cashew producers in Mozambique, in addition to being a good business prospect.

MCashew's strategic entry into Mozambique is supported by a thorough examination of the competitive environment, financial forecasts, and market dynamics in the region. This essay delves into the nuances of the cashew sector in Mozambique by examining MCashew's approach to cashew production, marketing tactics, and logistics management. This study intends to investigate agricultural practices, processing processes, and the subtleties of the value chain. Beyond only making money, MCashew is dedicated to promoting socioeconomic development in Mozambique.

MCashew aims to empower communities and create long-lasting good change through projects like skill development programs, infrastructure investment, and local collaborations. The organization's commitment to inclusive growth and sustainable development highlights its primary goal. MCashew seeks to provide value for all parties concerned by fusing social and environmental stewardship with economic development.

This paper presents a three- to five-year plan of action for MCashew's entrepreneurial initiative in Mozambique, with an emphasis on sustainable development and collaboration. MCashew seeks to promote a robust and just cashew business by improving the standard of living for Mozambican farmers and satisfying the needs of Chinese and international consumers.

2. Market Analysis

2.1 Market Trends

Global Cashew Consumption Growth: The global demand for healthy snacks has surged in recent years, and the consumption of cashews, a nutritious and low-fat healthy food, has risen significantly. According to website data, the global cashew market size is expected to grow from USD 7.82 billion in 2024 to USD 9.2 billion by 2029 (mordorintelligence.com), while the global nuts and seeds category of products is projected to grow at a CAGR of 6.5 per cent. In particular, cashews continue to expand their use in the bakery, snacking and catering industries due to their unique taste and nutritional value. In addition to this, China's cashew imports have also increased significantly, and according to the data we could find, imports are valued at $190,900,000 in 2021, an increase of 26.4 per cent from 2020 (customs.gov.cn).

Increased awareness of sustainable consumption: Consumers are becoming more aware of the sustainability of product origins, favouring brands that can demonstrate the use of environmentally friendly cultivation and fair trade principles. Chiquita's success in the banana industry reflects the importance of sustainable brand storytelling in enhancing brand image and market appeal. Globally, consumers are increasingly making care for the planet one of the critical factors in their consumption considerations, especially in China. This trend is particularly evident among Chinese consumers and applies to the cashew market.

E-commerce and digital transformation: With the popularity of the Internet and the convenience of mobile payment, e-commerce platforms have become an essential channel for selling agricultural products. Digital transformation is driving the e-commerce industry from a ‘new industry’ to a ‘new normal’, and the combination of the latest achievements in the digital field, such as intelligent manufacturing, digital marketing, and the use of 5G, with the e-commerce industry is helping traditional e-commerce companies to transform and upgrade. There is no doubt that the epidemic has accelerated the growth of the e-commerce industry's scale, as well as the adoption and development of business strategies and technologies. Especially in China, the e-tailing of agricultural products reached RMB 309.4 billion in 2020, a year-on-year growth of 31.8% (Source: China Internet Network Information Centre). Small programs and apps incorporating fun and interactive features, such as virtual farming games, have become a new way to attract young consumers.

2.2 Market Outlook

The cashew nuts market is expected to continue growing in the coming years. The global cashew market is expected to reach $11.6 billion by 2025, growing at a CAGR of 6.9% (mordorintelligence.com). China, the world's second-largest economy and a vast consumer market has a rising demand for high-quality, healthy food, and cashews have great potential as a high-end snack and nutritious ingredient.

Table1. China's cashew nuts import and export statistics, 1996-2019

(https://www.chyxx.com/ & customs.gov.cn)

Year	Import amount: USD	Amount imported: kilograms	Export amount: USD	Amount exported: kilograms
1996	$588,640	1,213,715	$475,834	166,225
1997	$1,845,588	2,701,258	$270,559	104,111
1998	$406,886	1,239,865	$11,211	10,937
1999	$73,684	367,000	$1,041	761
2000	$160,752	650,697	$36,756	19,543
2001	$264,687	406,205	$331	480
2002	$105,030	217,198	$8,531	10,060
2003	$52,160	25,757	$5	10
2004	$13,151	79,700	$0	0

2005	$43,828	131,935	$489	1,090
2006	$62,681	165,473	$387	100
2007	$224,690	815,074	$3,715	1,235
2008	$174,496	687,547	$0	0
2009	$294,545	906,728	$0	0
2010	$489,047	1,365,318	$636,096	656,800
2011	$934,433	943,089	$3,062	440
2012	$4,908,838	7,044,342	$1,065	450
2013	$5,503,403	9,038,246	$976,008	1,522,272
2014	$2,881,404	4,069,154	$922,483	952,020
2015	$3,595,441	4,771,593	$3,160	650
2016	$727,911	793,741	$74,234	69,073
2017	$11,687,094	7,862,963	$39,760	4,970
2018	$9,904,454	6,757,008	$0	0
2019	$18,766,696	12,805,609	$5,116	990

Mozambique, one of the world's leading cashew producers, a region in which we will be investing, has seen its share of global production rise. The country's government is increasing investment and policy support for agriculture to promote the export of agricultural products such as cashew nuts, providing a favourable policy environment for international trade.

2.3 Target Market

China's mid-to-high-end consumer group: Consumers concerned about healthy lifestyles and seeking quality and sustainability. This segment is well aware of the nutritional value of cashew nuts and is willing to pay a premium for it.

Online shopping enthusiasts: marketing with e-commerce platforms and social networks, targeting the younger generation who frequently use e-commerce services and are willing to try new things.

Enterprise customers: These include the bakery industry, restaurant chains, and health food manufacturers, which have a steady demand for high-quality raw materials and a higher demand for sustainability in the supply chain.

In conclusion, taking into account the current market trends and future outlook, the cashew import business for the Chinese market should focus on sustainability, digital marketing and supply chain optimisation while targeting mid-to-high-end consumers and corporate customers as the primary targets and capitalising on the opportunities presented by the boom in healthy eating and e-commerce.

3. Competition Analysis

3.1 Competitor Analysis

Key competitors in the market for Mozambique cashew imports into China are likely to include established international trading companies, large local farmers and international agribusinesses with supply chain strengths. These competitors are likely to have well-established logistics networks, stable customer bases and extensive industry experience. In particular, some international brands such as Olam International and Barry Callebaut (https://news.sohu.com/a/765663306_121666466,https://www.marketsandmarkets.com/ResearchInsight/nut-products-market.asp), which not only have deep roots in the agricultural products trade, but may also have ventured into the cashew business. It is worth noting that although Chiquita is primarily focused on the banana industry, its successful experience in global agricultural supply chain management can be used as a learning case,

especially in the areas of sustainable cultivation, branding, and e-commerce operations, offering a wealth of inspiration and potential strategies for our market analysis.

The table below illustrates the aspects that we will focus on for different segments of businesses in this sector.

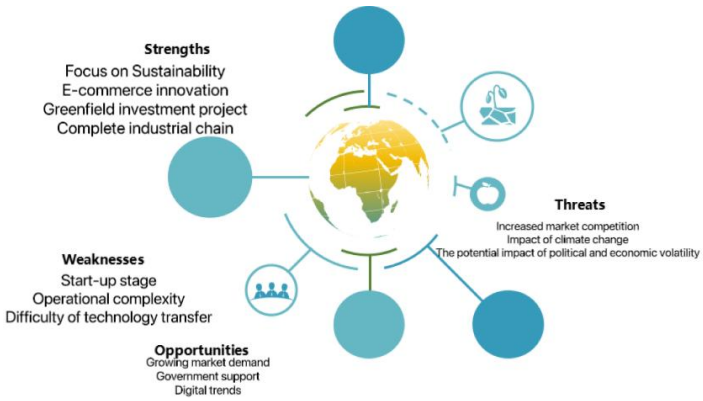
Table 2: Mozambique Cashew Nuts Market Analysis Table

Business Type	Focus
Market Leader	Supply chain management, product quality control, marketing strategy
Emerging Companies	New technologies or innovative business models, differentiation strategies, market share
Potential competitors	Threat of other agricultural product sectors switching to cashew trade

3.2 SWOT Analysis

Based on the business project we will create, we started with a minimal SWOT analysis.

Figure 1: SWOT Analysis



In conclusion, when formulating the three-year development plan, we need to pay close attention to the market dynamics, strengthen our advantages in sustainability and technological innovation, and at the same time, actively respond to the challenges posed by supply chain management and market competition, to steadily expand the business of importing cashew nuts from Mozambique to China through a flexible strategy and a close partnership.

4. Project Overview

4.1 Executive Summaries

This project aims to establish an integrated agri-business that combines cashew import/export trade, sustainable cultivation, product innovation and digital marketing, focusing on introducing Mozambique's premium cashew nuts to the Chinese market. By building complete chain management from field to table, combined with fun interactive consumer experiences and a commitment to supply chain sustainability, we aim to become a leader in healthy, environmentally friendly cashew brands in the Chinese market. The plan is to move from start-up to profitability within three years while helping to modernize and sustain the Mozambican farming community through technology transfer and training.

4.2 Company Name and Address

Company Name: MCashew Global Trading Co.

Address: 188 Yunqiao Road, Pudong New Area Pilot Free Trade Zone, Shanghai, China.

Also has an office in Maputo, Mozambique at Avenida Julius Nyerere, Maputo, Mozambique.

4.3 Description of the Project

MCashew Global Trading Co., Ltd. is committed to building an internationalised supply chain system for agricultural products with cashew nuts at its core. The project will initially focus on the import and export trade of cashew nuts and then gradually expand to planting, processing, brand building and e-commerce operations. Through the integration of Mozambique's high-quality cashew resources, combined with the Chinese market's strong consumption potential and innovative marketing tools and digital technology, the company will provide healthy, tasty and sustainable cashew products to satisfy consumers' pursuit of a healthy lifestyle.

4.4 Project Background and Objectives

As the global demand for healthy food grows, especially the Chinese market's preference for high-quality, sustainable agricultural products, the demand for cashew nuts as a nutritious and wholesome snack is rising rapidly. Meanwhile, Mozambique, one of the world's leading cashew producers, has enormous export potential. The project aims to seize this market opportunity and introduce Mozambique's cashew nuts to the Chinese market by establishing an efficient, transparent and sustainable supply chain while promoting local farmers' income and ecological and environmental protection, achieving a win-win situation regarding economic and social benefits.

5. Product services and introduction

5.1 Product introduction

Our product line revolves around high-quality cashew nuts, aiming to provide the Chinese market with a variety of choices from original flavors to multiple flavors to meet the taste preferences of different consumers. Product range includes:

5.1.1 Pure Natural Cashew Series

The all-natural cashew range occupies a core position in our product line-up. These cashew nuts are sourced from selected orchards in Mozambique, and each one is pure natural. We insist on not adding any chemical additives or preservatives and monitor the entire process from picking to packaging to ensure that all bite consumers take is the most authentic taste and nutrition of cashews. It’s a natural sweetness and delicate taste are very suitable for consumers who pursue a healthy lifestyle, as well as food lovers who have a high appreciation for the original flavor of ingredients.

5.1.2 Flavor Cashew Series

To meet the Chinese market's high demand for flavor diversity, we have carefully developed a flavored cashew series. The range includes flavors such as Sea Salt, Honey Roast, and Spicy, each uniquely formulated to provide consumers with an unprecedented taste experience. Sea salt cashews are lightly salted to enhance the flavor, highlighting the mellowness of cashews themselves; honey-roasted cashews combine the sweetness of honey and the crispiness of cashews, sweet but not greasy; spicy cashews bring a subtle spiciness and flavor to diners who like challenges. The aroma of nuts is endlessly memorable.

5.1.3 Sustainable Certified Cashew Series

Nowadays, when sustainable development is becoming increasingly important, we have launched a sustainable certified cashew series, which not only respects nature but also reflects our commitment to consumers. These cashews follow internationally recognized sustainable cultivation standards, from soil protection to water management, from biodiversity maintenance to fair trade practices, every step ensures environmental friendliness and social justice. Through the traceability system, consumers can know the detailed origin of the cashews they purchase and feel the transparency and peace of mind from farm to table.

5.1.4 Customized Gift Box Series

For holiday celebrations, business gifts and personalized gift needs, we have designed a series of exquisite, customized cashew gift boxes. These gift boxes are not only stylish and high-end in appearance but also contain

a variety of carefully selected cashew products, which can be personalized and combined according to customers' needs. Whether it is for Mid-Autumn Festival, Spring Festival gift-giving, or corporate customer appreciation, customized gift boxes can perfectly match the occasion, convey deep affection, and highlight the unique taste of the gift-giver and the noble status of the other party. Through customized services, we are committed to adding special meaning to every gift, making cashews a beautiful medium to connect people's hearts.

5.2 Service introduction

5.2.1 Personalized E-commerce Experience

We are committed to creating a unique shopping journey for every online customer. Through the self-developed e-commerce platform and creative mini-programs, shopping has become simple and fast, and you can complete your purchase with just a touch of your fingertips. What's even more fascinating is that we innovatively integrated the "Virtual Cashew Tree Planting Game" to make shopping no longer just a transaction, but a fun-filled interactive experience. Participants can not only "adopt" a real cashew tree in Mozambique online, but also learn about the growth cycle of cashews through gamified interactions, expect and finally harvest the fruits. This immersive sense of participation greatly enhances user stickiness, and also spread the concept of sustainable agriculture.

5.2.2 Supply Chain Transparency Services

We know that modern consumers are increasingly concerned about the origin of products. Therefore, we use cutting-edge blockchain technology to give each product a unique traceability code. This initiative not only makes the entire chain of cashew nut cultivation transparent, from soil selection, growth management, and manual picking to fine processing, safe packaging, and efficient transportation, but also allows consumers to easily trace the detailed journey of each cashew nut. Such transparent services not only enhance customers' trust in our brand but also demonstrate our commitment to quality.

5.2.3 Professional Customer Service

Building a comprehensive customer service system is the core of our service concept. We have established multi-dimensional communication channels, including online instant customer service, 24-hour telephone hotline, and social media interactive platform, to ensure that customers' questions can be responded to quickly and professionally answered no matter when and where. Our customer service team has been strictly trained to provide patient and meticulous services, whether it is product consultation, order tracking, or after-sales support, to ensure the highest level of satisfaction for each customer.

5.2.4 B2B Customized Services

For enterprise-level customers, we provide highly personalized B2B solutions. From cashew nut variety selection, and special specification customization, to exclusive packaging design, and even flexible logistics and distribution arrangements, we can customize it according to the specific needs of our customers. Whether it is the baking industry, catering service industry, or health food manufacturing industry, we strive to become their trusted supply chain partner, jointly develop products that meet the diversified needs of the market and work together to achieve a win-win situation.

5.3 Core Competencies

5.3.1 Sustainable Supply Chain Management

We have our own planting base and processing factory deeply rooted in Mozambique and have built a sustainable supply chain system from source to end. By implementing internationally recognized environmentally friendly planting standards and strict environmental protection measures, we ensure that the growing environment of each cashew nut is not only in line with the natural ecological balance but also has a positive impact on the local community. This persistent pursuit of sustainability not only enhances the market competitiveness of our products, but also wins us widespread respect from consumers and society.

5.3.2 Innovative marketing and digital operations

In the digital era, we make full use of advanced technological tools and innovative marketing thinking to transform consumers' purchasing behavior into a fun participation process through interactive experiences such as virtual planting games, which greatly enhances the interactivity and stickiness between the brand and users.

At the same time, we work closely with social media influencers (KOL) to use their online influence to quickly increase brand awareness and effectively expand market share. This series of digital strategies allows us to stand out in the fierce market competition and become a pioneer in industry innovation.

5.3.3 Quality control

Quality is our lifeline. We have introduced internationally advanced processing equipment and sophisticated quality inspection systems and implemented strict monitoring and standardized management in every link, from raw material screening to finished product packaging. This technology-driven quality control system ensures that our cashew products always maintain excellent quality and safety standards, winning the trust and praise of consumers.

5.3.4 Market Flexibility

Facing the rapidly changing market environment, we have established an efficient market feedback mechanism and flexible product adjustment strategies. Through continuous market research and data analysis, we can quickly capture changes in consumer preferences and emerging market trends, and then quickly adjust product lines and service models, launch new products that meet market demand, and maintain the market vitality and competitiveness of the brand.

6. Sales and Promotional Strategies

6.1 Social Media

6.1.1 Content Marketing

Set up a brand column on Weibo to regularly publish cashew-related health tips, such as the nutritional value, health benefits, and scientific combination suggestions of cashew nuts, to attract followers of healthy eating. The WeChat official account digs deeply into the story behind sustainable agriculture, telling the green journey of cashews from Mozambique plantations to the table, and enhancing the brand image. At the same time, on the Douyin platform, we cooperated with some people with a fan base to release a series of easy-to-learn and creative cashew recipe videos, such as cashew milkshakes, cashew vegetarian platters, etc., to stimulate the audience's interest in trying it and promote the content. Viral communication increases the frequency of interaction between users and the brand and brand exposure.

6.1.2 Cooperate With KOL

Select well-known KOLs in the field of healthy living and gourmet cooking who are consistent with the brand concept, such as nutritionists, fitness experts, food bloggers, etc., through live broadcast, let KOLs personally experience and recommend our cashew products, and have direct dialogue Its huge fan base. In addition, product trial evaluation activities are arranged, and KOLs are invited to analyze the quality and taste of cashew nuts from a professional perspective and use their authoritative voices to enhance consumers' trust in the brand and products.

6.1.3 Consumers Interact with Social Media

Launched the "Creative Ways to Eat Cashew Nuts" challenge on social media to encourage users to use their creativity and show off their own unique cashew nut dishes. The best works will receive brand rewards to encourage more users to participate in content creation and sharing. At the same time, the "Cashew Planting Diary" interactive activity was launched, inviting consumers to "adopt" a virtual cashew tree online, track its growth process, learn cashew planting knowledge, and share planting experiences, effectively increasing user participation and brand reputation to further expand brand influence.

6.2 Participate in Industry Exhibitions

6.2.1 International Food Exhibition

SIAL China (China International Food and Beverage Exhibition): As Asia's largest food innovation exhibition, it gathers global food and beverage suppliers and buyers. Carefully design the booth to highlight the high quality and diversity of cashew products, attract visitors through on-site tastings, new product releases, etc., establish direct contact with potential customers, and expand sales channels.

ANUFOOD China (China Candy and Snack Food Exhibition): A professional exhibition focusing on the candy and snack food market, suitable for promoting the brand image of cashew nuts as a healthy snack. An interactive experience area can be set up to allow consumers to make cashew snacks by themselves, deepen their brand impression, and at the same time communicate with other companies in the industry to explore cooperation opportunities.

6.2.2 Green Agriculture Forum

Choose influential international sustainable agriculture forums or green supply chain seminars, such as the "World Sustainable Development Summit" and "Global Green Agriculture Conference". On these platforms, through keynote speeches, case sharing, etc., the company's environmental protection practices in cashew planting, biodiversity protection measures, and sustainable management results in the supply chain are introduced in detail. During the forum, take the initiative to communicate with peers and research institutions Establish cooperative relationships with non-governmental organizations to jointly discuss and solve the challenges facing agricultural sustainability, enhance brand image, and demonstrate corporate social responsibility. At the same time, such cooperation will help introduce new technologies and new concepts and continue to optimize its performance in sustainable agriculture.

6.3 Promotion in Different Industries

6.3.1 Catering Industry Cooperation

First, we cooperate with well-known chefs and high-end restaurants to innovatively launch special dishes incorporating cashew elements, such as cashew chicken, cashew salad, etc., using the platform advantages of the restaurant to allow consumers to experience the unique charm of cashews while enjoying delicious food, and broaden the scope of cashews. application fields. Secondly, it cooperates with popular cafes to launch a series of cashew nut healthy drinks, such as cashew latte and cashew milkshake, to attract young consumers who pursue a healthy lifestyle.

6.3.2 Health Food Channel

First, cooperate with fitness institutions to recommend cashews as a health supplement to members, emphasizing its high-protein, low-fat health properties, setting up counters or holding joint activities, such as cashew energy packs, health lectures, etc.

Secondly, establish long-term cooperative relationships with specialty stores, launch packaging and promotional activities customized for health food channels, and use in-store displays, membership discounts, and other means to increase the product's share in the health food market.

6.3.3 Packaging gift box

First, a customized cashew nut gift box. Design a series of high-quality, beautifully packaged cashew gift boxes, with customized logos, blessings, etc. according to the needs of corporate customers. They are suitable for various business activities, festival celebrations, and other occasions, and meet the needs of enterprises for employee care, customer appreciation, or business dealings. Second is social responsibility and brand communication. When promoting customized gift boxes, we emphasize the sustainable cultivation background of cashew nuts and the brand's social responsibility concept, attracting companies that pay attention to CSR, and jointly deliver positive energy and enhance the brand image.

6.4 Pricing Strategy

6.4.1 Value Pricing Strategy

We adopt a value-based pricing approach to ensure that prices reflect the high quality of cashew products, the environmental value of sustainable cultivation, and the unique user experience provided through virtual planting activities and more. Compared with pure price competition, we focus more on conveying the intrinsic value and brand story of the product to attract consumers who are willing to pay a reasonable premium for health, environmental protection, and social responsibility.

6.4.2 Tiered pricing strategy

To meet the needs of different consumer groups, we divide our products into several different levels, and each level sets a corresponding price according to its characteristics.

Original cashew nut: Positioned as a basic model, the price is relatively affordable and suitable for mass consumption, emphasizing the natural purity and healthy attributes of the product.

Flavored cashews (such as sea salt, honey roasted, spicy, etc.): As a mid-to-high-end product line, the price is slightly higher, aiming to satisfy consumers who pursue diversified tastes and high-end experiences.

Customized gift boxes: Targeting the gift market, we provide personalized and high-end packaging with a higher price to reflect its unique customized services and added emotional value.

6.4.3 Promotional Campaign Strategy

We use holidays and important time points for the brand, such as Spring Festival, Mid-Autumn Festival, company founding anniversaries, etc., to launch limited-time promotions:

Limited-time discounts: discounts and promotions on some products during a specific period to attract consumers to take advantage of the opportunity to purchase.

Gift-with-purchase activity: After purchasing designated products for a certain amount, you will be given a small package of cashew nut-tasting packs or brand-customized peripheral products to increase customers' purchase intention and satisfaction.

Exclusive for members: Provide additional discounts or points feedback to members to enhance user stickiness and encourage repeat purchases.

6.5 Distribution strategy

6.5.1 Online and offline integration

Self-built e-commerce platform: Develop and maintain the company's exclusive e-commerce platform to provide a personalized shopping experience, including virtual planting game interaction, product customization services and other special functions, to enhance the interaction between the brand and consumers.

Settling in mainstream e-commerce platforms: Take advantage of the extensive user base and efficient logistics system of large e-commerce platforms such as Tmall and JD.com to quickly expand market share, and at the same time participate in various promotional activities on the platform to increase brand exposure.

Brand experience stores: Establish brand experience stores in core business districts of first-tier cities. They not only sell products, but also focus on creating immersive experiences. Through on-site tastings, cashew knowledge explanations, interactive activities, etc., they deepen consumers' brand memory and enhance brand image. .

6.5.2 Regional cooperation

Agent recruitment: Recruit powerful agents in key cities and regions with high consumption potential, and use their in-depth understanding of the local market, personal resources and sales network to quickly expand market coverage.

Training and support: Provide agents with comprehensive product knowledge training, marketing strategy support and after-sales service guidance to ensure that agents can effectively promote the brand and maintain a unified brand image and service standards.

6.5.3 Cross-border e-commerce expansion

Settling in international e-commerce platforms: Through Alibaba International Station, Amazon and other international e-commerce platforms, we will target the overseas Chinese market and global consumers, and use the convenience of cross-border e-commerce to broaden sales channels.

Localized marketing: Based on the characteristics of different overseas markets, develop localized marketing strategies, such as holiday promotions, regional limited products, etc., to enhance overseas consumers' purchasing interest and brand identity.

Logistics and payment optimization: Cooperate with international logistics service providers to ensure the timeliness and cost-effectiveness of cross-border logistics; at the same time, access a variety of international payment methods to enhance the shopping experience of overseas consumers.

Through the comprehensive application of the above distribution strategies, a multi-channel sales network can be constructed, which can not only quickly respond to market demand, but also effectively cover different

consumer groups, laying a solid market foundation for the company's long-term development.

6.6 Targeted customer development

6.6.1 Membership system

Establish multi-level membership levels, divide member rights according to consumption frequency, amount, and other indicators, such as ordinary members, silver card members, gold card members, etc., and provide differentiated services for members of different levels:

Points redemption: Accumulate points through consumption, which can be used to redeem products, deduct cash, participate in member-exclusive activities, etc.

Birthday privileges: Members can enjoy exclusive discounts or customized gifts on their birthday month to enhance their personalized experience.

New product trial: Gold card and above members have priority to trial new products, collect feedback, and promote word-of-mouth communication.

Exclusive activities: Regular membership day activities are held to provide special discounts, limited products, etc. to enhance members' sense of belonging and loyalty.

6.6.2 Data analysis and personalized marketing

Use big data technology to analyze user behavior, including purchase records, browsing preferences, interaction frequency, etc., to build user portraits:

Precise push: Based on user preferences, push personalized product recommendations, coupons, and health information to improve the pertinence and effectiveness of marketing.

Optimize experience: analyze user feedback, continuously adjust products and services, and improve customer satisfaction and conversion rates.

Forecast demand: Use historical data to predict market trends and individual consumption tendencies and adjust inventory and marketing strategies in advance.

6.6.3 Industry Alliance Cooperation

Establish in-depth cooperation with healthy living-related industries to expand customer acquisition channels and jointly enhance brand influence:

Fitness club cooperation: jointly organize health challenges, nutrition lectures, etc. with well-known fitness brands to promote the concept of cashews as healthy snacks and attract the attention of fitness enthusiasts.

Co-building of healthy communities: Cooperate with healthy eating and lifestyle communities, and participate in or sponsor community activities, such as online health forums and offline cooking workshops, to increase brand exposure and cultivate potential user groups.

Cross-border co-branding: Cooperate with healthy lifestyle brands to launch limited edition products or gift boxes, leveraging the brand effects of both parties to expand market influence.

7. Logistics and supply chain management

7.1 Logistics management

Intelligent Warehousing: Adoption of automated warehousing systems, including Automated Guided Vehicles (AGVs), high-bay shelving, and barcode tracking technology to improve storage efficiency and accuracy.

Real-time tracking: GPS technology and Internet of Things (IoT) devices are used to monitor the transportation process, ensuring that goods are visualized throughout the entire process, from origin to warehouse to consumer.

Green transportation: Promote the use of electric or low-emission vehicles, optimize distribution routes to reduce carbon emissions, and respond to the goal of sustainable development.

Flexible Delivery: Provide diversified delivery options in conjunction with customer needs, such as next day delivery, delivery by appointment, and pickup point pickup, to enhance customer satisfaction.

Reverse logistics: establish an efficient return processing process, implement environmentally friendly treatment for reusable or recycled products, and reduce resource waste.

7.2 Supply chain management

Supplier Relationship Management: Establishing long-term partnerships with local, high-quality cashew farms in Mozambique to ensure a stable supply of raw materials with controlled quality. Regularly evaluate supplier performance to incentivize continuous improvement.

Demand Forecasting: Using advanced data analysis tools, combined with historical sales data, seasonal factors, market trends, etc., we accurately forecast market demand and guide production plans.

Inventory optimization: Adoption of advanced inventory management systems, such as the EOQ model (Economic Order Quantity) and JIT (Just-In-Time), to balance inventory costs and service levels, and to avoid overstocking or running out of stock.

Risk control: Establishment of a supply chain risk management system, including identification, assessment and countermeasures for risks such as natural disasters, market price fluctuations and supply chain disruptions.

Digital Supply Chain: Integration of ERP (Enterprise Resource Planning) and SCM (Supply Chain Management) systems to realize seamless information linkage in all segments of the supply chain and improve decision-making efficiency and flexibility.

Sustainable Sourcing: Promote the adoption of environmentally friendly materials and packaging upstream and downstream of the supply chain, support fair trade certification, and ensure the social and environmental responsibility of the supply chain.

8. Team Composition

8.1 Composition of the workforce

Our core team consists of four members, each with a wealth of industry experience and expertise, to ensure that the project operates efficiently in all key areas:

Chief Executive Officer (CEO): responsible for overall strategic planning, business development and external cooperation, who has many years of experience in international trade and agricultural supply chain management, specializes in cross-cultural communication and negotiation, and has a keen insight into international market dynamics.

Chief Operating Officer (COO): responsible for daily operations, production management and supply chain optimization. With a deep background in agribusiness and food processing industry, COO is good at lean production and quality control to ensure the efficiency and quality of products from source to end.

Chief Marketing Officer (CMO): Responsible for brand building, marketing and digital marketing strategy. With expertise in digital marketing and brand management, familiar with social media and e-commerce channels, he/she is able to effectively enhance brand awareness and market penetration.

Director of Sustainability: Responsible for sustainable farming projects, environmental strategies and social responsibility programs. With an academic background in sustainable agriculture and environmental sciences, familiar with international sustainability standards, drive the company to practice green supply chain and work with international organizations to enhance brand image.

9. Financial Forecast

9.1 Cost projections

Cost Item / CNY	1st year	2nd year	3rd year

Cost Item / CNY	1st year	2nd year	3rd year
Raw Material Purchase	3 million	3.5 million	4 million
Production Processing	1.5 million	1.65 million	1.8 million
Transportation & Logistics	1 million	1.1 million	1.2 million
Labor costs	1.2 million	1.32 million	1.45 million
Marketing & Advertising	600,000	700,000	800,000
Rental and maintenance of facilities	300,000	330,000	360,000
R&D and Innovation	200,000	220,000	250,000
Administration and others	200,000	220,000	250,000
Total cost	8 million	8.94 million	10.01million

Description:

a. Raw material procurement:

The budget for the first year is $3 million, which is expected to increase to $3.5 million in the second year and further to $4 million in the third year, reflecting the upward trend in the cost of raw materials, as the scale of production expands and the price of raw materials fluctuates.

b. Production and processing:

It is projected to be $1.5 million in the first year, with the budget adjusted to $1.65 million in the second year and reaching $1.8 million in the third year, taking into account the increase in productivity but at the same time potentially facing rising labor and energy costs.

c. Transportation and logistics:

The first year's budget is $1 million, and as sales volume grows and logistics needs increase, expenditures are projected to be $1.1 million in the second year and $1.2 million in the third year, reflecting the fact that logistics costs rise with business expansion.

d. Labor costs:

This includes employee salaries and benefits, which are $1.2 million in the first year and are expected to grow to $1.32 million in the second year and $1.45 million in the third year due to salary adjustments and team expansion.

e. Marketing and advertising:

In order to enhance the brand influence and market share, the budget for the first year was 600,000 RMB, which was increased to 700,000 RMB in the second year and reached 800,000 RMB in the third year with the deepening of the marketing strategy and the development of new markets.

f. Rental and maintenance of facilities:

The fixed cost item, which includes office and production space rent and routine maintenance costs, is $300,000 for the first year, with a projected annual growth rate of about 10%, and $330,000 and $360,000 for the second and third years, respectively.

g. Research, development and innovation:

Critical to the continued optimization of products and services, the budget is $200,000 for the first year and then increases each year to $220,000 and $250,000 for the second and third years, respectively, demonstrating the company's continued commitment to innovation.

h. Administration and others:

Covering miscellaneous day-to-day operating expenses of $200,000 in the first year, increasing to $220,000 and $250,000 in the second two years, respectively, taking into account inflation and other unforeseen factors.

9.2 Revenue projections

Income items / CNY	1st year	2nd year	3rd year
Revenue from sales of cashew products	10 million	12 million	15 million
E-commerce and small program revenue	1 million	1.5 million	2 million
Enterprise Customization and B2B Sales	0.5 million	0.75 million	1 million
Total Revenue	11.5 million	14.25 million	18 million

Details of income line projections:

9.2.1 Income from the sale of cashew products:

Revenue for the first year is expected to be $10 million, reflecting the initial market entry and brand building phase. With the increase in market recognition and the expansion of the sales network, revenue grew to $12 million in the second year and further increased to $15 million in the third year, demonstrating the strong demand for the Company's products in the market and the expansion of the brand's influence.

9.2.2 E-Commerce & Small Program Revenue:

The e-commerce channel and mini-programs, an emerging sales platform, are expected to bring in $1 million in revenue in the first year. Given the continued rise in digital marketing and online shopping trends, revenue is expected to grow to $1.5 million in the second year and $2 million in the third year, reflecting the Company's focus on and effective execution of digital transformation.

9.2.3 Enterprise customization and B2B sales:

Customized services and B2B sales strategy for corporate and institutional clients are expected to contribute $0.5 million in revenue in the first year. As the company's business model matures and market penetration deepens, revenue is expected to rise to $750,000 in the second year and reach $1 million in the third year, demonstrating the company's success in expanding diversified sales channels.

9.2.4 Summary of total income:

Total revenue was $11.5 million in the first year, grew to $14.25 million in the second year, and is expected to reach $18 million in the third year. This growth trajectory suggests that the company is expected to realize sustained and significant revenue growth with the deeper implementation of its marketing strategy, the enrichment of its product line and the diversification of its sales channels.

9.3 Profit Forecast

Fiscal year	Total revenue/CNY	Total cost/CNY	Net profit/CNY
1st year	11,500,000	8,000,000	3,500,000
2nd year	14,250,000	8,940,000	5,310,000
3rd year	18,000,000	10,010,000	7,990,000

Description:

Total revenues include the sum of cashew product sales, e-commerce and applet revenues, and corporate customization and B2B sales revenues.

Total costs cover the total of all cost items such as raw material procurement, production and processing, transportation and logistics, labor costs, marketing and advertising, rent and facility maintenance, research and development and innovation, and administration.

Net profit is the total revenue minus the total cost for each year.

9.4 Financing analysis

9.4.1 Financing needs and purposes

Based on the cost forecasts and revenue projections described in the previous section, and in order to support the company's three-year development plan, we anticipate that a round of financing will be required to ensure that there are sufficient funds to support key aspects such as business expansion, market penetration, supply chain optimization and team building.

Considering the total cost of $8 million in the first year, in order to ensure the smooth running of the initial operation and leave some cushion, the total amount of financing is planned to be $10 million.

9.4.2 Use of funds:

Raw material procurement and supply chain optimization: about RMB 3 million, for expanding raw material reserve and ensuring supply chain stability and optimization.

Production and processing and technology upgrading: approximately RMB 2 million, invested in production equipment renewal, production efficiency improvement and product quality control.

Marketing and brand building: approximately RMB2 million, for strengthening brand marketing, e-commerce channel construction and market expansion activities.

Operating and management costs: approximately $1.5 million, covering labor costs, rent, daily management and other operating expenses.

Reserved funds: about 1.5 million yuan, as a risk reserve to cope with unforeseen market changes or emergencies.

Use of funds	Projected amount (CNY)
Raw Material Sourcing and Supply Chain Optimization	**3 million**
Production processing and technology upgrading	**2 million**
Marketing & Branding	**2 million**
Operational and administrative costs	**1.5 million**
Reserved funds (risk reserve)	**1.5 million**
Total financing	**10 million**

9.5 Financing options

Equity financing: Consider bringing in a strategic investor or venture capital, and offer a certain percentage of the company's shares in exchange for capital. This approach facilitates the introduction of industry resources and management experience to accelerate company growth.

Debt financing: Utilize debt funds to support business expansion through bank loans or bond issuance. Care needs to be taken to control the debt level and avoid excessive financial burden.

Government grants and subsidies: Research and apply for national and local government support policies for agricultural export and sustainable development projects, and seek non-dilutive funding sources.

9.5.1 Return on investment analysis

Projected payback cycle: Based on revenue projections, profitability is expected to start in the third year. The return on investment cycle is approximately 3-5 years, depending on market conditions and the company's operational efficiency.

Exit mechanism: A clear exit path is planned for investors, including but not limited to IPO, M&A or shareholder buyback, to ensure that investors can obtain reasonable returns.

9.5.2 Risk assessment and mitigation measures

Market Risk: Reduce the risk of single market dependence through diversified market strategies and continuous market research.

Supply Chain Risk: Establish a diversified supplier system and strengthen supply chain management to cope with natural disasters or other emergencies.

Financial risk: Strict financial management to ensure effective utilization of funds, while maintaining good cash flow management to reduce liquidity risk.

In conclusion, financing analysis should not only ensure the adequacy of funds, but also take into account the efficient use of funds and reasonable returns for investors, while building risk prevention and control mechanisms to ensure the company's sound development.

10. Progress of development

10.1 Detailed development progress in the first year

Quarter(s)	Tasks
First quarter	● Team building and training: Completed the construction of the core team and conducted training on business processes, teamwork and professional skills. ● Supply Chain Setup: Signed a cooperation agreement with Mozambique cashew nut suppliers and initiated a supply chain optimization plan. ● Market research: In-depth study of the Chinese cashew market, identify target consumer groups and market positioning.
Second quarter	● Brand building: initiate brand design and promotion, set up official website and social media accounts, and start content marketing. ● E-commerce and applet development: develop e-commerce platform and supporting applets, integrate virtual planting game function. ● First raw material procurement and processing: according to the market demand, complete the first batch of raw material procurement, and start production and processing.
Third quarter	● Product testing and launch: complete the first batch of product production, conduct market testing, collect feedback and optimize the product. ● Marketing: launch online and offline marketing campaigns, co-operate with KOL to enhance brand awareness. ● Logistics and Distribution System Establishment: Signed a contract with a logistics partner and initially established a domestic distribution network.
Fourth quarter	● Sales and Customer Service: Formalize large-scale sales, optimize customer service processes and establish customer feedback mechanisms. ● Annual Assessment and Adjustment: Evaluate the whole year's operation, adjust

	the strategy and prepare for the next year. ● Financial Audit and Planning: Conduct annual financial audit and formulate financial budget for the next year.

10.2 Year 2 to 3 planning (focusing on market expansion and supply chain optimization):

Project	Content
Ongoing Market Expansion	● Further increase marketing efforts and expand new sales channels, including co-operation with high-end supermarkets and health food chain shops. ● Through display and promotion in these well-known channels, the products will more directly reach a larger group of tasteful and health-conscious consumers, bringing greater exposure and sales opportunities.
Deep Supply Chain Optimization	● Increase the stock of key raw materials to cope with supply shortages or unexpected demand. ● Optimize the logistics network and transport solutions to reduce costs and improve transport efficiency. ● Speed up order processing and product delivery to ensure that customers can receive products in a timely manner.
Product Line Expansion	● According to the market demand, develop new cashew nut derived products, such as cashew nut paste, cashew nut milk, etc., in order to enrich the product line. ● Meet consumer demand for more flavors.
Technology Upgrade and Innovation	● Introduce more advanced processing equipment and technology to improve product quality and production efficiency. ● Maintain the leading position in the industry.
International layout	● Consider expanding to other Asian markets or European and American markets, and evaluate and initiate export business. ● Seek broader development space and growth opportunities.

10.3 Planning for Years 4-5:

Strategies	Specific measures
Brand internationalization	By participating in international food exhibitions such as the World Food Expo and establishing a network of overseas offices or agents, it can showcase products and brand image, promote brands to the global market and establish contacts with international buyers. At the same time, strengthen sales and service support in these markets to enhance brand awareness and competitiveness in the international market.
Diversified investment	Instead of limiting to product processing and sales, look further upstream in the supply chain and establish own plantations or bases in some important raw material origins to ensure better control of raw material quality and supply stability, reduce production costs and enhance product competitiveness.
Digital Transformation	Comprehensively upgraded digital systems: ● Increase investment in information technology and introduce a more advanced

	supply chain management system to achieve supply chain intelligence and optimization. ● Strengthen the collection and analysis of big data to gain insight into market trends and consumer demand, and provide a scientific basis for decision-making on product R&D and marketing strategies.
Sustainability Deepening	Continue to expand sustainable cultivation projects, including organic farming and rainforest-friendly cultivation, to reduce the impact on the environment and improve the quality and safety of agricultural products. Actively seek various international certifications, such as organic certification, Rainforest Alliance certification, etc., to prove that the products meet international standards and add colour to the brand image.
CSR	● Actively participate in various social welfare activities to support the development and improvement of local communities. ● Strengthen our concern for environmental protection and take more measures to reduce the negative impact on the environment, such as energy saving and emission reduction, reducing packaging pollution, etc. ● Actively promote fair trade, safeguard the rights and interests of farmers and laborers, and promote sustainable development.

An Empirical Study of Domestic Demand and Long-term Economic Growth——Based on an Empirical Study of Guangzhou

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Abstract

As the global economic landscape evolves and the domestic economic structure undergoes profound adjustments, China faces increasingly complex international and domestic economic development environment. In order to boost domestic demand and achieve sustainable growth of domestic economy ,Chinese government executes "dual circulation"new economic development pattern under current economic situation, the pattern encourage the domestic residents' consumption based on the large population and mitigate the adverse effect of Sino-American trade war. Guagnzhou as an important economic center city in China, its domestic market demand and economic growth will bring value to study Chinese economical growth model, the paper exerts the PVAR model to analyze the driving effect of domestic demand on Guangzhou's long-term economic growth which is based on the annual data ,including GDP, total fixed asset investment and total retail sales of consumer goods of 11 districts of Guangzhou from 2008 to 2019, the co-integration test shows that consumption investment can stimulate greater economic development in long-term; the impulse response value of the short-term active promotion of investment is greater than that of consumption on economic growth.

Keywords: **D**omestic Demand; Consumption Investment; Co-integration Theory; PVAR model

1.Introduction

As the global economic landscape continues to evolve and the domestic economic structure undergoes profound adjustments, the role of domestic demand in promoting economic growth is becoming increasingly prominent. Particularly, China, a large developing country,it faces increasingly complex international and domestic economic development environment, and the risks and challenges both exist.In this context, General Secretary Xi Jinping has proposed to accelerate the formation of a large domestic cycle as the main body,under which is mutually reinforcing by a dual domestic and international cycle , its was named a new "dual circulation" development strategic pattern,. Therefore,on December 14, 2022, the Central Committee of the Communist Party of China (CPC) and the State Council issued the Outline of *2022-2035 Strategic Planning for Expanding Domestic Demand* , which firmly proposes the strategy of expanding domestic demand in order to cultivate an integrated domestic demand system.The government firmly believes that the expansion and optimization of the domestic demand market is not only the key to maintain stable economic growth, but also the way to achieve high-quality economic development.

Guangzhou, as one of the pioneering and important economic center cities in China, has been placing the export-oriented economy at its leading position for many years, it needs to advance a strong domestic market based on the domestic circulation. Like the other cities in China, Guangzhou is also facing the problems about how to shift to a strategic development pattern which is dominated by the domestic macro-cycle to lift economic growth.It can not be ignored the fact that with the accelerated consumption upgrading and industrial restructuring, the domestic demand market is becoming a new driving force for Guangzhou's economic growth. Therefore, an in-depth study of the relationship between domestic demand and long-term economic growth is of realistic value for understanding the inner mechanism of Guangzhou's economic growth, also it will be beneficial for further development to help for adjusting economic policies.

2. Literature Review

The empirical study of domestic demand and long-term economic growth is of great significance in the field of economics, it focuses on the drivers and sustainability of a country's economic growth. Scholars have done in-depth research on this topic.

2.1 Development of grounded theory

John Maynard Keynes (1936) constructed the Effective Demand Theory to explain the impact of consumption on economic growth, arguing that appropriate inflationary policies could stimulate consumption and thus influence economic growth, and further proposed the theory of expanding aggregated demand through increased investment[1].Milton Friedman (1960) argued that the monetary policy could pull consumption, and then stimulate economic growth in the short run, however it will lead to inflation in the long run[2]. Roy Harrod and Evsey Domar (1939) introduced the time factor into the theory of economic growth and replaced the Keynesian "horizontal analysis" with “ratio analysis” ,emphasizing the dual effect of investment on increasing both income and production capacity, thus extending the long-term and dynamic of Keynes's framwork. Romer, P. M. (1986) shifted the focus to the role of domestic demand could contribute to long-run economic growth by boosting investment in R&D and education, which drive long-run economic growth in return[3]. These theories collectively provide framework for analyzing the complex interplay among consumption, investment ,monetary policy and economic growth and have laid the foundation for subsequent empirical studies .

2.2An empirical study of economic growth driven by domestic demand

Domestic demand is recognized as a pivotal driver for long-term economic growth, especially within substantial economies such as China and India.A number of academic studies have scrutinized the relationship between domestic demand and economic growth in terms of short-term effects, they suggest that both factors have significant impact on economic growth[3], and China’s lack of domestic demand in the process of economic transformation is mainly reflected in insufficient consumption [4].Consumption bolsters short-term economic growth is gradually increasing, so China's economic transformation model needs to avoid rely on consumption and take into account domestic production, distribution and exchange mechanisms (Javed, S. A., Bo, Y., Tao, L., & Dong, W. ,2021)[5].Hu Xiaohui and Ma Lixing (2020) conducted empirical research utilizing annual data and a multivariable framework from 1995 to 2017.Their research spanned 26 cities within the Yangtze River Delta region and included 41 prefecture-level cities across Anhui, Shanghai, Zhejiang, and Jiangsu.The findings reveal that the long-term impact of investment, exports, and consumption on the macro-economy may have been previously underestimated.The research also addressed the DFE(Demand Flow Enablement)deviation is eliminated and result in a higher estimate for the role of those factors[6].Moreover, scholars have delved into the long-term implications of domestic demand on economic growth, Listokin and Yair (2018)explored the correlation between foreign direct investment(FDI) and economic growth by creating a co-integration regression model, the study concluded with a negative correlation between the two variables[7] .Sholars have examined the long-term impact of domestic demand on economic growth,Listokin and Yair (2018) explored the nexus between FDI and economic growth by employing a co-integration regression model, they found the two are negatively correlated[7]; In the context of China's landscape, economic growth in the second quarter of 2023 showcased a pattern of growth which was more restorative than endogenous, this is exemplified by a year-on-year basis decrease of 2.7 per cent in the cumulative size of overall FDI utilized in the first half of the year , demonstrated by the increasing share of consumption and government expenditure has a significant positive effect on long-run economic growth. Specifically,the increasing proportion of consumption and government expenditure in the economy has been identified as having a significantly positive impact on long-term growth[8].Li Hui and Tang Zhipeng (2018) used structural decomposition technology and WIOD database to compare and analyze dynamics of domestic demand growth between China and other BRIC countries. The results showed that the contribution of industrialized countries’ investment to economic growth is marginal, which has a negative impact on the China’s economy, and the influence of consumption on the growth of China’s economy has gradually increased[9].Considering the impact of domestic demand on economic growth, the changes in income, consumption and average consumption trends indicate that China must rely on domestic demand and consumption to maintain sustainable and stable economic growth[10]. Meanwhile,there are also some scholars focus on the impact of investment on economic growth, Goumrhar et al. (2017) believed that the role of capital

investment will change with the level of economic development[11]. FDI plays a significant role in promoting China's economic quality development, but this effect varies in different regions, it negatively effect on the economic quality development of the eastern region of China and positively effect on the central and western regions (Zhou Zhongbao, Deng Li, Xiao Helu, Wu Shijian, Liu Wenbin, 2022)[12].Other scholars also prove it, Li Yuxin, Wang Shuailong (2023) used provincial panel data from 2006-2019 to test the causal relationship between the coordinated development of two-way FDI and industrial structure upgrading using the Geweke causality test, the coordinated development of two-way FDI significantly promotes the industrial structure upgrading of the eastern region, and also enhances the neighbouring regions through spatial spillover effects. Industrial structure upgrading level[13].

2.3 Policy recommendations and policy impact assessments

Scholars have conducted empirical analyses to explored the impact of domestic demand on investment, employment and output growth, offering significant insights for policymakers.Jianghuai Zheng and Chunmiao Shen (2019) proposed that an economy driven by domestic demand should accelerate the construction of a unified labor market and other pivotal factors of production. They suggested that the disparity in domestic income distribution could be bridged by reducing the negative impact of domestic demand expansion strategies on the low-skilled labour force[14].Hu Xiaohui, Ma Lixing (2020) discussed strategies to maximize the role of consumption as the primary engine of China's regional economic growth, these include fostering a favourable consumption environment, meeting the diversified needs of people , boosting their purchasing demand, and continuously enhancing their consumption capacity[6]. Guo Kesha, Yang Gao (2017) opined that long-term growth policy should integrate supply-side structural reform with demand-side structural reform [15]. Currently, China income distribution exists the problems of larger income gap , irrational social expenditure structure, savings-investment deviation, a dedceleration in the enhancement of consumption, and sluggish progress in the transformation of savings into investment (Rong Chen, Sheng Chaoxun, Yi Yu, Jin Chenxin, 2021) [16], in fact, the double-cycle strategy is a self-reliance to cope with a more hostile external environment (Garcia-Herrero, 2021) [17]. The double-cycle development pattern represents an economic ecosystem that catalyzes deeper and broader reforms (Yifu Lin, 2022) [18].

The existing literature offers a wealth of theoretical grounding and empirical evidences to deepen the academic understanding of economic growth from the perspective of domestic demand. However, the majority studies have focused on the short-term effects of domestic demand on economic growth, largely ignoring the dynamic effects of changes in domestic demand on long-term economic growth, which is the focus of this study.

3.Model Construction for Domestic Demand and Long-term Economic Growth

Regarding the long-term relationship between domestic demand and long-term economic growth, the co-integration test model is often used for research. This paper draws on the research methods of others and adds the PVAR(Panel Vector Auto regression) model for further in-depth research.

3.1 Index Selection and Data Description

This paper uses annual data from 11 districts (including Liwan District, Yuexiu District, Haizhu District, Tianhe District, Baiyun District, Huangpu District, Panyu District, Huadu District, Nansha District, Conghua District and Zengcheng District) in Guangzhou from 2008 to 2019 for empirical research. It studies three variables: the GDP variable obtained by applying the expenditure method to describe long-term economic growth, the CONS variable (the total retail sales of consumer goods in the whole society) to describe consumption, and the INV variable (the total fixed asset investment) to describe investment. The total retail sales of consumer goods in the Huangpu District of Guangzhou from 2008 to 2014 are taken from the Qianzhan Database, and others are taken from CEInet （China Economy Information NET） Statistics Database.

Due to the use of panel data analysis, it is necessary to eliminate heteroscedasticity. This study implements logarithmic transformation on all variables, as the co-integration relationship of the original sequence will not change after such processing. After processing, three new series of lnGDPt, lnCONSt and lnINVt are obtained. The results of descriptive statistical analysis of the data are shown in Table 1.

Table 1 Statistical Characteristics of GDP, Consumption and Investment

Variable	Sample	Average	Median	Standard Deviation	Min	MAX	Skewness	Kurtosis
GDP	132	13692088	10782814	9698892	1448720	50473850	1.410870	4.906686
CONS	132	6042715	5082339	4568290	329728	19240047	0.778560	3.001149
INV	132	3919284	3388991	2716522	340429	13987178	1.050486	4.060757

3.2 Model Setting

This paper uses the PVAR model to test the relationship between consumption, investment and long-term economic growth. The total retail sales of consumer goods, the total investment in fixed assets, and the gross regional product of the whole society are set as endogenous variables, and net exports are used as control variables (net exports is included in the lagging term of the model below). Other influencing factors are set as error terms, and the model is as follows:

$y\{lnGDP,lnCONS,lnINV\}it=\alpha i+\beta t+A1y_{t-1}+A2y_{t-2}+A3y_{t-3}+\mu_{it}$

where, $y\{lnGDP,lnCONS,lnINV\}t$ represents a vector composed of the logarithm of the regional GDP, the total retail sales of consumer goods, and the total fixed asset investment; each district in Guangzhou is represented by the subscript i, and the year is represented by the subscript t; α represents the individual effect vector, β represents the point effect vector, and μt represents the random error term that varies with the individual and time; y_{t-1}, y_{t-2}, and y_{t-3} represent the vectors lagging 1, 2, and 3 respectively. A1, A2, and A3 represent the coefficient matrix.

4.Model Checking

In order to make the whole model meaningful, it must go through seven steps: unit root test, determination of the optimal lag order, co-integration test, stability test, Granger causality test, impulse response and variance decomposition. All modeling studies in this paper are conducted at a significance level of 5%.

4.1 Unit Root Test

Before empirical analysis, we must first analyze the stability of the collected panel data. which can avoid spurious regression results. Traditional econometric methods are effective only when the data is stable. In this paper, ADF-Fisher is used to conduct the test. The original hypothesis of this test method is an unstable time series, i.e., there is a unit root. The unit root test aims to test the initial sequence value of each variable. If the test result is stable, the optimal lag order can be determined, otherwise, the original sequence value must be first differed and tested again. If the data is still not stable, a second difference is needed before it's tested again. If it is still not stable, it means that the data is not suitable for the analysis of this model. The significance level of this paper is 5%, and the ADF-Fisher test analysis results are shown in Table 2. In the test, for all variables, the P value corresponding to the statistical value t is less than 0.05, so the unit root test is passed and the null hypothesis is rejected, that is, the data is stable at the 5% significance level.

Table 2 Unit Root Test for Variables

Variables	Horizontal Sequence Values Statistic	ADF-Fisher Test Prob.**
lnGDP	171.083	0.0000
lnCONS	176.898	0.0000
lnINV	148.870	0.0000

4.2 Determine the Optimal Lag Order

The unit root test is passed, so the panel VAR model can be built with GDP, INV and CONS, and the optimal lag order can be selected. The higher the lag order is, the smaller the degree of freedom is. The optimal lag order is determined by its size. The result analyzed in the software shows that the order with the most * is the optimal lag order. In this paper, AIC, SC, and LR criteria are used to select the optimal lag order. The results obtained are shown in Table 3. The test starts from 0. When the three criteria are in the first order, the result of * sign appears. Therefore,

the optimal lag order selected in this paper should be the first order.

Table 3 Selection of Lag Order

Lag	LogL	FPE	AIC	AIC	SC	HQ
0	-4387.516	NA	4.35e+39	99.78447	99.86892	99.81849
1	-4050.842	642.7423*	2.54e+36*	92.33732*	92.67514*	92.47342*
2	-4046.972	7.125127	2.85e+36	92.45390	93.04508	92.69207
3	-4040.638	11.22834	3.04e+36	92.51449	93.35904	92.85474
4	-4039.517	1.910898	3.65e+36	92.69356	93.79147	93.13588

4.3 Co-integration Test

If the PVAR model passes the co-integration test, then "pseudo-regression" can be avoided to a certain extent. From the above unit root test, it can be known that the three economic variables are single-integration of the same order. There may be a co-integration relationship between the three, so a co-integration test needs to be carried out. The results obtained are shown in Table 4. There are 7 kinds of test results in this test, and there are two completely different results. Among them, the P value of three test results is greater than 0.05, and the null hypothesis is accepted, but the P value of the four test results is less than 0.05, that is, the null hypothesis is rejected. Therefore, it can be concluded that the test result rejected the null hypothesis. Therefore, there is a co-integration relationship between the panel data of the three economic variables: GDP, consumption and investment, which proves that the combination of the three has a long-term stable equilibrium relationship.

Table 4 Cointegration Test

Test Method	Hypothesis Testing	Statistics	Statistic Value (P value)
Pedroni	No co-integration relationship	Panelv-Statistic	-2.626088 (0.9957)
		Panelrho-Statistic	0.817463 (0.7932)
		PanelPP-Statistic	-9.898157 (0.0000)
		PanelADF-Statistic	-4.247072 (0.0000)
		Grouprho-Statistic	2.043366 (0.9795)
		GroupPP-Statistic	-11.51447 (0.0000)
		GroupADF-Statistic	-2.321898 (0.0101)

Combining the above-mentioned test and analysis results, it is not difficult to find that there is a long-term stable and balanced relationship among economic growth, consumption, and investment. In order to further explore the effect of Guangzhou's investment and consumption in boosting GDP over a long period of time, this paper further performs co-integration regression on the data, and the co-integration equation obtained is:

$$\ln GDP=49032.01+1.269857\ln CONS+1.012221\ln INV+\mu$$

$$(0.4257) \qquad (5.9302) \qquad (3.3493)$$

In this co-integration equation, the values in the bracket are t values, and their significance level is 5%. It can be seen from this equation that in the long term of economic growth, for every 1% increase in household consumption, Guangzhou's GDP growth will increase by 1.269857%. Every 1% increase in fixed asset investment will drive Guangzhou's GDP growth by 1.012221%. Therefore, there is a long-term positive equilibrium proportional relationship between regional GDP and consumption and investment. Moreover, since the absolute value of the coefficient of consumption proportion is larger than that of investment proportion, the influence of consumption factors on regional GDP is relatively large. The above analysis assumes that if the description of other variables remains the same, any changes to the specific description of that variable will have an impact on GDP. In this test, it can be concluded that consumption has a greater pulling effect on economic growth than investment. Therefore, we must promote the consumption of Chinese residents, tap the potential of consumption, and create new markets in order to ensure the residents' consumption to play a full role in promoting economic growth.

4.4 Stability Test

From the previous analysis, we can know that the optimal lag order of the model studied in this paper is the first order, so the stability test of its model is needed. The model has passed the stability test, and the subsequent modeling analysis is meaningful. The results of the test are shown in the table 3-5. The Modulus values of all the characteristic roots of the model are less than 1, and the PVAR(1) model is stable. In the empirical research, the cointegration equation, Granger causality test, impulse response and variance decomposition are all tested and demonstrated on the basis of the standard PVAR(1) model.

Table 5 Stability Test

Root	Modulus
0.639682	0.639682
0.520850	0.564296
0.520850	0.564296
-0.433299	0.485995
-0.433299	0.485995
-0.469101	0.469101

4.5 Granger Causality Test

Combining the results of the previous test and analysis, it is not difficult to find that there is a long-term stable and balanced relationship among economic growth, consumption, and investment. We will further conduct Granger causality test to study the impact of domestic demand on economic growth. The optimal lag order of the PVAR model is the first order, and the Granger causality test is highly sensitive to the optimal lag order, so it is used as the optimal lag order for this test.

Table 6 Granger Causality Test Results

Null Hypothesis	Lag Order	Observed Value	F Value	P Value
Consumption is not the Granger reason for GDP	First	110	2.80769	0.0375
GDP is not the Granger reason for consumption	First	110	1.87462	0.1355
Investment is not the Granger reason for GDP	First	110	2.98185	0.0175
GDP is not the Granger reason for investment	First	110	7.02518	0.0093
Investment is not Granger reason for consumption	First	110	1.75345	0.1883
Consumption is not Granger reason for investment	First	110	4.74627	0.0316

From the results in Table 6 above, the following Granger causality can be clarified.

First, investment and consumption are the Granger reasons for GDP. On one hand, these two parts maybe are components of GDP from analysis, on the other hand, this result is the same as the result of the previous

cointegration equation analysis and evaluation research, which proves that China still has potential for economic growth improvement. Local demand can promote the economy.

Second, GDP is the Granger reason for investment but not for consumption. This may reflect certain institutional characteristics of Guangzhou in income distribution. The share of wage income in Guangzhou has decreased, while the share of the government and enterprises has increased. The main body of consumption is the residents, and the counterpart of investment is the government and businesses. Therefore, the proportion of investment in GDP increases, but the proportion of consumption decreases.

Third, For investment, consumption is its Granger cause.The analysis may reflect the imbalance of consumption and investment in Guangzhou. There is a one-way relationship between consumption and investment. When total consumption equals total output, an increase in household consumption will promote an increase in investment, thereby promoting an increase in household income.

4.6 Impulse Response

After the Granger causality test is checked on the PVAR model, the impulse response is used to further study the relationship among consumption, investment and economic growth. The analysis chart specifically shows the impact of one factor on the current and future values of another factor (or the factor itself) under the premise the other factors remain unchanged. The vertical axis represents the degree of effect, and the horizontal axis represents lagging orders.

Figure 1 shows the impulse response function of Guangzhou's GDP under the positive influence of unit standard deviation INV. The figure shows that at a significance level of 5%, GDP reacted positively and grew very quickly after producing a positive investment effect, reaching its peak in the second period, but it was slightly lower than the value of short-term consumption. The impact of INV on GDP showed a rapid weakening trend from lag 2 to lag 3, but then rapidly increased from lag 3 to lag 4. Therefore, in the short term, investment has the greatest negative impact on GDP. Since then, the magnitude of the impulse response has gradually changed from a negative effect to a positive effect, that is, the increase in investment can stimulate economic growth in the initial stage. In addition, there is a certain time lag in converting investment into output. Therefore, in the initial stage, investment is currently further enhancing its stimulus and positive impact on economic development. However, the excessive growth of fixed investment may lead to inefficient investment or reinvestment, which may further increase inflationary pressure or overcapacity pressure. Especially nowadays, these problems have already appeared in many sectors, so these unfavorable factors may negatively affect the long-term economic growth.

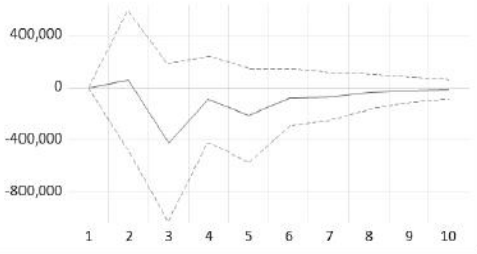

Figure 1 The impulse response of investment to GDP

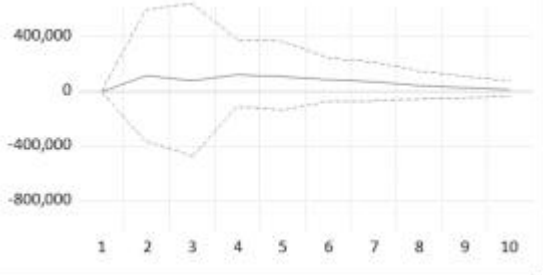

Figure 2 The impulse response of consumption to GDP

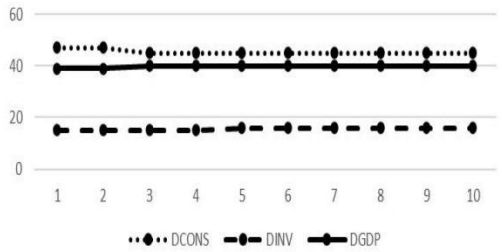

Figure 3 Variance decomposition diagram of GDP

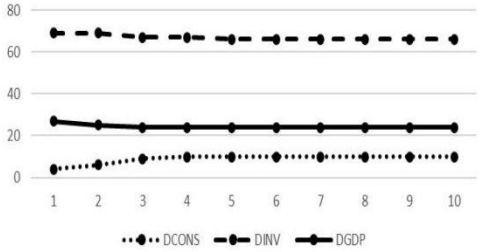

Figure 4 Variance decomposition diagram of investment

Figure 2 shows the impulse response function of Guangzhou's GDP under the positive influence of the unit standard deviation CONS. The figure shows that GDP will continue to produce a positive response after being positively affected by consumption, and will gradually increase until the fourth stage reaches its peak, and then the value of impulse response will slowly decrease, which has a positive influence on long-term and sustainable

economic growth. Initially, the increase in consumption will directly stimulate economic growth. Due to the imbalance between investment and consumption in our country, most of the commodities in the economy are in a state of surplus. The increase in consumption can convert China's surplus production into hard currency, which will greatly improve business performance and reinvestment enthusiasm. Therefore, the role of consumption in stimulating the economy not only occurs in the initial stage, but also has a prominent stimulus and positive promotion effect on its growth, which is consistent with the conclusions of long-term co-integration research. Therefore, it is necessary for us to further exert the long-term promotion role of consumption in the process of economic development, and actively take various measures to increase the consumption of the Chinese population.

4.7 Variance Decomposition

The main function of variance decomposition is to evaluate the contribution of variables, especially to examine the contribution of the dynamic changes and effects of variables in the system by using a specific decomposition method, and estimate the relative importance of its impact by comparing the contribution of each variable. This paper further uses the variance decomposition to examine the contribution value of each variable shock to better clarify the impact of consumption and investment on long-term economic growth, and explore the explanatory strength of consumption and investment on long-term economic growth. Figure 3 shows the standard error of GDP decomposed into the rate of change of GDP, investment, and consumption contribution. Among the fluctuations in GDP, the contribution of investment shocks has changed slightly, and the contribution rate has basically stabilized at about 16%; the contribution rate of consumption has fluctuated changes, and the overall contribution rate is about 45%. This analysis result is consistent with the previous analysis result of the cointegration equation. In the long run, the impact of consumption on GDP is greater than that of investment.

Figure 4 shows the standard error of investment in the rate of change of contribution of GDP, investment, and consumption.

Compared with the fluctuations in investment changes, the contribution rate of GDP shocks slowly declined and stabilized after the fourth stage, generally stabilizing at around 22%. The contribution rate of consumption shocks to investment volatility has risen slowly, tending to about 10%. Figure 5 shows the standard error of consumption broken down into the rate of change of contribution of GDP, investment, and consumption. The main reason for the dynamic changes and influencing factors of consumption is its own factors. Therefore, the contribution rate of consumption shocks will gradually decrease and then stabilize, accounting for about 95% of the contribution. The contribution of GDP shocks to the explanation by consumption fluctuations tends to increase slowly over time. However, GDP does not play a dominant role in explaining changes in consumption fluctuations. This shows that the share of people's wages in GDP in China's income distribution structure has been underestimated. The contribution of investment shock explanation is very small, with a contribution rate of about 4%.

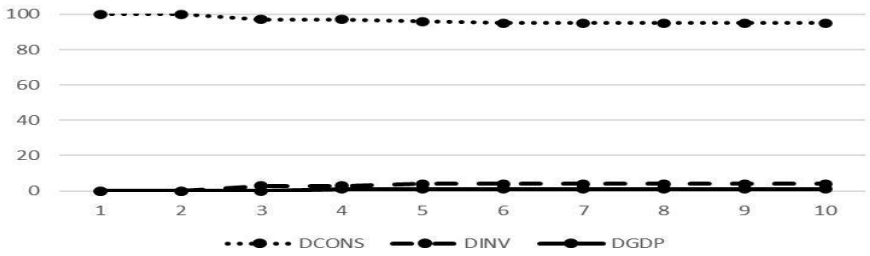

Figure 5 The Decomposition Diagram of the Variance of Consumption

5. Conclusions and Recommendations

5.1 Conclusion

The application of the Panel Vetor Autoregression(PVAR) model to Guangzhou's economy has yielded three pivotal conclusions reaging the nexus between domestic demand and long-term economic growth.

Firstly, the role of consumption in economic growth. the cointegration equation and Granger causality test analyses indicate that consumption is a potent stimulant for economic development and growth over the long term. However, the GDP of Guangzhou is not the Granger-cause for consumption, suggesting that combined with the results of variance decomposition, the dynamic changes of GDP itself do not have strong explanatory power for the dynamic changes of consumption. The reason is that the proportion of wage income in Guangzhou's GDP has decreased, residents' income has not keeping pace with the rapid growth of economic growth. Given that residents are the principal drivers of consumption, which has great effects on residents' spending, it is imperative to bolster income levels to enhance consumption's efficiency in propelling long-term economic growth. It can alleviate the current imbalance between investment and consumption in Guangzhou.

Secondly, the short-term impact of investment.In the analysis of the impulse response function, it is observed that the short-term positive promotion of investment yields a higher impact value than consumption. This implies that short-term investment can significantly and swiftly influence the economy, particularly during economic downturns, government-led capital infusion is a most direct and effective strategy to maintain economic growth. However, it is necessary to realize that repeated investment and low-efficiency investment may have a negative impact on long-term economic growth.

Finally, the influence of consumtion during economic downturns.In the Granger causality test, consumption is an important reason for Granger's GDP. During the COVID-19 epidemic, with the downturn of economy, it is imperative for the government intensify efforts to stimulate consumption and revive economic growth.

5.2 Suggestions

5.2.1 Increasing Wage Income to Expand Consumption

To expand domestic demand, the residents must have a strong consumption capacity. Therefore, it is necessary to increase residents' income and make full use of the stimulus effect of consumption on economic growth. In view of this, it is an important strategy for the expansion of domestic demand, the government needs to optimize residents' employment, create a good consumption environment, reform residents' income and reduce the scale of different groups. Also it should take the current inflationary pressures into account, formulate policy to stabilize prices at a good level, and stimulate residents' potential consumption willingness.

Besides, it needs further promote the development of urbanization, stimulate the vitality of domestic demand in rural areas, release the consumption potential of rural residents; underpin the science and technology development to meet the future China's research and development spending.

5.2.2 Adjusting Investment Structure

First, strengthening independent innovation and optimizing the structure of domestic demand. The government should maximize the role of investment in expanding and stimulating domestic demand, improve the investment mechanism and system, and avoid the problem of overproduction caused by excessive investment. In particular, it is necessary to give more support for independent innovation

such as providing trade, tax and credit policy preferences, supporting high-tech industries, building industrial clusters, creating more job positions with investment.

Second, promoting the development of new energy industries and create new hot spots for residents' consumption. Currently, people are paying more attention to environmental issues, the new energy industry is the key point for China's competitiveness in the international market, and is an important step to increase and adapt to structural changes. The new energy industry will be a hot spot for the next round of economic growth.

Although the study may offers significant insights to the future study, there are still some potential limitations:The study selects Guangzhou City as a sample to study, factors which mentioned in the paper influence economic growth can vary significantly across different locales in China.The data sample should update and keep track to understand the long-term dynamics between domestic demand and economic growth, other factors such as government spending and exports may also significantly influence economic growth, the future study may include those factors.

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A Case Study of the Student-Managed Investment Fund Program at Fresno State: History, Experiential Learning, and Challenges

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Abstract

The student-managed investment fund (SMIF) has gained its popularity not only in the U.S. but worldwide over the past 3 decades. The importance and popularity of SMIFs can be further evidenced by the two special issues recently published in *Managerial Finance* (Buser, 2020a and 2020b), showcasing a potpourri of twenty SMIFs with wide variation in administration and structure. Abukari, Oldford, and Willcott (2021) present more than 40 SMIFs with their respective highlights and novel contributions. As shown, many SMIF programs have multiple funds and employ multiple strategies. The SMIF program at Fresno State has also grown in number of students and assets under management (AUM) since 1999. The total number of active SMIF students now exceeded 50 per year and the AUM over $8.3 million as of March 2024. More importantly, the SMIF's pedagogical practices have also evolved over the years. Adding well-sequenced courses, mentoring practice, and the write covered call-option strategy has enhanced the pedagogical value and learning experience of the SMIF. The successful development and experiential learning of Fresno State's SMIF program can provide a useful blueprint for other business programs contemplating such programs. The purpose of this case study is to trace the history and evolution of the SMIF program at Fresno State and discuss the resulting experiential learning benefits and challenges.

Keywords: Student-managed investment fund, SMIF, experiential learning, portfolio management

For CEOs, It pays to be Ethical and is Lethal to Manage Earnings

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For CEOs, It pays to be Ethical and is Lethal to Manage Earnings

Abstract: We are the first paper in literature that shows Chief Executive Officer (CEO) forced turnover of firms that have Securities Class Act (SCA) litigation is four times as much as (300% more than) the Non-SCA firms in the year of SCA litigations. Up to five years before SCA litigation, SCA firms have significantly higher stock return, sales growth and earning management than the Non-SCA firms and we show that the higher stock returns are positively correlated with accounting performance and earning management. Accounting performance measured in terms of ROA and net income to sales fail to follow the higher sales growth and in the year of SCA litigation, stock return of SCA firms collapses and this is the reason for the much higher CEO forced turnover of SCA firms. This is also one of the first papers in Earning Accounting literature to use both Cox Proportional Hazard and Logistic models to study the multivariate relationship between CEO forced turnover and accounting and financial performance, earning management and other control variables.

1. Introduction

According to Wikipedia, the top 10 companies in the world by market capitalization in the first quarter of 2018 are Apple, Alphabet, Amazon, Microsoft, Tencent, Facebook, Berkshire Hathaway, Alibaba, JP Morgan Chase and Johnson & Johnson. Either these companies have some legendary past CEOs like Steve Jobs of Apple and Bill Gates of Microsoft or news media widely follow and report their current CEOs. Some people still credit Apple's climb to world number 1 in market capitalization to its former CEO Steve Jobs. These are examples of how important a CEO is to the success of a company. It follows that CEO turnover, forced or voluntary, are both very important to a company. So it is interesting both practically and academically to study CEO forced turnovers. We study CEO forced turnover in the context of Securities Class Act Litigations.

The ensuing impact of SCA litigation roots in agency problems. CEOs, making investment and financing decisions on behalf of investors, have more insider information in terms of the quality of assets and firm operational alternatives compared to creditors and shareholders, and are assumed to have incentives to take advantage of their private information and extract rent from firms (Evans, Luo and Nagarajan, 2014; Laux, 2008). CEOs may manage earnings out of their career concerns (Cohen, Dey and Thomas, 2008; Ali and Zhang, 2015; Evans, Nagarajan and Schloetzer, 2010). Studies show that CEO turnover is preceded by poor financial performance (Murphy and Zimmerman 1993; Denis and Denis 1995; Brickley 2003; Coughlan and Schmidt 1985). In addition, Warner et al. (1988) show the association between a firm's stock returns and subsequent top management changes. They present an inverse relation between the probability of management change and share performance. In order words, CEOs are more likely to be dismissed when stock and accounting performance is poor than when it is good.

Although in short run, accounting targets can be met and stock prices may be boosted up, building such illusive image of superior firm performance through overstating earnings cannot eliminate their chance of turnover, for accruals will ultimately reverse. In contrast, earnings management may increase their probability of turnover. Allen, Larson and Sloan (2013) show the negative influence of accrual reversal on future stock prices. Hazarika et al. (2012) indicate that earnings management, as reflected in absolute discretionary accruals, increases the likelihood of forced CEO turnover in the subsequent year. Arthaud-Day et al. (2006) find that CEOs and CFOs of firms filing a material financial restatement are more than twice as likely to be dismissed as

their counterparts in a matched sample of control firms. Our result is consistent with the prior literature. By analyzing up to five years before SCA litigation, we demonstrate that SCA firms have significantly higher-than-market stock return, sales growth and earning management, and their higher stock returns are positively associated with accounting performance. However, their accounting performance measured in terms of ROA, ROE and net income per employee fail to follow the higher sales growth, and hence, in the year of SCA litigation, stock return of SCA firms collapses, which gives rise to the much higher CEO turnover of SCA firms.

The fraud/lawsuit revelations following earnings management are found to be positively related to CEO turnover and have negative influence on stock prices (Aharony et al. 2015; Hennes et al. 2008; Persons, 2006). This is supported by our evidence that SCA firms are four times as likely to fire their CEOs as Non-SCA firms. In order to repair firm reputation, the boards tend to make forced CEO turnover decision. It is shown that forced resignations of top managers are preceded by large and significant declines in operating performance and followed by large improvements in performance (Denis and Denis, 1995). Hazarika, Karpoff and Nahata (2012) argue that it is highly probable that the boards proactively monitor managers' earnings management and take actions before the overly aggressive behavior are known publicly. They find that the degree of earnings management is positively related to the probability of forced CEO turnover and this relation is invariant of firm performance and the direction of accruals and conclude that the overly aggressive earnings management behaviour of CEOs can lead to CEO turnover before being detected externally.

2. Hypothesis

A CEO has a central role in both the daily management of a company and possibly in the future direction of a company. We develop below our hypotheses in CEO forced turnover:

H1: SCA firms have significantly higher CEO forced turnover ratios than Non-SCA firms and these higher CEO forced turnovers are positively and significantly related to lower stocks return, higher earning management and lower profits.

H2: CEOs of SCA firms try to manipulate earnings and sales growth in order to push up stock return and this manipulation is successful before the year of filing of SCA lawsuits.

3. Data, Measures and Methodology

We collect CEO turnover data from Compustat ExecuComp and group turnovers into forced turnover and voluntary turnover according to Parrino (1997). We then combine CEO turnover data with return data from CRSP, accounting performance data from Compustat and SCA data from Stanford University Law School Security Class Action Clearinghouse. Totally, there are 1538 CEO turnovers between 1997 and 2012[1], of which 369 are identified as forced turnover and 1169 are identified as voluntary turnover (see Table 1 Panel A). Table 1 Panel A also shows that forced turnover ratio is 0.032, voluntary turnover ratio is 0.101, and the total turnover ratio is 0.133, which are consistent with the literature, e.g., see Jenter and Kanaan (2015) and Lee, Matsunaga and Park (2012).

[Insert Table 1 Panel A around here.]

Table 1 Panel B shows the summary statistics for financial performance, accounting performance, earning management and other control variables in year -1[2]. For financial performance, in addition to unadjusted stock return we include industry adjusted stock return, stock return bottom decile dummy, stock return momentum loser and winner dummies. Jenter and Kanaan (2015) discuss why Strong-form relative performance test is preferred over Weak-form test though we provide both the Weak-form and Strong-firm tests in this paper. To do the Strong-form relative performance test, we need a two-stage regression approach. Following Jenter and Kanaan (2015), in the first stage, we derive industry adjusted stock return:

First Stage: $r_{j,Y-1} = \alpha_0 + \alpha_1 r_{\text{industry group, Y-1}} + u_{j, Y-1}$ (1)

Where $r_{j,Y-1}$ is unadjusted annual stock return of firm j at year Y-1 (Y=1996 to 2012), $r_{\text{industry group, Y-1}}$ is mean unadjusted annual stock return of industry groups[3] at year Y-1 and $u_{j, Y-1}$, the residual, is industry adjusted annual stock return of firm j at year Y-1.

[1] Our SCA data is from 1996 to 2012. We need to regress CEO turnover on previous 1 year financial performance, accounting performance, earning management and also common director ratio so CEO turnover has to start from 1997.

[2] In our Cox proportional hazard rate model and logistic model, we regress year t CEO forced turnover on year t-1 financial performance and other variables where t= -5 to +5. In year 0 regression, the accounting and financial performance variables, earning management and other control variables are in year -1.

[3] To be consistent with Gleason et al. (2008) we again use GICS to divide all stocks into industry groups.

Second Stage: Prob (CEO forced turnover $_{Y, j,t}$) $= \beta_{0,t} + \beta_{1,t}\, u_{Y-1,j,\,t}$

$+ \beta_{2,t}$ * other variables $_{Y-1,j,\,t} + v_{Y,j,\,t}$ (2)

Where Y=1996 to 2012, t= -5 to +5 and t=0 denotes year of filing of lawsuit.

$u_{Y,j,\,t-1}$, the residual in equation (1) is the industry adjusted annual stock return. Instead of following Jenter and Kanaan (2015) in including the estimated exogenous component of firm performance in equation (2), we put the annual stock return bottom decile dummy, the momentum loser and winner dummies in equation 2. In each year, we divide all stock available in CRSP by unadjusted annual stock return into 3 groups. If a stock's unadjusted annual stock return is in the bottom decile, then it has an annual stock return bottom decile dummy of 1, otherwise 0. This decile dummy shows the relative performance of a stock to the market. Similarly, for every year, we divided all stocks in CRSP in year -2 (2 year before) into three groups by unadjusted annual stock return. For stocks in the bottom 1/3, we further divide them into three groups by unadjusted annual stock return in year -1. For stocks in the bottom 1/3 in both years -1 and -2, we call them unadjusted annual stock return momentum loser and they have an unadjusted annual stock return momentum loser dummy of 1, otherwise 0. Similarly, for stocks in the top 1/3 in both years -1 and -2, we call them unadjusted annual stock return momentum winner and they have an unadjusted annual stock return momentum winner dummy of 1, otherwise 0. The momentum loser and winner dummies shows the relative performance of a stock in two consecutive years and reveal the relative performance of a stock in a dynamic fashion.

One of the most important variables in equation (2) is earning management. To be consistent with Jenter and Kanaan (2015), earning management needs to be industry adjusted too. For this industry adjustment requirement, we follow Hazarika et al. (2012) in obtaining the earning management variable for each of the GICS industry groups:

$$\text{Total accrual}_{j,\,Y} = (\Delta CA_{j,\,Y} - \Delta CL_{j,\,Y} - \Delta Cash_{j,\,Y} - \Delta CA_{j,\,Y} + \Delta STDEBT_{j,\,Y} - DEPN_{j,\,Y})/Asset_{j,\,Y-1} \quad (3)$$

Where Y=1996 to 2012, $\Delta CA_{j,\,Y}$ = change in firm assets for firm j from year Y-1 to year Y, $\Delta CL_{j,\,Y}$ = change in firm current liabilities for firm j from year Y-1 to year Y, $\Delta CA_{j,\,Y}$ = change in firm assets for firm j from year Y-1 to year Y, $\Delta Cash_{j,\,Y}$ = change in firm cash for firm j from year Y-1 to year Y, $\Delta STDEBT_{j,\,Y}$ = change in firm debt in current liabilities for

firm j from year Y-1 to year Y, $DEPN_{j, Y}$ = change in firm depreciation and amortization for firm j from year Y-1 to year Y and $Asset_{j, Y}$ = book value of asset for firm j from in year Y.

The abnormal accrual of firm j in year Y is obtained from the residual in the following equation:

$$Total\ accrual_{j, Y} = \beta_{0\,j} + \beta_{1\,j}\,(1/Asset_{j, Y-1}) + \beta_{2\,j}\,(\Delta Rev_{j, Y} - \Delta AR_{j, Y}) + \beta_{3\,j}\,(PPE_{j, Y}) + \beta_{4\,j}\,(ROA_{j, Y-1}) + w_{j, Y} \quad (4)$$

Where $\Delta Rev_{j, Y}$ = change in revenue for firm j from year Y-1 to year Y divided by $Asset_{j, Y-1}$, $\Delta AR_{j, Y}$= change in account receivables for firm j from year Y-1 to year t divided by $Asset_{j, Y-1}$, $PPE_{j, Y}$= gross value of property, plant and equipment for firm j in year Y divided by $Asset_{j, Y-1}$, and $ROA_{j, Y-1}$= return on asset for firm j in year Y-1 to year Y. Earning management of firm j in year Y is the absolute value of $w_{j, Y}$.

For accounting performance measures, we include ROA[4] and sales growth. ROA is net income / total asset and sales growth is sales at year Y/sales at year Y-1. Unadjusted ROA and sales growth can be unreliable with extreme values and to be consistent with our earning management variable, ROA and sales growth are also winsorized at 5% and 95% for each industry[5]. The other variables are:

inventory to cost of goods sold ratio (= (inventory/(cost of goods sold/365))/1000)

receivable to sales ratio (= (account receivable / (sales/365))/1000)

current ratio = (current asset/current liabilities)

debt ratio = (total liabilities / total asset)

and age of CEO, tenure in years of CEO and size (natural log of total assets).

[Insert Table 1 Panel B around here.]

All of the variables in Table 1 Panel B have a total number of observation of 11537, except for CEO tenure which has only 11526 observations. Annual unadjusted stock return shows large variation from -97% to 2619%, with a mean of 15% and a median of 9%. Age of CEO is from a minimum of 32 years to a maximum of 96 years, while CEO tenure (= number of days as CEO/365) is from 0 years (i.e., CEO tenure is less than 4 days) to 12.71 years with a

[4] We also try ROE and results are basically the same.
[5] We also try 1% and 99%. Results are basically similar.

mean of 7.29 years and a median of 5.25 years. ROA is from -185% to 53%, with a mean of 5% and a median of also 5%.

In each year, we divide all stocks (a total of 11537) into two groups. First, if a company has a SCA litigation in a year, we label this company as a SCA firm. Second, the remaining firms in the same year are in '*Non-SCA*' group. Table 1 Panel C shows the number of SCA firms and Non-SCA firms each year in year 0 (year of filing of lawsuit reported in SCA litigation database is denoted year 0)[6]. The total number of SCA firms and Non-SCA firms are 345 and 11192 respectively. Each group has a large enough sample size for Cox proportional hazard rate and logistic analysis later on.

[Insert Table 1 Panel C around here.]

In Table 1 Panel C, we show the number of observations, mean, minimum and maximum of unadjusted stock return, industry adjusted stock return, earning management, ROA, sales growth in year -1 and forced turnover ratios for SCA and Non-SCA firms in SCA filing year (year 0). In year 0, we need to regression year -1 accounting and financial performance variables, earning management and other control variables on year 0 CEO forced turnover dummy. 345 SCA filings are included in our study. The mean turnover ratio for SCA firms is 11.6%, much higher than of Non-SCA firms (2.9%).

4. Univariate Analysis

4.1 SCA firms have significantly higher CEO turnover ratios than that of Non-SCA firms and this is highly related to earning management and unsustainable sales growth

Figure 1 shows graphically the difference of CEO forced turnover ratios between SCA and Non-SCA forms with accounting and financial performance variables and the results are striking.

[6] Year of filing of lawsuit reported in SCA litigation database is denoted year 0. Years -1 to -5 are previous 1 to 5 years before year 0 and years 1 to 5 are next 1 to 5 years after year 0.

Figure 1 Panel A shows that unadjusted annual return of SCA firms is around 30 percentage points lower than that of Non-SCA firms in year 0 while CEO forced turnover ratio of SCA firms is three times higher than that of Non-SCA firms in the same year. The difference of annual return (SCA minus Non-SCA) is largely a "V-shape" curse and bottoms at year 0 and the difference of CEO forced turnover ratio (SCA minus Non-SCA) is largely in inverted "V-shape" curse and peaks at the same year. The fact that they both bottom and peak in the same year (year 0) shows the close relationship between CEO forced turnover and financial performance. The fact that stock return of SCA firms are substantially (I shall show below the difference is also statistically significant) higher than that of Non-SCA firms before year 0 and CEO forced turnover of SCA firms are substantially below that of Non-SCA firms further supports the hypothesis that CEO forced turnover is closely related to financial performance.

[Insert Figure 1 Panel A around here.]

Figure 1 Panel B shows the relationship between difference of unadjusted annual return of SCA firms and Non-SCA firm and difference of ROA. Both are "V-shaped curve" and both bottoms at year 0. In year 0 ROA of SCA firms is close to 5 percentage points below that of Non-SCA firms and this difference is huge. Figure 1 Panel B shows that financial performance is closely related to accounting performance and this supports the argument that the market is efficient.

[Insert Figure 1 Panel B around here.]

Figure 1 Panel C shows the difference of CEO forced turnover ratios between SCA and Non-SCA forms with several accounting and financial performance variables: net income to sales ratio, total assets growth ratio, unadjusted annual return, ROA, operating income before depreciation to sales and total property plant and equipment growth rate. Except for the difference of CEO forced turnover ratio, which is "V-shaped," the other financial and accounting

performance variables are "Inverted V-shaped," bottoming at or around year 0. So this panel shows the close relationship between CEO forced turnover ratio and financial and accounting performance ratios.

[Insert Figure 1 Panel C around here.]

Similar to Figure 1 Panel A, Figure 1 Panel D shows the relationship between the difference of industry adjusted return with the difference of CEO forced turnover ratio. The results are also similar. Both differences either bottoms or peaks in the same year (year 0) and industry adjusted return of SCA firms are around 27 percentage points lower than that of Non-SCA firms, a huge difference. Again I shall show below that this difference is statistically significant at a t-stat of 11.29, significant at 1% confidence interval. So it means whether we use unadjusted or industry return, there is a close relationship between CEO forced turnover ratio and financial performance.

[Insert Figure 1 Panel D around here.]

Finally, Figure 1 Panel E shows the relationship between the difference of industry adjusted return and the difference of ROA. Similar to Figure 1 Panel B, both are "V" shaped and bottoms at the same year (year 0). Again this show the close relationship between financial and accounting performance ratios, irrespective of whether adjusted or unadjusted annual return are used.

[Insert Figure 1 Panel E around here.]

Figure 1 shows the close relationship between CEO turnover ratio and accounting and financial performance variables, but I do not discuss statistical significance. Table 2 Panel A presents the mean forced turnover ratio[7] and other firm performance ratios for SCA and Non-SCA

[7] Forced turnover ratio for each firm each year is equal to the number of forced CEO turnover (the maximum number of forced turnover for all firms in a year is 1 except for 1 firm which is 2) in that year. Similarly, voluntary turnover ratio for each firm each year is equal to the number of voluntary CEO turnover (the maximum number of voluntary turnover for all firms in a year is 1). If there is no forced or voluntary turnover for a firm in a year, then

stocks with statistical significance. Due to space limitation, we only show years -5, -2, -1, 0, 1, 2 and 5.[8] Five years before SCA lawsuit, the mean forced turnover ratio of SCA and Non-SCA groups are 0.021 and 0.028 respectively (t=0.81 for Non-SCA minus SCA, hereafter Non - SCA), i.e., Non-SCA firms have higher CEO turnover ratio, though statistically no significant. When time gets closer to SCA year (the year of filing of lawsuits), mean forced turnover ratio of SCA firms start to be higher than the corresponding mean of Non-SCA firms, which may be a result of information leak, but the difference is still insignificant. In the year of SCA litigation, mean difference of CEO forced turnover ratio increases sharply. The mean forced turnover ratio of SCA stocks becomes as high as 0.116, whereas that of Non-SCA related stocks is only 0.029 (t stat for the difference= -4.99, significant at 1%). Mean forced turnover ratio of SCA is around 300% higher than that of Non-SCA firms, where the difference is notably significantly negative. Moreover, the mean forced turnover ratio of SCA stocks continues to be substantially higher than of Non-SCA firms for the next 2 years. Hence, these results, from both mean difference magnitude and significance, show that SCA litigation is deadly to CEO. When there is a SCA litigation, the CEO of a company is significantly more likely to be kicked out than those in Non-SCA companies, and this trend persists into five year after the lawsuit.

[Insert Table 2 Panel A around here.]

Table 2 Panel A also presents the mean of firm performance and other ratios. First, mean unadjusted annual return of SCA is higher than of Non-SCA firms in years -5 and -2 (significant at year -2), but then becomes significantly lower than of Non-SCA firms in years -1 and 0. In year 0, mean unadjusted return of SCA firms is 30.4 percentage points lower (and also significant at

the forced or voluntary turnover ratio for that firm in that year is 0. The total turnover ratio for each firm each year is equal to the sum of forced turnover and voluntary turnover ratios for that firm in that year.

[8] Other years are available upon request and year 0 is the year of the filing of SCA lawsuits.

1%) than that of Non-SCA firms, a highly significant difference. Figure 1 Panel A denotes this graphically and from the figure we can notice that the difference of forced turnover ratio (SCA minus Non-SCA) peaks in year 0, while the difference of unadjusted return (SCA minus Non-SCA) reaches bottom in the same year.

4.2 High Sales and Asset growth of SCA firms are not sustainable

We show below that this peak and bottom relationship is not a coincidence. SCA firms have substantially higher unadjusted stock return than that of Non-SCA firms from years -5 to -2. From Table 2 Panel A, we also observe that the mean of earning management of SCA firms is significantly higher than that of Non-SCA firms in all years. Moreover, mean sales growth of SCA firms is significantly above that of Non-SCA firms from years -5 to -1. Interestingly, mean sales growth of SCA firms is insignificantly below that of Non-SCA firms in year 0 and significantly below that of Non-SCA firms in years 1 and 2. The bottom line of a firm's management is profit. In all years except year -2, mean ROA of SCA firms is below that of Non-SCA firms and the difference is significant in year 0, 1 and 2. Coupled with the collapse of SCA firms' returns in year 0, compared with that of Non-SCA firms, a reasonable hypothesis to explain this collapse in return is that CEOs of SCA firms try to manipulate stock return by high earning management and high sales and asset growth. This is successful in early year before year 0 as suggested by higher unadjusted stock return than Non-SCA firms up to year -2. But this manipulation is not sustainable because profit as measured by ROA of SCA firms is below that of Non-SCA firms in all but year -2 and mean ROA of SCA firms is even negative in year 0 as compared with a positive 5.5% for Non-SCA firms. The inferior performance of SCA firms in ROA is the major reason that leads to a collapse of stock return of SCA firms in year 0. This relationship is shown graphically in Figure 1 Panel B. Figure 1 Panel B clearly shows that the difference of unadjusted stock return basically

moves in unison with that of ROA. Both reach the bottom in year 0. This collapse in stock return of SCA firms would then lead to the significantly higher CEO forced turnover ratio for SCA firms.

4.3 Sales not generating profit for SCA firms

But why is ROA not following the substantially higher sales growth for SCA firms? From Table 2, Panel B, we can see that sales growth, total asset growth rate and property, plant and equipment growth rate of SCA firms are substantially higher than that of Non-SCA firms before year 0, while ROA, operating profit to sales ratio and net income to sales ratio of SCA firms are basically lower before and including year 0. The relationship is also shown graphically in Figure 1 Panel C.

[Insert Table 2 Panel B around here.]

In Figure 1 Panel C, most if not all of the differences of mean measure reach bottom at year 0 and become negative. Both operating profit to sales ratio and net income to sales ratio are negative for all years. For SCA firms, negative operating profit to sales ratio means that the firms sacrifice profit for higher sales growth. The negative net income to sales ratio clearly demonstrate that for SCA firms, sales generate lower profit than Non-SCA firms. From Table 1 Panel A, net income to sales ratio of SCA firms itself, without looking at the difference, is negative in all years except year 5. This negative net income to sales ratio is better than ROA in showing that SCA firms sacrifice profits for sales growth and this leads to the collapse of the stock return in year 0 for SCA firms.

5. Regression Analysis

5.1 Strong-form relative performance test

To do the strong-form relative performance test, we first used equation 1 to do the first-stage test to derive the industry adjusted values for stock return and other measures. Results are

in Table 3 Panel A. Consistent with Jenter and Fanaan (2015), the parameter for the industry mean is 1.00 but our adjusted R^2 is much higher than theirs.

[Insert Table 3 Panel A around here]

Table 3 Panel B presents the results of second-stage Cox proportional hazard regression of forced CEO turnover on industry adjusted stock return and other industry adjusted ratios. This is one of the first papers in accounting literature that employ Cox proportional hazard regression. According to some literature, such as Jenter and Fanaan (2015), Cox proportional hazard regression is preferred to Logistics regression because Cox proportional hazard regression includes CEO tenure in the dependent variable. However, we also include Logistic regression in my study. The dependent variable is CEO forced turnover dummy at year t where t= -5 to +5 and t=0 means the year of filing of lawsuit. The independent variables are values of 1 year before the dependent variable except for the SCA dummies which are always values at t=0. I provide Chi square statistics.

Consistent with univariate results in section four, SCA dummies are positive and significant at t=0 and 1, i.e. SCA firms have significantly higher forced CEO turnover than Non-SCA firms in year of filing of lawsuit and also in 1 year after the filing. This further supports our hypothesis in a multivariate setting our hypothesis H1: SCA firms have significantly higher CEO forced turnovers than Non-SCA firms. We include four measures in financial performance: industry adjusted stock return, industry adjusted bottom decile dummy, industry adjusted momentum loser dummy and industry adjusted momentum winner dummy. Industry adjusted stock return is negative and significant at 1% in all years which is consistent with the literature. This illustrates that one of the top concern, if not the top concern for board of directors in deciding CEO turnover is stock return. This is obvious because a top objective for investors for investing in

a company is stock return. Higher stock return usually implies shareholders are more satisfied, which in turn puts less pressure on the board to remove the CEO. The bottom decile dummy, which shows whether the company's stock return is in the bottom 1/10 of all stocks available in CRSP is not significant in any year. We follow Jenter and Kanaan (2015) in providing the momentum loser and winner measures.[9] The momentum loser dummy, which shows whether a company's stock return is consistently in the bottom 1/3 of all stocks in CRSP both in previous 1 and 2 years before t, is positive and significant in all years except -5. The momentum winner dummy, which shows whether a company's stock return is consistently in the top 1/3 of all stocks in CRSP both in previous 1 and 2 years before t, is not significant in any year. These three measure are complementary to the stock return measure because they measure the relative performance of a company's return to the market. When we compare the bottom decile dummy with the momentum loser dummy, we find that the board of directors is more concerned if a company's stock return was consistently in the bottom 1/3 in both previous 1 and 2 years than whether the stock's return is in the bottom 1/10 in the past 1 year. This implies that the board is more concerned about the consistent performance of a company in stock return than whether the company is doing very poorly in a particular year. If we compare the momentum loser dummy with the momentum winner dummy, the insignificance of the momentum winner results show that when considering to force a CEO out, consistent poor performance of a company is more important than consistent good performance.

For accounting performance, we include industry adjusted ROA and industry adjusted sales growth. Both are negative and significant at 1% in all but one year, especially in year 0. Our results show that board of directors, in deciding whether to force a CEO out, are very interested in the

[9] Jenter and Kanaan (2015) used 90th percentile while we use top and bottom 1/3

measure of ROA and sales growth. ROA and sales growth are major drivers of a company's stock return as ROA is a measure of the profitability of a company and sales growth is one of the factors that will determine whether a company's profit is sustainable. Our results show that when a company's ROA and sales growth are good, it is less likely that the CEO will be forced out.

Our earning management variable shows that it is negative but not significant before t=0. It is positive starting from year 0 until year 5 but is only significant at year 0. It seems that the board of directors accepts the earning management of the company's CEO before year 0. But earning management is not sustainable, as can be seen from the deteriorating stock return, ROA and net income to sales of both SCA firms relative to Non-SCA firms in Table 2 though sales growth of both SCA firms are consistently above that of Non-SCA firms before year 0. Our results show that a firm's CEO, through manipulating the earning management and sales growth measures, may be able to fool both the board of directors, shareholders and the market for a few years, but in year 0, when the company is being sued, stock return collapses. This leads to higher CEO forced turnover for SCA firms as they have higher earning management than Non-SCA firms in year 0.

In summary, first, it indicates that SCA lawsuit is lethal to CEOs in SCA firms. In year 0, dummy variables are highly significant and positive, supporting the univariate analysis that CEOs in SCA companies are more likely to be fired than Non-SCA firms. This relationship extends into year 1. The parameter estimate of SCA dummy is 1.239 (t stat=52.09) at year 0 which is extremely high. Second, it shows the importance of previous stock performance in CEO forced turnover decision (Table 3). It shows that good (poor) past performance leads to the decrease (increase) of probability of CEO being fired.

For robustness test, we also regress CEO forced turnover on market adjusted variables in Table 4. The results are basically consistent with Table 3 and this implies that our results are very robust and they are independent of the choice of variables.

[Insert Table 4 around here.]

I also have done robustness check by using logistic regression and by replacing control variables. All results show that SCA litigation increases the risk of CEO being fired. SCA dummy are significantly and positively related to forced turnover dummy, and the relation is the highest at the SCA year. Notice that different from Cox proportional hazard model, CEO tenure is one of the independent variables.

[Insert Table 5 around here.]

6. Conclusion

We are the first paper in literature that shows Chief Executive Officer (CEO) forced turnover of firms that have Securities Class Act (SCA) litigation is four times as much as (300% more than) the Non-SCA firms in the year of SCA litigations. Up to five years before SCA litigation, SCA firms have significantly higher stock return, sales growth and earning management than the Non-SCA firms and we show that the higher stock returns are positively correlated with accounting performance and earning management. Accounting performance measured in terms of ROA and net income to sales fail to follow the higher sales growth and in the year of SCA litigation, stock return of SCA firms collapses and this is the reason for the much higher CEO forced turnover of SCA firms. This is also one of the first papers in accounting literature to use both Cox Proportional Hazard and Logistic models to study the multivariate relationship between CEO forced turnover and accounting and financial performance, earning management and other control variables

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Figure 1 Panel A Difference of Mean Unadjusted Annual Return VS difference of Mean Forced Turnover Ratio for SCA and Non-SCA Stock (a positive value means the value of SCA stocks is higher than that of Non-SCA stocks and vice versa)

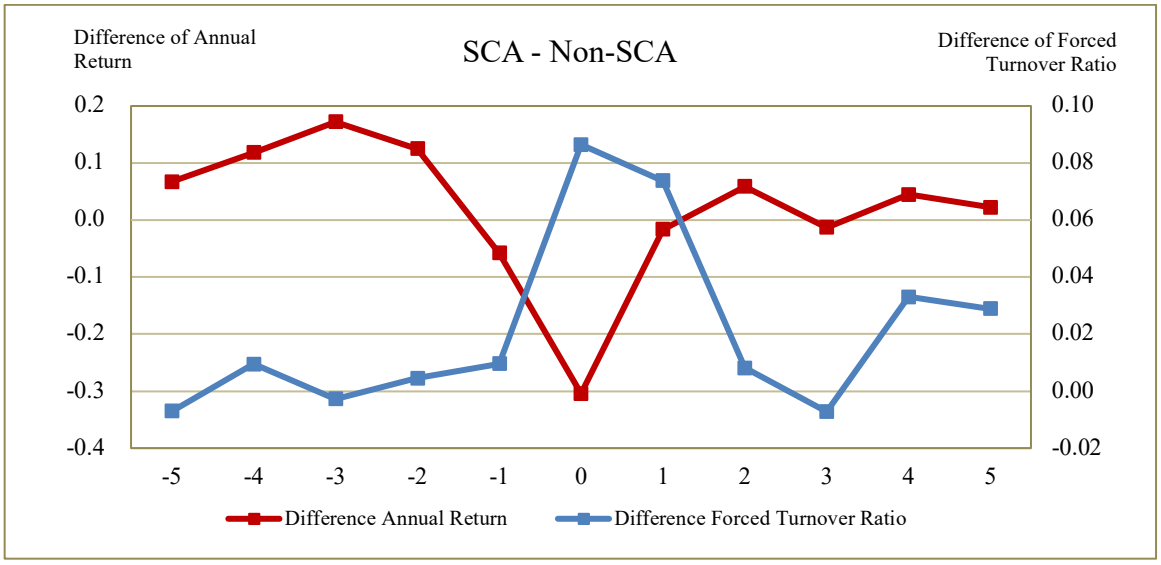

Figure 1 Panel B Difference of Mean Unadjusted Annual Return VS Difference of Mean ROA for SCA and Non-SCA Stock (a positive value means the value of SCA stock is higher than that of Non-SCA stock and vice versa)

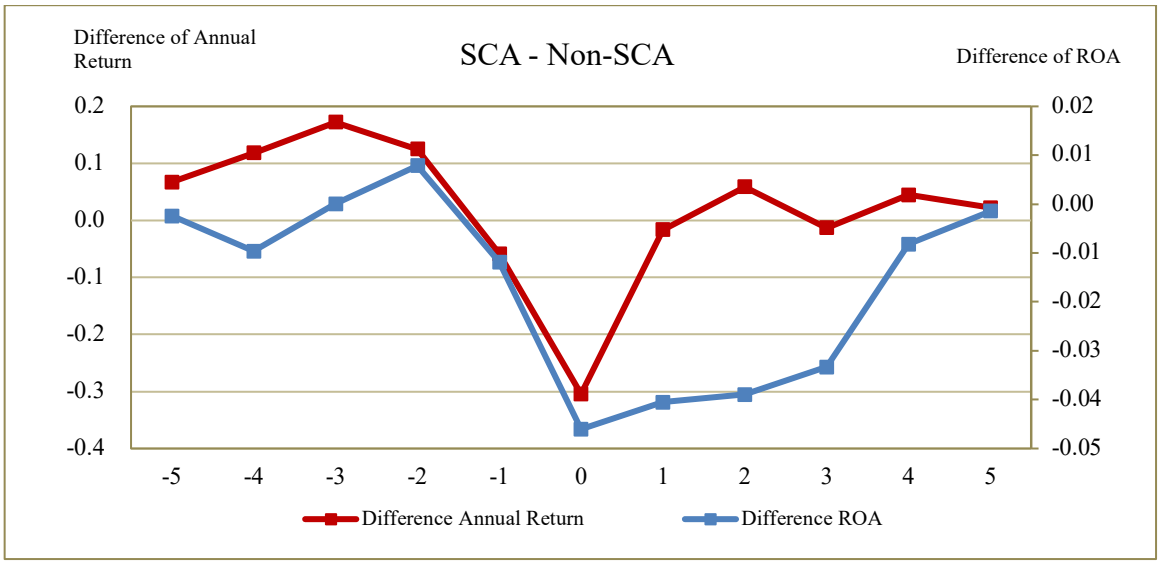

Figure 1 Panel C Difference of Mean Unadjusted Annual Return VS difference of Accounting Performance measures (a positive value means the value of SCA stocks is higher than that of Non-SCA stocks and vice versa)

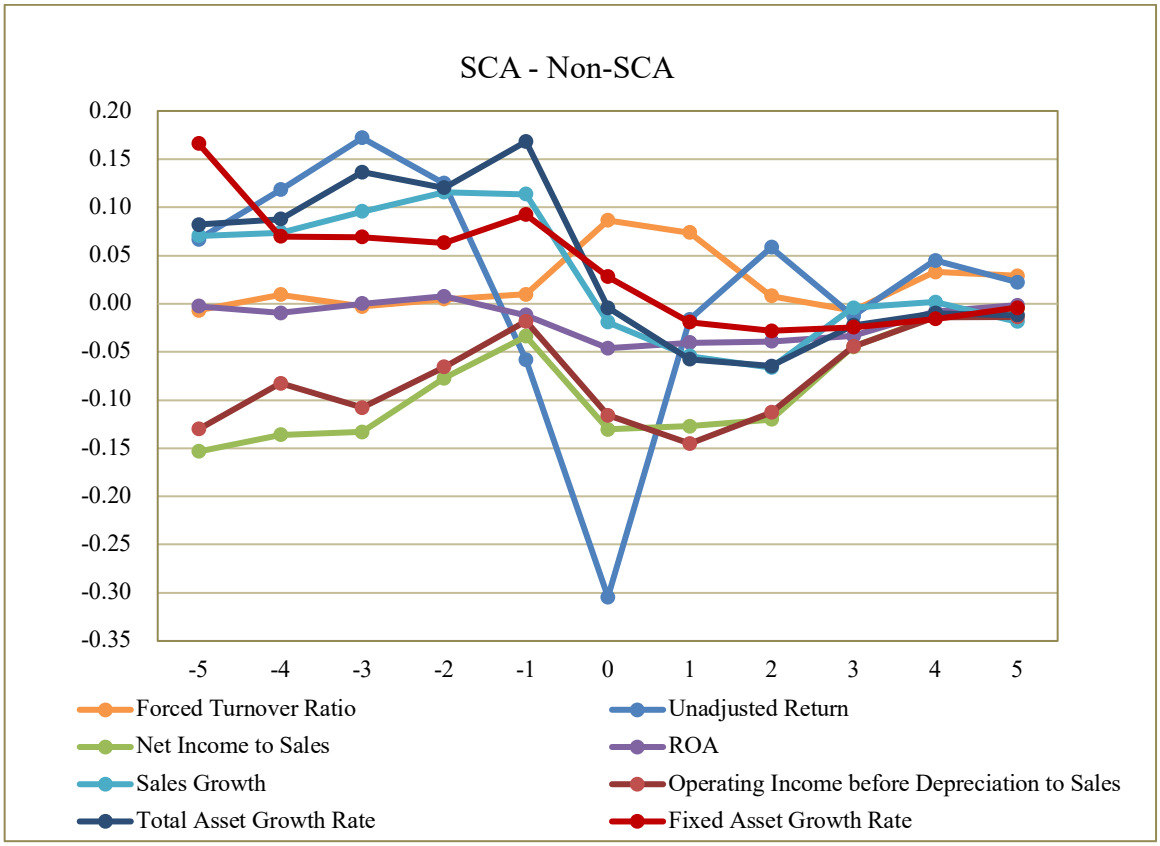

Figure 1 Panel D Difference of Industry Adjusted Return VS difference of Forced Turnover Ratio for SCA and Non-SCA Stock (a positive value means the value of SCA stock is higher than that of Non-SCA stock and vice versa)

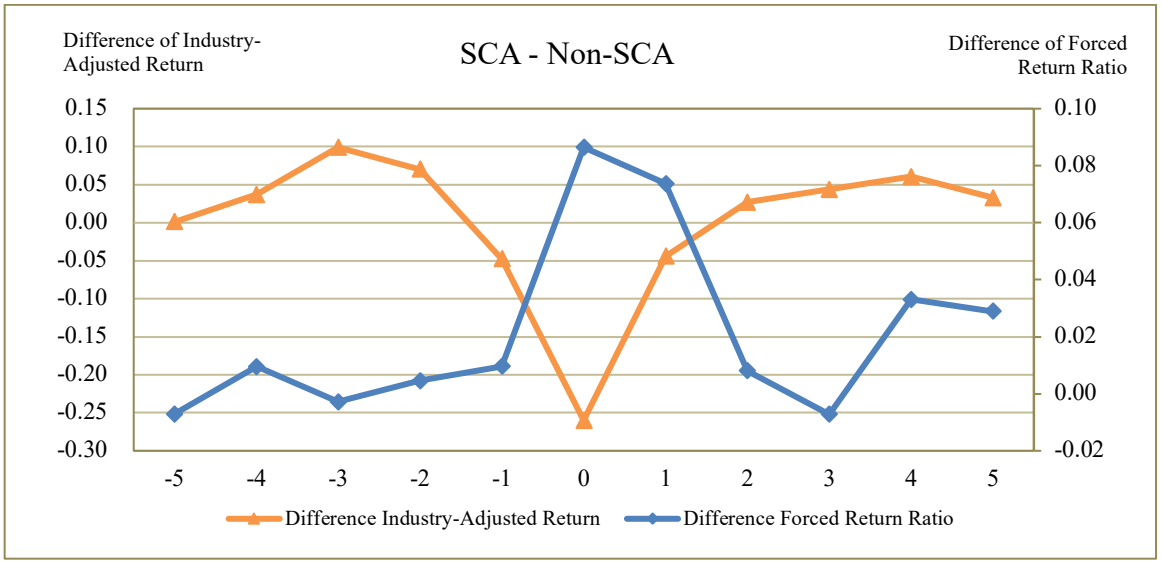

Figure 1 Panel E Difference of Industry Adjusted Return VS Difference of ROA for SCA and Non-SCA Stock (a positive value means the value of SCA stock is higher than that of Non-SCA stock and vice versa)

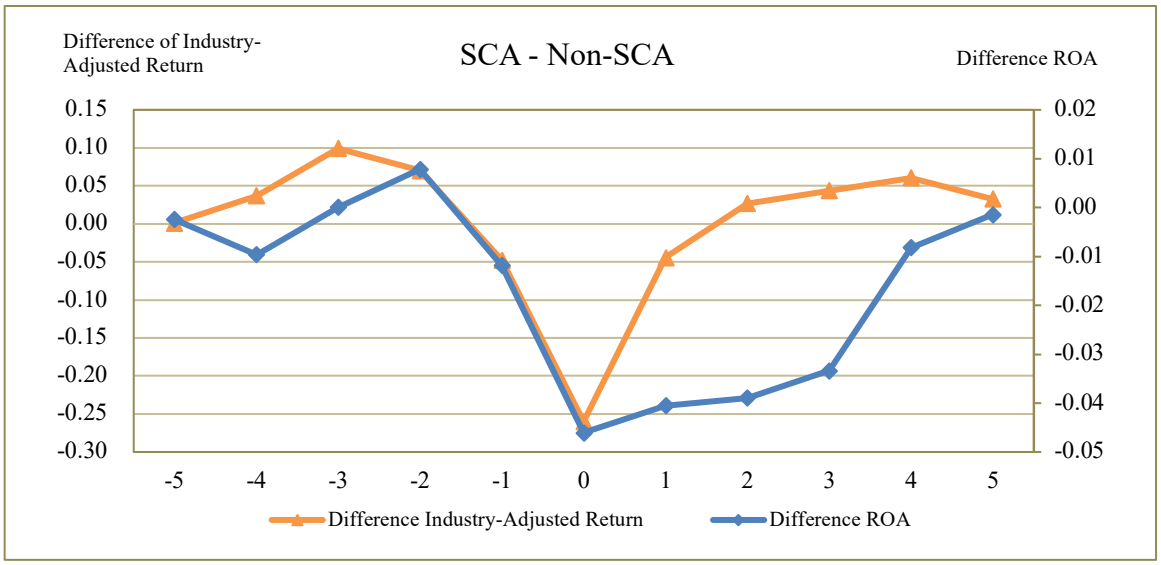

Table 1 Summary Statistics

Panel A: CEO Turnover

Year	No. of Forced Turnover	No. of Voluntary Turnover	Number of Firm Years	Forced Turnover Ratio	Voluntary Turnover Ratio	Total Turnover Ratio
1997	25	52	546	0.046	0.095	0.141
1998	26	75	692	0.038	0.108	0.146
1999	43	103	756	0.057	0.136	0.193
2000	36	96	774	0.047	0.124	0.171
2001	23	88	818	0.028	0.108	0.136
2002	22	82	790	0.028	0.104	0.132
2003	21	64	774	0.027	0.083	0.110
2004	33	69	787	0.042	0.088	0.130
2005	29	91	763	0.038	0.119	0.157
2006	26	69	745	0.035	0.093	0.128
2007	17	49	556	0.031	0.088	0.119
2008	14	55	569	0.025	0.097	0.121
2009	13	61	739	0.018	0.083	0.100
2010	10	60	745	0.013	0.081	0.094
2011	19	80	717	0.026	0.112	0.138
2012	12	75	766	0.016	0.098	0.114
Total	369	1,169	11,537	0.032	0.101	0.133

Table 1 Panel B: Descriptive Statistics

Variable	No. of Obs.	Min	Max	Mean	Median
Unadjusted Annul Stock Return	11,537	-0.97	26.19	0.15	0.09
Industry-Adjusted Stock Return	11,537	-2.94	23.60	0.00	-0.03
Bottom Decile Dummy	11,537	0.00	1.00	0.03	0.00
Momentum Loser Dummy	11,537	0.00	1.00	0.05	0.00
Momentum Winner Dummy	11,537	0.00	1.00	0.13	0.00
Current Ratio	11,537	0.20	57.61	2.25	1.80
Earning Management	11,537	0.00	1.49	0.06	0.04
Inventory COGS ratio	11,537	0.00	1.29	0.07	0.05
Receivable to Sales ratio	11,537	0.00	0.67	0.05	0.05
Debt Ratio	11,537	0.02	2.16	0.52	0.53
ROA	11,537	-1.85	0.53	0.05	0.05
Sales Growth	11,537	-0.87	5.25	0.11	0.08
Age	11,537	32.00	96.00	56.07	56.00
Tenure	11,526	0.00	61.04	7.29	5.25
Log of Total Assets	11,537	3.04	12.71	7.56	7.42

Table 1 Panel C Descriptive Statistics for SCA and Non-SCA Firms in Year -1

Firm Type	Type	Unadjusted Annul Stock Return	Adjusted Annul Stock Return	Earning Management	ROA	Sales Growth	Forced Turnover Ratio (year 0)
SCA	N	345	345	345	345	345	345
	Mean	0.094	-0.049	0.080	0.036	0.216	0.116
	Min	-0.878	-2.227	0.000	-1.099	-0.705	0.000
	Max	3.240	3.183	1.488	0.356	5.248	1.000
	Median	0.006	-0.104	0.051	0.049	0.127	0.000
Non	N	11,192	11,192	11,192	11,192	11,192	11,192
	Mean	0.152	-0.001	0.057	0.048	0.103	0.029
	Min	-0.966	-2.942	0.000	-1.845	-0.875	0.000
	Max	26.194	23.601	1.330	0.531	3.837	2.000#
	Median	0.096	-0.029	0.035	0.054	0.077	0.000

One company has 2 forced turnovers in the same year, so the forced turnover ratio is 2. We need to regress year -1 accounting and financial performance, earning management and other control variables on CEO forced turnover dummy at year 0.

Table 2 Panel A Summary of Forced Turnover Ratio and Firm Performance for SCA and Non-SCA Stock

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	SCA	Obs	284	335	345	345	324	313	232
		Mean	0.021	0.036	0.038	0.116	0.105	0.042	0.056
	Non	Obs	9,272	11,018	11,181	11,192	10,825	10,412	7,561
		Mean	0.028	0.031	0.028	0.029	0.031	0.033	0.027
	SCA-Non	t-stat	[0.81]	[-0.45]	[-0.92]	[-4.99***]	[-4.30***]	[-0.71]	[-1.90*]
Unadjusted Annual Return	SCA	Obs	330	345	345	345	343	332	263
		Mean	0.291	0.300	0.094	-0.159	0.127	0.196	0.156
	Non	Obs	10,853	11,192	11,192	11,192	11,185	10,902	8,485
		Mean	0.224	0.175	0.152	0.145	0.143	0.137	0.133
	SCA-Non	t-stat	[-1.38]	[-2.90***]	[1.92*]	[12.40***]	[0.46]	[-1.53]	[-0.42]
Industry-Adjusted Return	SCA	Obs	222	345	345	287	260	225	151
		Mean	0.017	0.073	-0.049	-0.265	-0.057	0.009	0.017
	Non	Obs	7,322	11,177	11,192	9,617	8,420	7,325	4,910
		Mean	0.015	0.003	-0.001	-0.005	-0.013	-0.018	-0.016
	SCA-Non	t-stat	[-0.04]	[-2.02**]	[1.79*]	[11.29***]	[1.55]	[-0.71]	[-1.28]
Earning Management	SCA	Obs	310	343	345	345	331	320	239
		Mean	0.081	0.078	0.080	0.065	0.060	0.064	0.065
	Non	Obs	10,138	11,108	11,192	11,192	10,884	10,499	7,726
		Mean	0.068	0.060	0.057	0.055	0.052	0.050	0.047
	SCA-Non	t-stat	[-2.25**]	[-2.78***]	[-3.71***]	[-2.49**]	[-2.17**]	[-3.18***]	[-3.47***]
ROA	SCA	Obs	341	345	345	345	332	326	245
		Mean	0.055	0.057	0.036	-0.001	0.002	0.002	0.040
	Non	Obs	11,121	11,192	11,192	11,192	10,974	10,656	7,911
		Mean	0.057	0.049	0.048	0.045	0.043	0.041	0.042
	SCA-Non	t-stat	[0.38]	[-1.05]	[1.53]	[3.17***]	[3.91***]	[4.37***]	[0.21]
Sales Growth	SCA	Obs	335	345	345	345	332	325	244
		Mean	0.233	0.227	0.216	0.074	0.032	0.013	0.047
	Non	Obs	10,999	11,190	11,192	11,192	10,974	10,648	7,903
		Mean	0.162	0.111	0.103	0.093	0.086	0.080	0.066
	SCA-Non	t-stat	[-3.36***]	[-5.31***]	[-4.27***]	[1.30]	[5.03***]	[6.99***]	[1.48]
Net income to sales	SCA	Obs	341	345	345	345	332	326	245
		Mean	-0.113	-0.057	-0.009	-0.104	-0.099	-0.092	0.026
	Non	Obs	11,119	11,192	11,192	11,192	10,974	10,655	7,906
		Mean	0.041	0.021	0.024	0.026	0.028	0.028	0.031
	SCA-Non	t-stat	[0.99]	[1.01]	[1.42]	[1.61]	[1.35]	[1.74*]	[0.32]

*, ** and *** denote significance at 10%, 5% and 1% respectively and t-stat is the statistics for the difference of mean.

Table 2 Panel B Difference of Mean Unadjusted Return and Accounting Measures (SCA – Non)									
year	Forced Turnover Ratio	Unadjusted Return	Net Income to Sales	ROA	Sales Growth	Operating Income before Depreciation to Sales	Total Asset Growth Rate	Net income to Sales	Property, Plant and Equipent Growth Rate
-5	-0.007	0.067	-0.153	-0.002	0.071	-0.130	0.082	-0.153	0.166
-4	0.009	0.118	-0.136	-0.010	0.074	-0.083	0.088	-0.136	0.070
-3	-0.003	0.172	-0.133	0.000	0.096	-0.108	0.137	-0.133	0.069
-2	0.005	0.125	-0.077	0.008	0.116	-0.066	0.120	-0.077	0.063
-1	0.010	-0.058	-0.034	-0.012	0.113	-0.018	0.168	-0.034	0.092
0	0.086	-0.304	-0.130	-0.046	-0.019	-0.116	-0.004	-0.130	0.028
1	0.074	-0.016	-0.127	-0.041	-0.054	-0.145	-0.058	-0.127	-0.019
2	0.008	0.059	-0.120	-0.039	-0.066	-0.113	-0.065	-0.120	-0.028
3	-0.007	-0.013	-0.045	-0.033	-0.004	-0.044	-0.022	-0.045	-0.025
4	0.033	0.045	-0.013	-0.008	0.002	-0.014	-0.010	-0.013	-0.016
5	0.029	0.022	-0.005	-0.001	-0.019	-0.014	-0.012	-0.005	-0.004

Table 3 Two-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Financial Performance, Accounting Performance and Earning Management

In the first-stage regressions, we follow Jenter and Kanaan (2015) in using industry mean to obtain industry adjusted variables for the following variables: unadjusted annual stock return, return in bottom decile, momentum loser dummy, momentum winner dummy, ROA, sales growth, receivable to sales ratio, current ratio, inventory to cost ratio, debt ratio and net income to sales ratio. In the second-stage we use Cox proportional hazard regression to predict CEO forced turnover using financial performance, accounting, earning management and other variables in the previous year, except the SCA dummy, which is always the value at year 0.

Panel A: First-Stage Regression

	Dependent Variable					
	Annual Return	**Bottom Decile**	**Momentum Loser**	**Momentum Winner**	**ROA**	**Sales Growth**
Intercept	0	0	0	0	0	0
t-stat	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Industry Mean	1.00	1.00	1.00	1.00	1.00	1.00
t-stat	[73.00***]	[40.47***]	[41.51***]	[49.27***]	[54.63***]	[67.68***]
R^2	0.32	0.12	0.13	0.17	0.21	0.28
	Dependent Variable					
	Current Ratio	**Receivable to Sales**	**Debt Ratio**	**Inventory to COGS Ratio**	**Net Income to Sales Ratio**	
Intercept	0	0	0	0	0	
t-stat	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	
Industry Mean	1.00	1.00	1.00	1.00	1.00	
t-stat	[73.44***]	[75.13***]	[73.79***]	[99.77***]	[82.80***]	
R^2	0.32	0.33	0.32	0.46	0.37	

Table 3 Penal B Second-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Industry Adjusted Financial and Accounting Performance, Earning Management and Other Control Variables

	Year						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
SCA Dummy				1.239	0.704	-0.042	0.962
				[52.05***]	[10.06***]	[0.02]	[6.54**]
Financial Performance							
Industry Adjusted Return	-0.806	-0.891	-0.948	-0.910	-0.912	-1.044	-1.626
	[19.18***]	[37.17***]	[45.41***]	[46.87***]	[36.14***]	[39.81***]	[36.34***]
Industry Adjusted Return in Bottom Decile Dummy	0.337	0.104	0.158	-0.079	-0.113	-0.524	-0.910
	[0.60]	[0.09]	[0.26]	[0.08]	[0.11]	[1.91]	[2.29]
Industry Adjusted Momentum Loser Dummy	0.120	0.377	0.500	0.335	0.432	0.417	0.652
	[0.12]	[2.86*]	[6.17**]	[3.07*]	[4.71**]	[3.85**]	[5.67**]
Industry Adjusted Momentum Winner Dummy	0.333	0.287	0.065	-0.156	0.075	0.039	-0.047
	[1.65]	[2.01]	[0.09]	[0.58]	[0.11]	[0.03]	[0.02]
Accounting Performance							
Industry Adjusted ROA	-0.933	-1.295	-1.444	-1.682	-1.831	-2.065	-3.623
	[1.68]	[12.01***]	[20.51***]	[20.76***]	[21.15***]	[20.97***]	[38.75***]
Industry Adjusted Sales Growth	-0.618	-0.439	-0.644	-0.505	-0.524	-0.751	-0.123
	[3.62*]	[3.48*]	[10.56***]	[7.33***]	[5.75**]	[9.16***]	[0.06]
Industry Adjusted Earning Management	-0.304	-0.156	-0.012	1.112	0.344	0.605	-0.107
	[0.10]	[0.05]	[0.00]	[4.81**]	[0.23]	[0.62]	[0.01]
Other Ratios							
Industry Adjusted Receivable Sales Ratio	1.672	0.570	-0.784	0.130	0.453	-0.047	-3.995
	[0.79]	[0.16]	[0.36]	[0.01]	[0.11]	[0.00]	[1.73]
Industry Adjusted Current Ratio	-0.019	0.039	0.035	0.017	0.039	0.025	0.064
	[0.14]	[2.71*]	[2.42]	[0.62]	[3.16*]	[0.83]	[6.01**]
Industry Adjusted Inventory Cost Ratio	4.320	3.200	3.154	3.096	3.241	3.342	3.670
	[22.54***]	[16.95***]	[14.41***]	[18.71***]	[17.06***]	[13.83***]	[8.86***]
Industry Adjusted Debt Ratio	0.447	0.818	0.688	0.672	0.724	0.516	0.195
	[1.11]	[7.92***]	[5.60**]	[5.73**]	[5.51**]	[2.00]	[0.14]
Age	-0.107	-0.094	-0.081	-0.084	-0.088	-0.087	-0.076
	[100.38***]	[127.07***]	[101.71***]	[120.52***]	[106.46***]	[88.48***]	[31.57***]
Log of Total Asset	0.040	-0.003	-0.053	-0.086	-0.033	0.037	-0.032
	[0.52]	[0.00]	[1.63]	[4.82**]	[0.59]	[0.65]	[0.23]
N	6,278	9,586	11,168	11,525	9,856	8,593	5,638

All independent variables are at year t-1 except SCA dummies which are always at year 0. Chi square statistics in brackets are provided. For space reason we proved results for t = -5, -2 to 2 and 5. Results for years -4, -3, 3 and 4 are available upon request. Year 0=Year of filing lawsuit.

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 4 Second-Stage Cox Proportional Hazard Regression of Forced CEO Turnover Market Adjusted Financial and Accounting Performance, Earning Management and Other Control Variables

	Year						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
SCA Dummy				1.248	0.659	-0.031	0.836
				[52.20***]	[8.78***]	[0.01]	[4.69**]
Financial Performance							
Industry Adjusted Return	-0.713	-0.809	-0.887	-0.888	-0.890	-1.033	-1.577
	[15.28***]	[31.61***]	[40.77***]	[44.40***]	[35.53***]	[38.86***]	[35.29***]
Market Adjusted Return in Bottom Decile Dummy	0.125	0.125	0.101	-0.189	-0.064	-0.464	-1.035
	[0.08]	[0.16]	[0.12]	[0.44]	[0.04]	[1.59]	[2.53]
Market Adjusted Momentum Loser Dummy	0.363	0.518	0.562	0.451	0.502	0.466	0.747
	[1.48]	[7.00***]	[9.93***]	[6.90***]	[7.83***]	[5.93**]	[9.34***]
Market Adjusted Momentum Winner Dummy	-0.050	-0.048	-0.306	-0.386	-0.196	-0.262	-0.608
	[0.04]	[0.06]	[1.84]	[3.38*]	[0.75]	[1.10]	[2.01]
Accounting Performance							
Market Adjusted ROA	-0.490	-1.035	-1.085	-1.155	-1.223	-1.489	-2.436
	[0.39]	[9.18***]	[11.58***]	[10.79***]	[11.76***]	[13.60***]	[23.97***]
Market Adjusted Sales Growth	-0.783	-0.520	-0.862	-0.428	-0.488	-0.606	0.436
	[4.67**]	[3.98**]	[10.50***]	[4.55**]	[3.79*]	[4.59**]	[1.18]
Industry Adjusted Earning Management	-0.072	-0.047	0.299	1.100	0.330	0.397	-1.003
	[0.01]	[0.00]	[0.21]	[4.24**]	[0.21]	[0.26]	[0.58]
Other Ratios							
Market Adjusted Receivable Sales Ratio	1.228	0.684	-1.218	0.152	0.709	0.575	-0.723
	[0.50]	[0.26]	[0.65]	[0.01]	[0.31]	[0.16]	[0.11]
Market Adjusted Current Ratio	-0.013	0.029	0.026	0.010	0.025	0.021	0.050
	[0.09]	[1.79]	[1.57]	[0.24]	[1.20]	[0.65]	[4.32**]
Market Adjusted Inventory Cost Ratio	3.335	1.903	2.236	1.981	2.076	1.917	1.103
	[20.27***]	[9.13***]	[12.29***]	[12.17***]	[11.60***]	[7.58***]	[1.05]
Market Adjusted Debt Ratio	0.184	0.653	0.618	0.696	0.821	0.626	0.624
	[0.21]	[6.17**]	[5.60**]	[7.63***]	[9.20***]	[3.94**]	[1.89]
Age	-0.110	-0.094	-0.082	-0.086	-0.090	-0.088	-0.074
	[103.44***]	[125.88***]	[102.43***]	[125.61***]	[110.45***]	[90.16***]	[29.85***]
Log of Total Asset	0.053	-0.001	-0.054	-0.097	-0.045	0.024	-0.065
	[0.84]	[0.00]	[1.68]	[5.83**]	[1.07]	[0.27]	[0.96]
N	6,278	9,586	11,168	11,525	9,856	8,593	5,638

All independent variables are at year t-1 except SCA dummies which are always at year 0. Chi square statistics in brackets are provided. For space reason we proved results for t = -5, -2 to 2 and 5. Results for years -4, -3, 3 and 4 are available upon request. Year 0=Year of filing lawsuit.

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 5 Logistic Regression of Forced CEO Turnover on Financial and Industry Adjusted Accounting Performance, Earning Management and Other Control Variables

	Year						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
SCA Dummy				0.704	0.361	0.032	0.363
				[56.21***]	[9.37***]	[0.04]	[3.49*]
Financial Performance							
Industry Adjusted Return	-0.849	-0.946	-0.981	-0.904	-0.926	-1.062	-1.809
	[19.22***]	[36.62***]	[41.17***]	[39.59***]	[33.77***]	[34.27***]	[32.46***]
Industry Adjusted Return in Bottom Decile Dummy	0.316	0.034	0.005	-0.114	-0.124	-0.463	-0.584
	[0.44]	[0.01]	[0.00]	[0.14]	[0.12]	[1.33]	[0.91]
Industry Adjusted Momentum Loser Dummy	0.077	0.389	0.524	0.341	0.504	0.532	0.734
	[0.05]	[2.75*]	[6.09**]	[2.80*]	[5.77**]	[5.77**]	[6.39**]
Industry Adjusted Momentum Winner Dummy	0.309	0.256	0.039	-0.153	0.034	0.017	-0.069
	[1.32]	[1.48]	[0.03]	[0.52]	[0.02]	[0.00]	[0.03]
Accounting Performance							
Industry Adjusted ROA	-0.651	-1.115	-1.240	-1.233	-1.195	-1.570	-2.407
	[0.59]	[6.25**]	[10.16***]	[9.41***]	[7.08***]	[9.54***]	[11.32***]
Industry Adjusted Sales Growth	-0.141	0.016	-0.337	-0.362	-0.318	-0.498	0.081
	[0.16]	[0.00]	[1.89]	[3.11*]	[1.59]	[3.05*]	[0.03]
Industry Adjusted Earning Management	0.381	0.438	0.585	1.323	0.627	1.088	0.760
	[0.16]	[0.39]	[0.75]	[5.35**]	[0.72]	[1.74]	[0.31]
Other Ratios							
Industry Adjusted Receivable Sales Ratio	1.697	0.077	-1.966	-0.452	-0.717	-1.396	-5.216
	[0.74]	[0.00]	[1.53]	[0.08]	[0.20]	[0.57]	[3.18*]
Industry Adjusted Current Ratio	-0.016	0.055	0.057	0.041	0.062	0.049	0.082
	[0.09]	[4.51**]	[5.75**]	[3.02*]	[6.08**]	[2.75*]	[5.97**]
Industry Adjusted Inventory Cost Ratio	3.464	2.205	2.160	2.348	2.261	2.632	2.308
	[10.64***]	[6.77***]	[6.20**]	[8.68***]	[6.68***]	[6.97***]	[2.72*]
Industry Adjusted Debt Ratio	0.572	0.907	0.708	0.728	0.799	0.533	0.368
	[1.45]	[7.60***]	[4.68**]	[5.53**]	[5.49**]	[1.90]	[0.46]
Age	-0.062	-0.050	-0.036	-0.038	-0.039	-0.035	-0.018
	[30.47***]	[32.63***]	[17.84***]	[21.84***]	[19.26***]	[13.11***]	[1.67]
Log of Total Asset	-0.021	-0.052	-0.094	-0.123	-0.062	0.006	-0.056
	[0.14]	[1.45]	[4.92**]	[9.40***]	[2.00]	[0.02]	[0.72]
Tenure	-0.041	-0.045	-0.035	-0.034	-0.033	-0.033	-0.022
	[6.37**]	[11.84***]	[8.67***]	[8.98***]	[6.89***]	[6.10**]	[1.61]
N	6,278	9,586	11,168	11,526	9,857	8,593	5,638

All independent variables are at year t-1 except SCA dummies which are always at year 0. Chi square statistics in brackets are provided. For space reason we proved results for t = -5, -2 to 2 and 5. Results for years -4, -3, 3 and 4 are available upon request. Year 0=Year of filing lawsuit.

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Appendix

Year	Year of SCA lawsuit filing date in the Stanford University Law School database is *year 0*. We study from years -5 to years +5, totally 11 years.
Forced Turnover Ratio	Number of forced CEO turnover in a year for that firm
Forced Turnover Dummy	Equals 1 if there is a forced CEO turnover in that year, otherwise 0.
Total Turnover Ratio	Number of total CEO turnover in a year for that firm. It equals the sum of forced turnover ratio and voluntary turnover ratio.
Total Turnover Dummy	Equals 1 if there is a CEO turnover (forced or voluntary) in that year, otherwise 0.
Voluntary Turnover Ratio	Number of voluntary CEO turnover in a year for that firm
Voluntary Turnover Dummy	Equals 1 if there is a voluntary CEO turnover in that year, otherwise 0.
SCA Dummy	Equals 1 if a firm has SCA lawsuit filing in that year, otherwise 0. A company is a SCA firm in a year if it has SCA lawsuit filing in that year.
Stock Return	Unadjusted annul stock return
Bottom Decile Dummy	Equals 1 if stock return in the bottom 1/10 of all stocks in CRSP in a year, otherwise 0
Momentum Loser Dummy	Equals 1 if stock return in the bottom 1/3 of all stocks in CRSP in both previous 1 and 2 years, otherwise 0
Momentum Winner Dummy	Equals 1 if stock return in the top 1/3 of all stocks in CRSP in both previous 1 and 2 years, otherwise 0
Earning Management	Absolute value of winsorized earnings management accrual, according to Hazarika, et al. (2012). Hazarika, et al. (2012) use 5^{th} and 95^{th} percentile to winsorize, we use the same percentiles throughout the paper for consistency.
Inventory COGS ratio	(Inventory/(Cost Of Goods Sold/365))/1000
Net income per employee	Winsorized Net Income Per Employee/1000[10]
Receivable to Sales ratio	(Account Receivable/(Sales/365))/1000
Debt Ratio	Total Liability/ Total Asset
ROA	Winsorized ROA[11]
ROE	Winsorized ROE[12]
Market-Adjusted Ratio	The ratio of the firm less the mean of the ratios of all firms in the CEO sample in that year. For example, Market Adjusted Stock Return = annual return of the stock in a year - mean of annual return of all firms in the CEO sample in the same year
Industry-Adjusted Stock Return and other measures	We compute industry-adjusted stock return and other measures based on Jenter and Kanaan (2015). We use GICS to classify stocks into industries as Gleason et al (2008) use GICS for industry classifications. Jenter and Kanaan (2015) has 48 industries, to be compatible, we use 6-digit GICS that has 73 industries from 1996 to 2015.

[10] In this study, we winsorize at 5% and 95%
[11] In this study, we winsorize at 5% and 95%
[12] In this study, we winsorize at 5% and 95%

Investment and financial illiteracy and behavioral biases in trading

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Abstract

Unlike most prior research focusing on examining how financial literacy affects people's decision-making processes, this paper analyzes the impacts of individuals' investment and financial illiteracy on retail investors' trading behaviors. Using the survey data of the *2021 National Financial Capability Study* and its subsequent *Investor Study*, this study highlights that the more incorrect answers investors get in the investment and financial literacy quizzes, the more likely they are to trade meme stocks and believe in beating the market. On the contrary, the more "don't know" option investors select in the quizzes, the less likely they are to have such trading behavior and belief. These effects are more pronounced in male than in female investors, and among retail investors younger than 75 years old (inclusive).

Not knowing too much about finance is by no means what the paper advocates for, however, it does work as a natural protective barrier for the retail investors who select "don't know" responses in the investment and financial literacy quizzes.

Key words: Investment and financial illiteracy, trading, behavioral bias

1. Introduction

Financial literacy has long been recognized as a crucial ability that enables us to make informed economic decisions throughout life. There is an extensive literature showing that people with higher levels of financial literacy realize better financial outcomes. Individuals equipped with financial knowledge and skills are able to manage personal finance well and achieve different life goals.

Most previous research focuses on testing the effects of financial literacy (measured by the number or percentage of correct answers one gets in a financial literacy quiz) on outcome variables. Few studies analyze the impacts of the opposite side of financial literacy, which consists of incorrect answers and "don't know" responses, on dependent variables. The research on financial or investment illiteracy is relatively scant. This paper aims to fill the gap by looking at how investment illiteracy affects investors' trading behavior and belief.

To the best of my knowledge, this study is among the pioneering work that tackles the problem from a different perspective, and it contributes to the literature by showing the effects of incorrect answers and "don't know" responses on investor's behavioral biases in trading. Instrumental variable estimates highlight that investors who give more incorrect answers are more likely to trade meme stocks and believe in beating the market. Those who choose more "don't know" responses are less likely to do so. These effects are more pronounced in male than in female investors, and in the group of people younger than 75 years old.

The paper develops as follows: Section I surveys the literature on financial literacy and investors' behavioral biases; Section II describes data and methodology; Section III reports the results of hypothesis testing; and Section IV concludes.

2. Literature review

In the 2020 OECD Recommendation on Financial Literacy, financial literacy is defined as "A combination of financial awareness, knowledge, skills, attitudes and behaviors necessary to make sound financial decisions and ultimately achieve individual financial wellbeing" (OECD, n.d., p.6).

When it comes to measuring financial literacy, there are two approaches researchers take: subjective and objective financial literacy. Subjective financial literacy can be derived by using people's ratings of their financial knowledge, while objective financial literacy is determined by the correct answers people get in financial literacy quizzes. Most financial literature use the objective measure rather than the subjective one, as people tend to overestimate their actual financial knowledge (Lusardi & Mitchell, 2014). The difference between subjective and objective financial literacy measures can be used as a proxy of overconfidence (Barber et al. 2019; Xia et al., 2014).

There is a rich literature showing positive impacts of financial literacy on individual's economic decision making. Bellofatto et al. (2018) use survey data and examine the relation between subjective financial literacy and trading. They show that investors with a higher level of self-reported financial literacy achieve higher gross and net returns and excess Sharpe ratios by trading a small set of stocks and simultaneously holding investment funds (Bellofatto et al., 2018). Using objective financial literacy measures, researchers find that financially savvy households plan and save for their retirements and accumulate greater amounts of wealth when they retire (Clark et al. 2016; Hilgert et al., 2003; Kotlikoff & Beinheim, 2001; Lusardi & Mitchell, 2007a, 2007b, 2011a, 2011b). People with higher levels of financial literacy are more likely to participate in stock markets (Bucher-Koenen et al., 2016; Kimball & Shumway, 2006; Rooij et al., 2011; Sivaramakrishnan et al., 2017). Sophisticated investors pay less fees (Jiang et.al, 2019; Müller & Weber, 2008) and achieve better financial outcomes by holding diversified portfolios (Abreu & Mendes, 2010; Chu et al., 2017; Gaudecker, 2014). Binachi (2017) shows that the portfolios held by the most financially literate households yield 0.4% higher return than those owned by the least literate ones. Financially literate investors actively rebalance their portfolios and keep risk exposures constant over time by switching to the funds that experienced lower return in the past (Binachi, 2017). Guiso & Viviano (2013) find that financially savvy investors are better at timing the market.

Financial literacy also plays an important role in influencing investors' behavioral biases. Ates et al. (2016)

analyze the survey data of individual investors in Turkey and show that financial literacy positively correlates with the biases of overoptimism, confirmation, and representativeness, and negatively associates with overconfidence, cognitive dissonance, framing, and loss aversion. Using the survey data of Indian investors, Baker et al. (2018) demonstrate that financial literacy negatively associates with disposition effect and herding bias, positively associates with mental accounting bias, and does not significantly correlate with overconfidence and emotional biases. Bellofatto et al. (2018) suggest that investors with a higher level of subjective financial literacy trade more and are less prone to the disposition effect. Rasool & Ullah (2020) indicate that the probability of financially savvy investors suffering from behavioral biases is low.

In terms of the relation between knowledge and confidence, May (1986) claims that incomplete and wrong knowledge leads to overconfidence. Lackner et al. (2023) analyze the data of four large surveys conducted in Europe and the United States over 30 years and find that people's overconfidence reaches the top at intermediate levels of actual scientific knowledge. Chen and Garand (2018) investigate the gender gap of financial literacy using incorrect and "don't know" responses and point out that compared to men, women are more likely to pick incorrect answers and select "don't know" options. Cucinelli and Soana (2023) examine how incorrect and "don't know" responses affect the likelihood of people becoming victims of financial frauds. They suggest that overconfident individuals are more likely to be deceived.

3. Data and Methodology

FINRA carries out an online survey of National Financial Capability Study (https://finrafoundation.org/sites/finrafoundation/files/NFCS-2021-State-by-State-Questionnaire.pdf) every three years. In this survey, it gathers peoples' demographic information, financial situations, and their responses to a financial literacy quiz. In total, 27,118 individuals participated in the 2021 state-by-state survey. There are six financial literacy quiz questions included in the survey, examining respondents' basic financial knowledge in inflation, risk diversification, and interest compounding etc. If respondents indicated in the state-by-state survey that they have non-retirement accounts and are responsible for making investment decisions, they were invited to a follow-up Investor Study (https://finrafoundation.org/sites/finrafoundation/files/NFCS-2021-Inv-Quest.pdf). Questions with a focus on investing are asked in the study and respondents need to take an investment literacy quiz which consists of 11 questions. These questions are more complicated than those asked in the financial literacy quiz, testing retail investors' advanced financial knowledge. The 2021 Investor Study, the main data set I use for this paper, consists of 2,824 adult observations. I also obtain several data points from the original state-by-state survey for robustness checks. All of the data in the National Financial Capability Study and its subsequent Investor Study are self-reported information. Throughout my study, an analytical weighting scheme is employed to ensure that the sample FINRA selected in each state is representative of the total population of the US.

A. Model

The main model used in this study is as follows:

$$\text{Dummy} = \alpha_0 + \alpha_1 \text{Investment illiteracy} + \alpha_2 \text{Controls} + \epsilon \quad (1)$$

For each of the scenarios described in part B Hypothesis testing, the dependent variable equals one if the respondent falls in the specific category, and zero otherwise.

The investment illiteracy has two categories: incorrect answers and "don't know" responses, measured by the ~~number of the corresponding responses in the~~ investment literacy quiz. Although the focus of this paper lies in investment illiteracy, the effects of investment literacy, measured by the number of correct answers, on the outcome variables are also provided as a benchmark for comparison purposes.

There are several explanations for why investors get incorrect answers. They may think that they know the financial concepts asked in the quiz, but in fact they don't, which is a signal of being overconfident in one's ability. Alternatively, investors do know that they don't fully understand the concepts, but still they would like to attempt the questions by making guesses rather than selecting the "don't know" option. If their guesses turn out to be wrong, they get incorrect answers. In this case, investors are considered to be bold and risk loving.

For the investors who pick "don't know" options, some of them do have no clues about the financial terms asked in the investment literacy quiz. However, others may have the financial knowledge, but they lack confidence and are hesitant to choose an answer in the quiz. Thus, they just select "don't know" options.

Having said that, identifying the motives behind the incorrect answers and "don't know" responses is not the main purpose of the paper, given that such granular information is unavailable and cannot be extracted from the data set used. Instead, this study quantifies investment illiteracy by counting how many questions investors get wrong and pick "don't know" for and investigates the relations between investment illiteracy and investors' behaviors and belief.

Regarding the control variables, there are seven demographic variables and one dummy showing whether investors would like to take substantial or above-average risks. The demographics include gender, ethnicity, marital status, age, education, portfolio value, and investment experience. All of these are binary variables, equaling one if the respondent falls in the specific category, and zero otherwise. The male dummy is set to one for men. For the two ethnicity groups of white and nonwhite, the white dummy is assigned the value of one if the person is white, and zero otherwise.

In terms of the martial status, those who are married are treated as dummy. There are three age groups: 18-34, 35-54 and 55+. Each of the first two groups is represented by a dummy variable in the regressions, while the age group of 55+ is treated as the base one. When it comes to the education level, the whole sample is divided into two categories: with college or above degrees vs. without college degrees. People without college degrees are set as the reference group. In terms of portfolio values, there are three levels: less than 50K, 50K-250K and 250K+. The dummy variable representing respondents with portfolio values less than 50K is left out. Three groups of investment experience are as follows: less than 2 years, between 2 and 10 years, and more than 10 years. The group of investors with less than 2 years experience is the base one.

B. Hypothesis testing

One aspect of investment and financial illiteracy is getting incorrect answers. There is ample research exploring why people make mistakes. Dunning et al. (2003) point out that there are two reasons behind: 1) people do not have the expertise to give correct answers; 2) they fail to recognize their incompetence, and their self assessment of how they perform is uncorrelated with their actual performance. Individual investors who produce incorrect responses either lack financial knowledge to get correct answers or overestimate their skills when attempting questions. Although their performance turns out to be poor, they believe that they do well.

Another aspect of investment and financial illiteracy is selecting "don't know" options. Confucius said 26 centuries ago: "Real knowledge is to know the extent of one's ignorance." There are two kinds of retail investors choosing "don't know" responses: 1) they know that they have no ideas of what the concepts asked in the quizzes; 2) they don't have too much confidence in the answers their would like to select, and pick "don't know" options instead. In the former case, it is human nature to avoid trying something people are uncertain about. In the latter scenario, Bucher-Koenen et al. (2021) show that compared to men, women lack confidence and are more likely to select "don't know" responses. However, women often choose correct answers when the "don't know" option is unavailable in the financial literacy quiz (Bucher-Koenen et al.,2021).

1.Trading meme stocks

The *2021 Investor Study* asks respondents whether they bought or sold shares of GameStop, AMC, or Blackberry in 2021. Individual investors who pick wrong answers in the investment literacy quiz might know a little bit of, rather than fully understood, these financially under performing stocks discussed on social media. They probably failed to calibrate the likelihood of making a profit before they traded such stocks. For those who choose "don't know", on the other hand, they are possibly afraid of meme stocks which they have no clues about, and prefer to stay away from such investments. Therefore, the following hypothesis is tested:

H1a*: Investors who give more incorrect answers are more likely to trade meme stocks, while those who select more "don't know" are less likely to do so.*

The dummy variable on the left-hand side of the regression equals one if the respondent traded meme stocks in 2021. The coefficient α_1 in model (1) is expected to be positive (negative) for those who give more incorrect answer ("don't know" responses).

The testing is first conducted in the full sample and then in the sub samples of male and female retail investors, respectively.

Given that the gender gap exists in financial literacy and men are more likely to take risks than women, the following hypothesis is tested:

H1b*: For male investors, the more incorrect answers ("don't know") they get, the more (less) likely they are to trade meme stocks. The effect is more pronounced in men than in women.*

2. Believing in beating the market

Holding a belief in beating the market is often considered to be a signal of overconfidence. Although a small number of sophisticated retail investors can outperform the market, the majority of them cannot achieve the goal in the long run (Barber & Odean, 2013). The *2021 Investor Study* asks respondents how well they expect their portfolio of investments to perform. There are five options available for investors to select: worse, about the same as, better than the market, don't know, and prefer not to say.

Investors who get incorrect answers probably overestimate their abilities to beat the market, while those choosing "don't know" responses either possibly know the boundary of their knowledge or do not have the confidence in themselves, when it comes to outperforming the market. Accordingly, the hypothesis below is tested:

H2a*: Investors who give more incorrect answers are more likely to believe in beating the market, while those who select more "don't know" are less likely to do so.*

The dummy variable on the left-hand side of the regression equals one if the respondent believes that he/she can beat the market. The coefficient α_1 in model (1) is expected to be positive (negative) for those who give more incorrect answer ("don't know" responses).

A testing on the full sample is performed first, followed by the sub samples testing for male and female retail investors.

H2b*: For male investors, the more incorrect answers ("don't know" responses) they get, the more (less) likely they are to believe in beating the market. The effect is more pronounced in men than in women.*

C. Endogeneity concern

A major concern about model (1) setup is the endogeneity issue. There may be omitted variables that affect both sides of the model. For example, "ability" is the unobserved variable, often thought to affect both the dependent variable and the main independent variables, i.e. the numbers of correct, incorrect, and "don't know" responses. Omitted variables would bias the OLS estimates upward. It is also possible that the model suffers from simultaneity bias. When investors participate in the activity denoted by the dummy variable on the l eft hand side of the model, they are likely to come across a broad range of financial knowledge which they are initially unfamiliar with but they will learn later either through self education or by other means. This may have impacts on the explanatory variable: peoples' financial literacy, measured by the number of correct answers they get. This process is often referred to the 'learning by doing' process. It is also likely that investors misinterpret or do not get the gist of the new financial concept they encounter, although they believe that they fully grasp it. In this case, the number of incorrect answers will be influenced by engaging in the event indicated by the dependent variable. Another possible scenario is that when investors trade, they are exposed to more financial terms they don't know. All of these scenarios affect the measures of the numbers of correct, incorrect, and "don't know" responses. Such potential reverse causalities bias the OLS estimates upward. In addition, the explanatory variables, i.e. the numbers of correct, incorrect, and "don't know" responses, may have measurement errors which bias the OLS estimates downward. Among all kinds of biases OLS estimates may have, the one caused by measurement errors dominates those caused by omitted variables or reverse causality. Therefore, the OLS estimates are expected to be smaller than the true parameters.

In order to mitigate the concerns on omitted variables, reverse causation, and measurement errors, an instrumental variable is used in the regression. Inspired by Card (1993) and Lusardi & Mitchell (2014), the variable showing whether investors have access to financial education either at school or in the workplace is selected as the instrument.

Since investors' access to financial education is related to the endogenous variable of investment literacy and illiteracy, the IV satisfies the relevance condition. On the other hand, whether investors have access to financial education does not directly affect the dependent variables examined in this paper, i.e. whether investors traded meme stocks in 2021 and whether investors believe in beating the market. Therefore, the IV also meets the requirement of being exogenous to the dependent variables. In summary, the IV, investors' access to financial education, satisfies both the relevance and exogeneity conditions.

For comparison purposes, a linear probability model is estimated first as the benchmark. Then, the coefficient obtained from the baseline model is compared to that derived from the 2SLS estimation to check whether the sign of investment illiteracy maintains and whether the new coefficient derived using the IV method is stronger, given that the OLS estimate is biased downward primarily by measurement errors. Furthermore, the F statistic will be checked against the typical criterion of 10 to make sure the IV is not a weak instrument.

D. Robustness checks

D.i. New measures

For robustness testing, I use the numbers of correct, incorrect, and "don't know" responses from the financial literacy quiz to measure investors' investment literacy and illiteracy instead.

Given that endogeneity concerns still exist in the model (1), the same IV, investors' access to financial education, is used to instrument the endogenous variable of financial literacy and illiteracy. Coefficients derived from the 2SLS regressions will be compared to their counterparts, i.e. the ones derived when the numbers of correct, incorrect, and "don't know" responses in the investment literacy quiz are used in the 2SLS estimations, to see whether the findings obtained before still hold.

D.ii. Exclusion of respondents older than 75 years old

Since cognitive decline comes with age, older individuals tend to experience a decrease in financial literacy (Gamble et al., 2015; Finke et al. 2017), leading to negative financial outcomes (Angrisani & Lee, 2019). From the perspective of asset allocation, senior citizens, especially those close to or already in retirement, should lower the proportion of stocks in their investment portfolios. Therefore, the majority of stock market participants are the ones with relatively younger ages.

From the summary statistics in Table I, it is noted that 64% of the survey participants are older than 55 years old. A closer look at this group of people reveals that 268 out of the total 2,824 respondents are above 75 years old. A robustness check is performed by excluding the respondents older than 75 years old, making the sample size shrink to 2,568.

The measures of the key explanatory variables used are the number of correct, incorrect, and "don't know" responses from the investment literacy quiz. Both ***H1 & H2*** are tested in the sub sample of individuals younger than 75 years old (inclusive) using 2SLS regressions. The corresponding results can be compared to those obtained using the same measures in the full sample testing to check if the preliminary effects observed are still valid, and whether they become even more pronounced for retail investors younger than 75 years old (inclusive).

4.Results

A. Descriptive Statistics

1. Explanatory variables

There are four categories of responses in the investment literacy quiz: correct, incorrect, don't know, and prefer not to say. As shown in Table I, the average number of correct, incorrect, "don't know", and "prefer not to say" responses are 5.10, 3.21, 2.12, and 0.07 out of 11 investment quiz questions, respectively. The respondents examined by this study are those who have brokerage accounts in addition to their retirement accounts. Although they get 2.39 questions correct out of the Big 3 which test individuals' basic financial knowledge, their investment literacy is low: they answer correctly only 46.4% of the 11 investment literacy quiz questions. Since the sum of the average numbers of incorrect and "don't know" responses is greater than the mean of correct answers, this suggests that the opposite side of investment literacy cannot be overlooked. Examining the impacts of incorrect answers and "don't know" responses, rather than focusing on correct answers, provides different angles on behavioral biases. Given that the mean of "prefer not to say" responses is less than 0.1 out of 11 investment quiz questions and such response does not reveal much information on either sides of investment literacy, this category is not within the scope of discussion in the paper.

Among the total 2,824 survey respondents, the demographics are as follows: 61% men, 72% white, 66% married, 12% aged 18-34, 25% aged 35-54, 64% aged more than 55, 56% college educated or above , 29% with a portfolio value below $50,000, 29% with a portfolio value of $50,000-$250,000, and 41% with a portfolio value of more than $250,000, 13% with less than 2 years investment experience, 20% with investment experience between 2-10 years, and 66% with more than 10 years investment experience.

When it comes to investors' risk appetite, 35% of the respondents are willing to take substantial or above-average financial risks.

The instrument variable used in this paper is an dummy variable indicative of whether investors were exposed to financial education offered by their schools or employers. The binary variable has a mean of 0.35, suggesting that 35% of the respondents in the *2021 Investor Study* had access to financial education before.

2. Dependent variables

In terms of the descriptive statistics of the dependent variables shown in Table I , 13% traded meme stocks in 2021 and 26% believe that they could beat the market among all 2,824 retail investors surveyed.

3. Correct, incorrect, and "don't know" responses across demographics[1]

The distributions of correct answers demonstrates that, at the 5% level, male, white, people aged 55+, those with a Bachelor's degree or higher and individuals with incomes more than $100K, on average, get more correct answers than their counterparts, respectively. A close look at the distributions of correct answers for males vs. females suggests that the percentages of men falling in each quartile of the number of correct responses are more or less the same, while there are more women in the first quartile than in the last one. When it comes to ethnicity, the distributions of correct answers for white and nonwhite are relatively even. With regards to age, for those in the age groups of 18-34 and 35-54, the distributions of correct answers are decreasing. For those aged 55+, however, there is an even distribution of correct responses across four quartiles. Similarly, within-group heterogeneities are also observed in the distributions of correct answers across education and income level. For those without a college degree, more people cluster in the first quartile than the subsequent ones, while for those with a college or higher degree, the number of correct answers follows a quasi-uniform distribution. Comparisons of distributions in three different income groups indicate that for those with an income level less than $50K or $50K-$100K, fewer people score high in the investment literacy quiz. On the contrary, the scores of those making more than $100K a year are evenly distributed.

[1] For the sake of space, tables for this part are omitted in the paper. However, they are available upon request.

When it comes to the distributions of incorrect answers across demographics, at the 5% level, investors that are white, aged 55+, with a Bachelor's degree or higher and incomes more than $100K get fewer incorrect answers, on average, than their counterparts, respectively. However, the average numbers of incorrect answers men and women get are indistinguishable given that the p value of the mean equality test is greater than 5%, unlike what happens when comparing the numbers of correct answers by gender in which men score significantly higher than women. Both distributions of incorrect answers for men and women have two peaks in the second and the fourth quartile. Bimodal distributions of incorrect answers are also seen for other demographic groups. Having said that, the highest percentages of investors within each subgroups appear in the fourth quartile of incorrect answers. The dynamics in the last quartiles of age, education and income suggest that as individuals age, receive higher education and earn more incomes, they get fewer incorrect answers in the investment literacy quiz.

The distribution of "don't know" responses across the same demographic variables shows that at the 5% level, investors that are males, aged 18-34, with a Bachelor's degree or higher, or make incomes more than $100K choose fewer "don't know" responses than their counterparts, respectively. Although the average number of "don't know" nonwhite selects is lower than that white picks, the difference is significant at the 10% level. The distribution for men has two peaks that are in the first and the third quartile, respectively. Instead, the distribution for women is increasing with much more respondents in the last two quartiles than in the first two ones. The percentage of women in the highest quartile of "don't know" responses is more than twice that of men, consistent with the finding of prior literature: women are more likely to indicate that they don't know (Lusardi & Mitchell, 2014). With respect to ethnicity, the "don't know" responses distribute evenly for white, while the responses decline modestly for nonwhite. There is a quasi-uniform distribution for people in the age group of 55+, but the distributions for individuals in the age groups of 18-34 and 35-54 are both decreasing with more (fewer) younger people in the first (fourth) quartile of "don't know" than older ones. The distribution for those without a college degree is almost constant. In contrast, the distribution for the people with a Bachelor's degree or higher drops gradually, which suggests that investors receiving a higher level of education are less likely to select "don't know". Last but not least, for people making less than $50K or $50K-100K a year, the numbers of "don't know" they choose follow a quasi-uniform distribution. For those earning more than $100K, however, the percentage of respondents picking the "don't know" option falls as the number of "don't know" increases, which demonstrates that as people make more money, they are less likely to select the "don't know" response.

4. Consecutive incorrect and "don't know" responses

In order to alleviate the concerns that respondents did not take the investment literacy quiz seriously and picked answers at random, the probabilities of them having consecutive four or more incorrect and "don't know" responses are computed to check whether such investors, if exist, are a small group of people. As Table IIA points out that 12% of respondents got four consecutive incorrect answers out of 11 questions. This proportion decreases to 6% if someone incorrectly answered five questions in a row. Only 2% of the respondents got six or seven consecutive incorrect answers. No one had more than 7 back-to-back incorrect answers.

For the consecutive "don't know" responses displayed in Table IIB, 13% of the respondents selected four straight "don't know" options, 8% picked five, and 6% chose six in sequence. The percentages of individuals with a streak of seven or more "don't know" drop to 3% and even lower levels.

Taking into account both scenarios in which investors had six or more (i.e. more than half of the 11 quiz questions) consecutive incorrect or "don't know" responses, the proportion of respondents not making efforts in taking the investment literacy quiz is less than 6%, relieving the worry that the incorrect and "don't know" choices contain unwanted noises.

B. Regression Analyses

1. Trading meme stocks

According to the *2021 Investor Study*, 310 out of 2,824 survey respondents traded meme stocks in 2021. The results of hypothesis testing for ***H1*** in the full sample are discussed first, followed by the analyses in the sub samples of male vs. female investors. The purpose of running OLS baseline regressions is to provide a big picture

of the relations between investment illiteracy and trading meme stocks before 2SLS estimates are introduced to address the endogeneity concerns about the model specification.

1.1 Full sample testing

Using the full sample of 2,824 retail investors, the testing of the impacts of investment illiteracy, together with the correct answers as the benchmark for comparison purposes, on trading meme stocks are performed and presented in Table IV.

OLS regressions

At the 1% level, the first OLS estimation result in Table IV shows that the coefficient -0.004 of investment literacy measured by the number of correct answers is statistically insignificant. However, when the explanatory variable is replaced by investment illiteracy, quantified respectively by the number of incorrect answers and the number of "don't know" responses, the coefficients turn significant. As the third OLS regression demonstrates, every one additional incorrect answer investors get, on average, is associated with 2.5% points higher in the probability of them trading meme stocks in 2021. Alternatively, a one standard deviation increase in the number of incorrect answers is correlated with 5.6% points higher for investors to trade meme stocks. On the contrary, the OLS regression in the fifth column reveals that the number of "don't know" responses is negatively correlated with the probability of trading meme stocks. Every one additional "don't know" response investors select is associated with 1.32% points lower in the probability of them trading meme stocks. In other words, a one standard deviation increase in the number of "don't know" responses is correlated with 3.52% points lower for investors to trade meme stocks.

In terms of the demographic variables in column (1), (3), & (5), the coefficients for the dummies of male, married, willingness to take risks, aged 18-34, aged 35-54, and portfolio value 50K-250K are all positively significant, while the ones for the dummy variables of investment experience 2-10 years and more than 10 years are both negatively significant across the three OLS regressions. These relations reveal that investors that are males, married, willing to take risks, younger than 55 years old, have portfolio values between 50K-250K, or with less than 2 years of investment experience are more likely to trade meme stocks, holding other variables constant.

2SLS estimations

Given that there is an endogeneity issue involved in the model (1) specification, an instrumental variable of investors' access to financial education is employed in the 2SLS estimation. This IV relates to the endogenous variables of investment literacy (measured by the number of correct answers) and illiteracy (measured by the number of incorrect answers and that of "don't know" responses), thus it satisfies the relevance condition. It does not, however, directly affect the dependent variable, i.e. whether investors traded meme stocks in 2021.

Table III reports the results from the first stage regressions in which the endogenous variables (i.e. the numbers of correct, incorrect, and "don't know") are regressed on the IV, together with control variables. All of the coefficients of the IV in the first stage regressions are statistically significant at the 1% level, confirming that the exposure to financial education positively correlates with the number of correct and that of incorrect answers, and negatively associates with the number of "don't know" responses. The F statistics of the three first stage regressions are greater than 10: 41.83, 25.41, & 36.24, satisfying the typical rule of thumb when using IVs. Thus, a weak IV is less of a concern in this study.

Since the same IV is used in the testing of the second hypothesis on investors' beliefs in beating the market, the results from the first stage regressions are the same. Discussions about the IV is skipped in the relevant parts for the sake of space.

Compared to the linear probability models, i.e. regression (1), (3), & (5), used in Table IV, 2SLS regressions in column (2), (4), & (6) produce corresponding estimates with a bigger magnitude as expected. Consistent with the OLS result in column (1), the 2SLS estimate 0.158 of the impact of investment literacy on the behavioral bias in column (2) is also insignificant. In contrast, significant results at the 1% level are obtained in column (4) & (6)

respectively when regressing the dummy of trading meme stocks on the number of incorrect answers and that of "don't know" responses, both instrumented by the access to financial education, with other control variables. The 2SLS result reported in column (4) confirms that there is a positive causal relationship between the number of incorrect answers and the dependent variable. Every one additional incorrect answer investors get leads to 6.8% points increase in the probability of investors trading meme stocks, which means a one standard deviation increase in incorrect answers causes the dependent variable to go up by 15.23% points. Unlike the positive relation derived for the incorrect answers, the 2SLS estimate for the "don't know" responses in column (6) suggests a negative causal relationship between the explanatory and the dependent variables. Every one additional "don't know" response investors pick results in 5.16% points decrease in the probability of investors trading meme stocks. Equivalently, a one standard deviation increase in "don't know" responses brings down the dependent variable by 13.78% points.

Among control variables, the coefficients for the people aged 18-34 are positively significant at the 1% level across 2SLS regressions (2), (4), & (6), suggesting that younger investors are more likely to trade meme stocks. Another two consistently significant demographic variables, at the 10% level, are investment experience 2-10 years and more than 10 years. Holding other variables constant, individuals with less than two years of investment experience are more likely to trade meme stocks than their counterparts.

In sum, there is no evidence showing that investment literacy, measured by the number of correct answers, meaningfully impacts meme stock trading. However, investment illiteracy, measured by the number of incorrect answers and that of "don't know", significantly influences the dependent variable. Their effects are in opposite directions. The more incorrect answers investors get, the more likely they are to trade meme stocks. By contrast, the more "don't know" investors choose, the less likely they are to trade meme stocks.

1.2 Sub sample testing

According to prior literature, a gender gap exists in investment literacy. In order to examine whether men exhibit different behaviors from women, the same 2SLS testing is conducted in the two sub samples for male and female investors. There are 1,714 male and 1,110 female investors in each data set. Table V reports similar findings when the investment literacy is used as the main explanatory variable in the first two columns. There is no significant impact of the number of correct answers on trading meme stocks for both men and women. When it comes to the incorrect answers in column (3) & (4), its coefficient is positively significant at the 5% level in the male sample but insignificant in the women group. Every one more incorrect answer male investors get results in 8.47% points higher in the probability of them trading meme stocks. Therefore, a one standard deviation increase in the incorrect answers boost the dependent variable by 18.97% points for men. When comparing the impacts of "don't know" responses on trading meme stocks between men and women, in column (5) the coefficient is negatively significant at the 5% level for men, while in column (6) it is insignificant for women. Every one extra "don't know" response male investors choose decreases the probability of them trading meme stocks by 7.62% points. Correspondingly, a one standard deviation increase in the "don't know" responses for males lowers the dependent variable by 20.35% points.

For the subgroup of men shown in column (3) & (5), the coefficients of the age groups of 18-34 and 35-54 are both positively significant, while those for investment experience 2-10 years and more than 10 years are both negatively significant at the 10% level. This suggests that male investors who are younger and have less investment experience are more likely to trade meme stocks than their counterparts, controlling for other demographic variables.

For the subgroup of women displayed in column (4) & (6), investors who are willing to take risks or aged between 18-34 are more likely to trade meme stocks.

Overall, instrumental variable estimates highlight that investors who give more incorrect answers are more likely to trade meme stocks. Those who select more "don't know" responses are less likely to do so. These effects are more pronounced in male than in female investors.

2. Believing in beating the market

Among 2,824 retail investors, 734 of them believe that their portfolio would perform better than the market as a whole.

2.1 Full sample testing

Similar to the hypothesis testing for ***H1***, a full sample testing is conducted before moving onto the sub samples of men vs. women to explore the gender differences.

OLS regressions

When the dummy variable of believing in beating the market is regressed on the numbers of correct, incorrect, and "don't know" responses along with control variables, the OLS regressions in Table VI produce significant coefficients for the main explanatory variables at the 5% level, respectively. As the first column shows, every one additional correct answer investors get is associated with 0.76% points decrease in the probability of them holding such belief, which means a one standard deviation increase in the number of correct answers lowers the dependent variable by 2% points. This suggests that financially savvy investors are less likely to become overconfident in their performances against the market indexes. On the contrary, column (3) indicates that the probability of investors believing in beating the market increases by 2.59% points for every one additional incorrect answer they have. In other words, the dependent variable increases by 5.80% points for a one standard deviation increase in the number of incorrect answers. When it comes to the impact of "don't know" responses on the behavioral bias, column (5) shows that the dependent variable decreases 0.99% points for every one additional "don't know" response. Thus, the probability of investors believing in the beating the market goes down by 2.64% points for a one standard deviation increase in "don't know" responses.

In short, the more correct answers and "don't know" responses investors have, the less likely they are to believe in beating the market. However, the more incorrect answers they get, the more likely they are to hold such belief.

The OLS regressions in column (1), (3), & (5) also reveal that investors that are males, willingness to take risks, with portfolio values more than 250K, or with less than 2 years of investment experience are more likely to believe in beating the market.

2SLS estimations

In order to address the endogeneity issue in the model, 2SLS regressions are introduced and displayed side by side along the OLS regressions in Table VI. The same IV, investors' access to financial education, is used in the 2SLS estimation given that it satisfies both the relevance and exogeneity requirements. The second stage regressions establish a causal relationship between the endogenous variables of the numbers of correct, incorrect, and "don't know" responses and the dependent variable respectively.

According to the results demonstrated in column (2), the coefficient for the number of correct answers is insignificant when the dummy of believing in beating the market is regressed on the main explanatory variable and other controls, similar to the finding when testing the relation between the number of correct answers and trading meme stocks. With respect to the incorrect answers, column (4) shows a positively significant relation instead. As expected, the magnitude of the coefficient for the number of incorrect answers is bigger than that of the OLS estimate. Every one additional incorrect answer investors get increases the probability of them believing in beating the market by 7.52% points. In other words, a one standard deviation increase in the explanatory variable leads to 16.84% points higher in the dependent variable. When it comes to the "don't know" responses in column (6), the relation turns negatively significant. Again, the 2SLS estimate is greater than the corresponding OLS one in the absolute value term. Every one additional "don't know" response investors select lowers the dependent variable by 5.70% points, which translates to a one standard deviation increase in the "don't know" response causing the dependent variable to decline by 15.22% points.

In addition, the 2SLS regressions in column (4) & (6) for the investment illiteracy suggest that investors who are willing to take risks, with portfolio values more than 250K, or with less than two years of investment experience are more likely to hold a belief in themselves outperforming the market.

Overall, the 2SLS estimates confirm that investors with a higher number of incorrect answers are more likely to believe in beating the market, while those with a larger number of "don't know" responses are less likely to hold such belief. There is no significant effect of the number of correct answers on the dependent variable.

2.2 Sub sample testing

Table VII compares men vs. women and reports the 2SLS estimates for the impacts of investors' performances in the investment literacy quiz on their belief in beating the market. Consistent with the finding in the OLS estimation, the 2SLS estimates in column (1) & (2) are both insignificant for men and women when the main explanatory variable used is the number of correct answers. The coefficient for the number of incorrect answers, however, is statistically positive for men but insignificant for women. Column (3) shows that every one more incorrect answer male investors get increases the probability of them believing in beating the market by 7.45% points, which means a one standard deviation increase in the number of incorrect answers makes the dependent variable higher by 16.69% points for men. In terms of the "don't know" responses, neither of the coefficients in column (5) & (6) are significant for men and women.

Moreover, column (3) & (5) reveal that male investors that are willing to take risks, with portfolio values more than 250K, or with less than two years of investment experience are more likely to believe in beating the market. According to column (4) & (6), women investors that are willing to take risks are also likely to hold such belief.

In short, the more incorrect answers male investors get, the more likely they are to believe in beating the market. There is no evidence showing that female investors suffer from this behavioral bias. Also, the relation between the number of "don't know" and holding such belief is insignificant in the sub samples of both men and women.

C. Robustness tests[2]

In order to check whether the findings documented above still hold, the first strategy I adopt in robustness check is to use the numbers of correct, incorrect, and "don't know" responses investors have in the financial literacy quiz as the main explanatory variables, and re run the 2SLS regressions in the full sample first, before moving onto the sub samples of men and women.

Another robustness test performed in this section is to re run 2SLS regressions on the sub sample of retail investors younger than 75 years old (inclusive). The key explanatory variables used here are the same measures as those used in the preliminary testing: the numbers of correct, incorrect, and "don't know" responses in the investment literacy quiz.

As Table I displays, the average numbers of correct, incorrect, "don't know" and "prefer not to say" responses out of six questions asked in the financial literacy quiz are as follows: 4.17, 0.92, 0.74, and 0.03. The sum of incorrect answers and "don't know" responses equals 1.66, taking up 27.67% of the total number of quiz questions. This proportion cannot be ignored, and it also justifies the usage of financial illiteracy rather than the conventional financial literacy in regression analyses. The number of the "prefer not to say" responses is not included in the testing, since it is trivial and does not provide much information.

Given the endogeneity concerns on the model setup, the same IV, i.e. investors' exposure to financial education, is used to instrument the measures of financial illiteracy. The baseline regression examining the relation between financial literacy, measured by the number of correct answers, and behavioral biases is presented for comparison purposes.

1. Trading meme stocks

The dependent variable is the same dummy used before with the average of 0.13 and standard deviation 0.31.

Full sample testing

The 2SLS estimate for the number of correct answers is insignificant, which suggests that being financially literate can hardly explain how likely one traded meme stocks. In contrast, the coefficient for the number of incorrect answers ("don't know" responses) is positively (negatively) significant at the 5% level, consistent with the previous findings when the corresponding measures from the investment literacy quiz are used. The probability of investors trading

[2] For the sake of space, tables for this part are omitted in the paper. However, they are available upon request.

meme stocks increases 16.4% (17.55%) points for every one additional unit (a one standard deviation increase in the number) of incorrect answers investors get in the financial literacy quiz. On the other hand, the dependent variable decreases 13.4% (15.68%) points for every one additional unit (a one standard deviation increase in the number) of "don't know" responses investors choose.

In addition, other significant control variables indicate that investors that are younger than 55 years old, willing to take risks, or with portfolio values between 50K-250K are more likely to trade meme stocks, but those with more than 10 years of investment experience are less likely to do so.

Sub sample testing-men vs. women

When the 2SLS regressions are run in the sub samples of men and women, the findings in the full sample still hold. The coefficients for the number of correct answers for both male and female investors remain insignificant, as expected. Therefore, investors' financial literacy has no significant impact on the probability of them trading meme stocks. When it comes to the number of incorrect answers, the coefficient for men is positively significant at the 5% level, but it is insignificant for women. The probability of men trading meme stocks increases 19.9% (21.29%) points for one more (standard deviation increase in the number of) incorrect answer they get in the financial literacy quiz. The number of "don't know" responses has a negative effect on the dependent variable for men at the 5% level, but no significant impact is noted for women. The probability of men trading meme stocks decreases 25.4% (29.72%) points for one more (standard deviation increase in the number of) "don't know" response they pick.

The significant control variables for men reveal that male investors that are younger than 55 years old or willing to take risks are more likely to trade meme stocks, but those with more than 10 years of investment experience are less likely to do so. For women, they are more likely to trade meme stocks if they are willing to take risks, holding other variables constant.

In conclusion, the more incorrect answers ("don't know" responses) male investors get, the more (less) likely they are to trade meme stocks. There is no significant finding between financial illiteracy and the behavioral bias for female investors.

Sub sample testing-investors younger than 75 years old (inclusive)

When individuals older than 75 years old are excluded from the full sample, the 2SLS regressions produce findings consistent with those in column (2), (4), & (6) of Table IV. It is noted that the magnitudes of the α_1 coefficients for the numbers of correct, incorrect, and "don't know" responses are all greater than those obtained in the full sample testing, suggesting that the effects observed before are more pronounced for retail investors younger than 75 years old (inclusive). This finding is not surprising, as people aged more than 75 years old are less likely to be active participants in the stock market due to their increasing risk aversion and cognitive decline associated with aging.

In terms of control variables, people with willingness to take substantial risks or aged 18-34 are more likely to trade meme stocks and to believe in beating the market, while those with more than 2 years investment experience are less likely to do so or to hold such an ambitious belief.

2. Believing in beating the market

The same dummy variable for investors who believe in beating the market is used as the dependent variable. The weighted mean of the dummy is 0.26 and standard deviation 0.43.

Full sample testing

The 2SLS tests report consistent findings as before. The coefficient for the number of correct answers is still insignificant in explaining the variations in the dependent variable. On the contrary, there is a positive (negative) relation at the 10% level of significance between the number of incorrect answers ("don't know" responses) and dependent variable. Every one unit increase in the number of incorrect answers ("don't know" responses) leads to 18.2% points higher (14.9% lower) in the probability of investors believing in beating the market. In other words, the dependent variable goes up 19.47% (down 17.43%) points for a one standard deviation increase in the number of incorrect answers ("don't know" responses) investors get in the financial literacy quiz.

Investors that are willing to take risks, with portfolio values more than 250K, or with investment experience less

than two years are more likely to exhibit such behavioral bias.

Sub sample testing-men vs. women

The 2SLS estimates for men and women are similar to those derived above. The number of correct answers is again insignificant for both male and female investors. Financial literacy fails to explain how investors' belief in beating the market would change. The number of incorrect answers ("don't know" responses), however, does have a positive (negative) relation with the dependent variable for men at the 10% level. But these effects are insignificant for women. The probability of men believing in beating the market increases 17.5% (decreases 22.4%) points for every one additional unit increase in the number of incorrect answers ("don't know" responses). This means that the dependent variable will be 18.73% points higher (26.21% points lower) if there is a one standard deviation increase in the number of incorrect answers ("don't know" responses).

For men, they are more likely to become overconfident if they are willing to take risks, with portfolio values more than 250K, or with less than two years of investment experience. For women, they are more likely to hold a belief in outperforming the market if they are willing to take risks, with other variables unchanged.

Sub sample testing-investors younger than 75 years old

Previous findings hold, when it comes to the testing of beating the market belief. The probability of individuals believing in beating the market increases by 9.27% points for each additional question they get wrong in the investment literacy quiz. However, this probability goes down by 7.38% points if investors pick an additional "don't know" response. The magnitudes of the α_1 coefficients are both greater than those derived in the preliminary testing, suggesting that the effects are more pronounced among investors younger than 75 years old.

It is also noted that respondents who are willing to take risks or those with portfolio values above $250K are more likely to have such a belief. In contrast, people with investment experience between 2 and 10 years are less likely to think so.

Overall, the robustness checks conducted above confirm that all the causal relations tested so far hold between investment/financial illiteracy and investors' behavioral biases in trading.

5. Concluding remarks

Unlike most prior research using financial literacy to examine how it affects respondents' decision making, this study is the first one that assesses the impacts of investment illiteracy, measured by the numbers of incorrect answers and "don't know" responses, on individuals' behavioral biases in trading. It contributes to the literature by highlighting that investors who give more incorrect answers are more likely to trade meme stocks and believe in beating the market. Those who select more "don't know" responses are less likely to do so. These effects are more pronounced in male than in female investors, and among individuals younger than 75 years old.

Although not knowing too much about finance works as a natural preventive barrier for investors who choose "don't know" responses, this paper encourages people to learn more about finance and become financially savvy in order to make wise decisions throughout life.

My results could shed light on designing and implementing financial education programs in the future. The objectives of effective training programs should not be limited to only improving people's financial knowledge. Making individuals aware of their behavioral biases and helping them come up with solutions to alleviate such biases are equally important.

Table I: Summary statistics (weighted)

	N	Mean	SD	Min	Max
Explanatory variables					
Investment literacy quiz					
Correct answers	2824	5.10	2.64	0	11
Incorrect answers	2824	3.21	2.24	0	10
Don't know	2824	2.12	2.67	0	11
Prefer not to say	2824	0.07	0.65	0	11
Financial literacy quiz					
Big 3	2824	2.39	0.88	0	3
Correct answers	2824	4.17	1.49	0	6
Incorrect answers	2824	0.92	1.07	0	6
Don't know	2824	0.74	1.17	0	6
Prefer not to say	2824	0.03	0.26	0	6
Demographics					
Male (Dummy)	2824	0.61	0.49	0	1
White (Dummy)	2824	0.72	0.40	0	1
Married (Dummy)	2824	0.66	0.47	0	1
Aged 18-34 (Dummy)	2824	0.12	0.31	0	1
Aged 35-54 (Dummy)	2824	0.25	0.44	0	1
Aged more than 55 (Dummy)	2824	0.64	0.48	0	1
College and or above (Dummy)	2824	0.56	0.49	0	1
Portfolio value below 50K (Dummy)	2824	0.29	0.45	0	1
Portfolio value between 50K-250K (Dummy)	2824	0.29	0.46	0	1
Portfolio value more than 250K (Dummy)	2824	0.41	0.49	0	1
Investment experience less than 2 years (Dummy)	2824	0.13	0.34	0	1
Investment experience 2-10 years (Dummy)	2824	0.20	0.40	0	1
Investment experience more than 10 years (Dummy)	2824	0.66	0.47	0	1
Risk appetite					
Willingness to take above average risks (Dummy)	2824	0.35	0.48	0	1
Instrumental variable					
Access to financial education (Dummy)	2824	0.35	0.48	0	1
Dependent Variables					
Dummy=1 for investors who bought or sold shares of GameStop, AMC, or Blackberry in 2021	2824	0.13	0.31	0	1
Dummy=1 for investors who believe that they could beat the market	2824	0.26	0.43	0	1

Table IIA: Consecutive incorrect answers

	N	Mean	SD	Min	Max
4 incorrect answers in a row (Dummy)	2824	0.12	0.33	0	1
5 incorrect answers in a row (Dummy)	2824	0.06	0.23	0	1
6 incorrect answers in a row (Dummy)	2824	0.02	0.15	0	1
7 incorrect answers in a row (Dummy)	2824	0.02	0.13	0	1
8 incorrect answers in a row (Dummy)	2824	0.00	0.03	0	1
9 incorrect answers in a row (Dummy)	2824	0.00	0.03	0	1
10 incorrect answers in a row (Dummy)	2824	0.00	0.03	0	1
11 incorrect answers in a row (Dummy)	2824	0.00	0.00	0	0

Table IIB: Consecutive “don’t know” responses

	N	Mean	SD	Min	Max
4 “don’t know” in a row (Dummy)	2824	0.13	0.33	0	1
5 “don’t know” in a row (Dummy)	2824	0.08	0.27	0	1
6 “don’t know” in a row (Dummy)	2824	0.06	0.23	0	1
7 “don’t know” in a row (Dummy)	2824	0.03	0.16	0	1
8 “don’t know” in a row (Dummy)	2824	0.02	0.13	0	1
9 “don’t know” in a row (Dummy)	2824	0.01	0.12	0	1
10 “don’t know” in a row (Dummy)	2824	0.01	0.11	0	1
11 “don’t know” in a row (Dummy)	2824	0.01	0.10	0	1

Table III: First stage regressions

	(1) (No. of correct)	(2) (No. of incorrect)	(3) (No. of "don't know")
Access to financial education (IV)	0.233**	0.542***	−0.714***
	(0.112)	(0.101)	(0.116)
Male	1.504***	−0.314***	−1.122***
	(0.112)	(0.101)	(0.121)
White	0.033	−0.316**	0.266**
	(0.135)	(0.126)	(0.134)
Married	0.049	0.112	−0.177
	(0.114)	(0.101)	(0.125)
Willing to take risks	0.556***	0.523***	−1.076***
	(0.118)	(0.108)	(0.118)
Aged 18-34	−0.484**	0.872***	−0.500**
	(0.217)	(0.208)	(0.233)
Aged 35-54	−0.578***	0.704***	−0.219
	(0.143)	(0.130)	(0.138)
College or above	0.738***	−0.359***	−0.341***
	(0.111)	(0.101)	(0.117)
Portfolio value 50K-250K	0.172	0.457***	−0.645***
	(0.143)	(0.132)	(0.148)
Portfolio value > 250K	0.316**	0.124	−0.497***
	(0.149)	(0.133)	(0.151)
Investment experience 2-10 years	0.365**	0.046	−0.392*
	(0.185)	(0.202)	(0.214)
Investment experience > 10 years	1.274***	−0.808***	−0.508**
	(0.192)	(0.200)	(0.216)
Constant	2.535***	3.451***	4.972***
	(0.222)	(0.225)	(0.257)
Observations	2824	2824	2824
F statics	41.83	25.41	36.24

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table IV: Estimates of the impacts of incorrect and "don't know" responses on trading meme stocks

	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS
No. of correct answers	-0.00400	0.158				
	(0.00307)	(0.104)				
No. of incorrect answers			0.0250***	0.0680**		
			(0.00392)	(0.0284)		
No. of "don't know"					-0.0132***	-0.0516**
					(0.00255)	(0.0221)
Male	0.0619***	-0.183	0.0631***	0.0756***	0.0407***	-0.00354
	(0.0152)	(0.161)	(0.0138)	(0.0163)	(0.0146)	(0.0301)
White	-0.0265	-0.0311	-0.0184	-0.00444	-0.0229	-0.0122
	(0.0195)	(0.0294)	(0.0193)	(0.0229)	(0.0193)	(0.0211)
Married	0.0309**	0.0212	0.0273*	0.0214	0.0279*	0.0199
	(0.0148)	(0.0236)	(0.0146)	(0.0160)	(0.0147)	(0.0160)
Willingness to take risks	0.132***	0.0381	0.115***	0.0904***	0.114***	0.0706**
	(0.0179)	(0.0616)	(0.0176)	(0.0249)	(0.0177)	(0.0306)
Aged 18-34	0.172***	0.241***	0.148***	0.106**	0.165***	0.139***
	(0.0360)	(0.0662)	(0.0348)	(0.0421)	(0.0354)	(0.0374)
Aged 35-54	0.0935***	0.185***	0.0775***	0.0461	0.0924***	0.0826***
	(0.0195)	(0.0669)	(0.0190)	(0.0288)	(0.0195)	(0.0212)
College or above	-0.0264*	-0.148*	-0.0213	-0.00720	-0.0345**	-0.0492***
	(0.0155)	(0.0807)	(0.0153)	(0.0188)	(0.0153)	(0.0176)
Portfolio value 50K-250K	0.0651***	0.0370	0.0529**	0.0332	0.0558***	0.0310
	(0.0215)	(0.0365)	(0.0210)	(0.0263)	(0.0213)	(0.0268)
Portfolio value > 250K	0.0212	-0.0299	0.0169	0.0117	0.0134	-0.00557
	(0.0195)	(0.0459)	(0.0192)	(0.0208)	(0.0194)	(0.0236)
Investment experience 2-10 years	-0.0632*	-0.122**	-0.0655*	-0.0671*	-0.0696*	-0.0841**
	(0.0382)	(0.0619)	(0.0373)	(0.0369)	(0.0378)	(0.0381)
Investment experience > 10 years	-0.185***	-0.392***	-0.170***	-0.136***	-0.197***	-0.217***
	(0.0348)	(0.140)	(0.0340)	(0.0426)	(0.0347)	(0.0360)
Constant	0.140***	-0.279	0.0404	-0.113	0.193***	0.378***
	(0.0394)	(0.274)	(0.0405)	(0.111)	(0.0410)	(0.112)
Observations	2,824	2,824	2,824	2,824	2,824	2,824
R-squared	0.210		0.234	0.161	0.219	0.137

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table V: Sub sample testing - 2SLS estimates of the impacts of incorrect and "don't know" responses on trading meme stocks

VARIABLES	(1) 2SLS Male	(2) 2SLS Female	(3) 2SLS Male	(4) 2SLS Female	(5) 2SLS Male	(6) 2SLS Female
No. of correct answers	0.623	0.0316				
	(1.052)	(0.0421)				
No. of incorrect answers			0.0847**	0.0422		
			(0.0334)	(0.0540)		
No. of "don't know"					-0.0762**	-0.0217
					(0.0309)	(0.0276)
White	-0.108	0.00498	-0.0273	0.0240	-0.0382	0.0142
	(0.143)	(0.0248)	(0.0303)	(0.0351)	(0.0285)	(0.0259)
Married	0.135	0.0231	0.0368	0.0235	0.0492**	0.0209
	(0.180)	(0.0207)	(0.0240)	(0.0212)	(0.0234)	(0.0223)
Willingness to take risks	-0.209	0.109***	0.0872***	0.100**	0.0521	0.0999**
	(0.566)	(0.0375)	(0.0285)	(0.0495)	(0.0383)	(0.0471)
Aged 18-34	0.681	0.175***	0.0977*	0.142**	0.158***	0.156***
	(0.851)	(0.0554)	(0.0528)	(0.0640)	(0.0467)	(0.0572)
Aged 35-54	0.512	0.0411	0.0680*	0.00275	0.115***	0.0221
	(0.655)	(0.0329)	(0.0396)	(0.0361)	(0.0302)	(0.0258)
College or above	-0.549	-0.0165	-0.0251	0.0205	-0.0858***	-0.000831
	(0.855)	(0.0316)	(0.0256)	(0.0284)	(0.0273)	(0.0186)
Portfolio value 50K-250K	-0.103	0.0408	0.0213	0.0327	0.00364	0.0357
	(0.315)	(0.0292)	(0.0363)	(0.0323)	(0.0410)	(0.0299)
Portfolio value > 250K	-0.170	-0.0221	0.0233	-0.0136	-0.00639	-0.0204
	(0.370)	(0.0274)	(0.0293)	(0.0258)	(0.0348)	(0.0256)
Investment experience 2-10 years	-0.311	-0.0899	-0.0851*	-0.0555	-0.112**	-0.0753
	(0.447)	(0.0549)	(0.0502)	(0.0563)	(0.0531)	(0.0495)
Investment experience > 10 years	-1.226	-0.134**	-0.159***	-0.0779	-0.290***	-0.112**
	(1.674)	(0.0614)	(0.0577)	(0.0599)	(0.0502)	(0.0483)
Constant	-2.267	-0.0178	-0.0587	-0.0908	0.506***	0.166
	(4.200)	(0.125)	(0.123)	(0.213)	(0.127)	(0.133)
Observations	1,714	1,110	1,714	1,110	1,714	1,110
R-squared		0.112	0.155	0.152	0.106	0.175

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table VI: Estimates of the impacts of incorrect and "don't know" responses on believing in beating the market

VARIABLES	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS	(5) OLS	(6) 2SLS
No. of correct answers	-0.00757**	0.175				
	(0.00376)	(0.124)				
No. of incorrect answers			0.0259***	0.0752*		
			(0.00478)	(0.0388)		
No. of "don't know"					-0.00994***	-0.0570*
					(0.00353)	(0.0297)
Male	0.0785***	-0.198	0.0745***	0.0888***	0.0556***	0.00127
	(0.0211)	(0.193)	(0.0195)	(0.0227)	(0.0207)	(0.0407)
White	-0.0314	-0.0366	-0.0232	-0.00712	-0.0288	-0.0157
	(0.0246)	(0.0354)	(0.0242)	(0.0266)	(0.0246)	(0.0261)
Married	-0.0166	-0.0276	-0.0206	-0.0274	-0.0192	-0.0290
	(0.0207)	(0.0295)	(0.0205)	(0.0218)	(0.0206)	(0.0221)
Willingness to take risks	0.190***	0.0843	0.170***	0.142***	0.174***	0.120***
	(0.0227)	(0.0773)	(0.0226)	(0.0316)	(0.0229)	(0.0409)
Aged 18-34	0.00670	0.0852	-0.0158	-0.0650	0.00335	-0.0280
	(0.0398)	(0.0770)	(0.0397)	(0.0546)	(0.0398)	(0.0442)
Aged 35-54	-0.00121	0.102	-0.0158	-0.0518	0.000557	-0.0114
	(0.0249)	(0.0777)	(0.0246)	(0.0383)	(0.0248)	(0.0267)
College or above	-0.0130	-0.150	-0.0102	0.00593	-0.0225	-0.0405*
	(0.0201)	(0.0969)	(0.0198)	(0.0240)	(0.0199)	(0.0234)
Portfolio value 50K-250K	0.0532**	0.0216	0.0400	0.0174	0.0455*	0.0149
	(0.0258)	(0.0428)	(0.0257)	(0.0316)	(0.0258)	(0.0325)
Portfolio value > 250K	0.107***	0.0500	0.102***	0.0960***	0.100***	0.0769**
	(0.0255)	(0.0555)	(0.0252)	(0.0261)	(0.0256)	(0.0304)
Investment experience 2-10 years	-0.114***	-0.180**	-0.117***	-0.119***	-0.120***	-0.138***
	(0.0386)	(0.0702)	(0.0382)	(0.0396)	(0.0384)	(0.0412)
Investment experience > 10 years	-0.138***	-0.371**	-0.127***	-0.0875*	-0.153***	-0.177***
	(0.0387)	(0.169)	(0.0381)	(0.0495)	(0.0381)	(0.0420)
Constant	0.276***	-0.194	0.165***	-0.0106	0.305***	0.533***
	(0.0449)	(0.324)	(0.0463)	(0.143)	(0.0482)	(0.153)
Observations	2,824	2,824	2,824	2,824	2,824	2,824
R-squared	0.071		0.084	0.030	0.072	0.001

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table VII: Sub sample testing –2SLS estimates of the impacts of incorrect and "don't know" responses on believing in beating the market

VARIABLES	(1) 2SLS Male	(2) 2SLS Female	(3) 2SLS Male	(4) 2SLS Female	(5) 2SLS Male	(6) 2SLS Female
No. of correct answers	0.548	0.0621				
	(0.965)	(0.0678)				
No. of incorrect answers			0.0745*	0.0830		
			(0.0443)	(0.0889)		
No. of "don't know"					-0.0670	-0.0427
					(0.0408)	(0.0443)
White	-0.0830	-0.0253	-0.0124	0.0121	-0.0220	-0.00718
	(0.129)	(0.0387)	(0.0338)	(0.0511)	(0.0344)	(0.0390)
Married	0.0523	-0.0225	-0.0344	-0.0218	-0.0235	-0.0268
	(0.163)	(0.0341)	(0.0299)	(0.0340)	(0.0301)	(0.0353)
Willingness to take risks	-0.113	0.152**	0.148***	0.134*	0.117**	0.133*
	(0.523)	(0.0592)	(0.0351)	(0.0724)	(0.0503)	(0.0719)
Aged 18-34	0.430	0.0241	-0.0836	-0.0412	-0.0305	-0.0138
	(0.780)	(0.0659)	(0.0662)	(0.100)	(0.0550)	(0.0751)
Aged 35-54	0.318	0.0562	-0.0726	-0.0191	-0.0315	0.0189
	(0.592)	(0.0514)	(0.0481)	(0.0644)	(0.0362)	(0.0386)
College or above	-0.463	-0.0527	-0.00123	0.0200	-0.0546	-0.0218
	(0.783)	(0.0527)	(0.0300)	(0.0475)	(0.0350)	(0.0298)
Portfolio value 50K-250K	-0.0697	-0.00267	0.0398	-0.0186	0.0243	-0.0127
	(0.287)	(0.0411)	(0.0426)	(0.0462)	(0.0496)	(0.0420)
Portfolio value > 250K	-0.0429	0.0227	0.127***	0.0395	0.101**	0.0261
	(0.343)	(0.0453)	(0.0350)	(0.0391)	(0.0434)	(0.0414)
Investment experience 2-10 years	-0.342	-0.128*	-0.144***	-0.0603	-0.167***	-0.0991*
	(0.416)	(0.0741)	(0.0542)	(0.0687)	(0.0602)	(0.0590)
Investment experience > 10 years	-1.050	-0.145	-0.111*	-0.0362	-0.227***	-0.103*
	(1.542)	(0.0889)	(0.0653)	(0.0795)	(0.0595)	(0.0606)
Constant	-1.842	0.0640	0.100	-0.0794	0.597***	0.426**
	(3.849)	(0.191)	(0.152)	(0.337)	(0.171)	(0.216)
Observations	1,714	1,110	1,714	1,110	1,714	1,110
R-squared			0.030			0.049

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, *p<0.1

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A Factor Analysis of Accounting Quality for Listed Companies on China Stock Exchanges

Abstract: Accounting quality and performance of listed companies not only affect the companies' ratings but significantly impact the overall goodness of the financial market and economy in overall. However, as the methods and practices of accounting become increasingly complex, audit firms often struggle to assess accounting activities and qualities promptly during audits. This study aims to identify and quantitatively analyze the factors influencing the accounting performance and quality using both financial indicators including profitability, operational efficiency, solvency, and growth potential and non-financial indicators including the proportion of executive directors, legal entity ownership ratio, internal control level, and the size of the supervisory board. The results of the study have significant implications for both theory development and industry practice for accounting and auditing.

Keywords: Factor analysis; Accounting Quality; China Listed companies

Investment Strategy and Guidance for Young Investors

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Abstract

Are you seeking tips to accelerate your financial investment returns? This paper provides general investment guidance for inexperienced investors in the digital age. These individuals face several limitations. First,their investment knowledge remains rudimentary. Second, their risk tolerance may be underdeveloped. Third, access to reliable information poses a challenge. Despite these hurdles, the digital marketplace offers both challenges and opportunities. The study specifically analyzes the problems faced by investors with limited investment experience and makes corresponding recommendations to facilitate their better adaptation to the digital investment environment and realize informed decision-making in investment.

Keywords: Young Novice Investors, Stock Market Investment, Digital Age

1 Introduction

In today's digital age, the emergence of a large number of young novice investors undoubtedly injects new vitality into the financial market, but at the same time, it also brings many challenges. Although many previous studies have explored investor behavior, investment strategies, and market trends, most of them often focus on traditional investor groups, and there is a clear lack of in-depth analysis of the specific behavior of the younger generation in the secondary investment market. Based on this, we clearly propose the key research question of this article: How should young novice investors effectively invest in the secondary investment market in the digital age? We show that young novice investors often blindly pursue high-yield investments to a certain extent, and they are easily influenced by the development of social technology and accidentally fall into investment traps. Moreover, their economic strength is relatively weak, and the funds available for investment are relatively limited. Their investment tendency shows a polarized trend, and their understanding of investment risks is also low. At the same time, they often exhibit a negative attitude towards learning relevant investment knowledge.

2 Background

In the digital age, electronic data has become the core of investment, and emerging technologies are driving the current market to change and transform, and the global economic landscape is gradually changing. In this era,there are more opportunities and challenges for investment than in the past, but at the same time, the risks of investment are rising.

In the past, when technology was not developed, most of the dissemination of information relied on newspapers, industry journals and so on, and investors could only obtain investment information from them. With

the continuous development of science and technology, the application of the Internet has made the dissemination of information more rapid, and for investors, the availability of information is higher, and they can easily obtain the investment information they need from the Internet. But this also creates a problem - how to distinguish the truth from the fake. For young investors, who are not yet experienced, it is difficult to discern the authenticity of the information. Abnormal stock price fluctuations often occur in China's stock market, and this situation occurs because investors have obtained incorrect information and thus misjudged the information in the market. At the same time, all the factors that can make the stock rise can be regarded as a "hot" topic, and even a small increase in stock appreciation will be speculated to a relatively high level, and young investors will invest in the stock in large quantities because it is difficult to identify, which will eventually lead to losses. (Junyi Tang, 2022)

In addition to the lack of experience and difficulty in distinguishing the truth and practicality of information, young investors are not very knowledgeable about investment, and the development of science and technology has also led to the emergence of many new types of investment, which there are some investment traps that attract young investors to be fooled. Our common investment pitfalls include, but are not limited to: allowing investors to invest in precious metals, promoting high-yield,risk-free, obscure financial products, etc. Without exception, these traps are created by taking advantage of young investors in their quest for higher returns As shown in this paper, among the 100 respondents, in addition to bank deposits, more people will tend to invest in stocks, funds and gold, which are relatively risky and will also obtain greater returns. This also reflects the tendency of today's young investors to pursue high returns, and they do not know much about risks, and inadequate research on investment decisions makes them incur huge losses in the face of investment pitfalls.

Atypical example, a lady in Henan, in a software that claims to be able to get 10% of the income in a short period of time, invested about 150,000 yuan, and soon after, the APP was found to be unable to continue to log in, the lady not only failed to get a high income, but also failed to recover the principal. According to the "Consumer Financial Literacy Survey and Analysis Report (2021)" released by the People's Bank of China, only 28.23% of respondents expect the return to be less than 5%, and the investment irrationality of young and middle-aged people is greater. In other words,young investors often have unrealistic illusions about investing.

3 Preliminary analysis and results

In order to gain a deeper understanding of the investment characteristics of novice investors, online questionnaires are distributed and in-depth interviews are conducted to obtain information about inexperienced investors. The research sample covers investment novices from different regions across the country, and a total of 115 questionnaires were collected, of which 105 were valid, with an effective rate of 91.3%. In order to gain a deeper understanding of novice investment information, a total of 4 respondents were randomly selected from the questionnaire, including those from the Southwest, Southeast, and North China regions. Both online and face-to-face interviews were conducted. Through research and data analysis, novice investors have the following practical performance:

Young and inexperienced investors are mostly college students around the age of 20 and graduates who have just started working at around the age of 25, and they do not have much savings. At the same time, because the main source of funding for college students is living expenses provided by their parents, graduates who have just started working also have many places to spend, so the amount available for investment is limited. The survey results on the

current total investment in the securities market show that investments below 50,000 yuan accounted for 81.9%, while those between 50,000 and 100,000 yuan accounted for 9.52%.

Due to considerations of investment risk, liquidity, and other factors, the preferred investment method for novice investors is often bank deposits with longer periods of time and lower returns. The case interviewee stated that,without a good grasp of risk, they tend to prefer low-risk bonds and bank deposits. But due to the development of new technologies such as artificial intelligence and big data analysis, and people's expectations for investment returns continue to rise. In the digital age, young investors are more eager to achieve high investment returns in a short period of time. They rely on new investment technologies to obtain real-time market information, observe market trends, and use information advantages to help make investment choices. Therefore, young investors tend to choose investment projects with higher risks.According to the survey data on "Investment Product Types (Multiple Choice)", the most preferred investment methods for novice investors are bank deposits account for 71.43%, funds account for 33.33%, gold account for 25,71%, and stocks account for 25.71%.

Through case interviews, it was found that the majority of young investors are not very familiar with investment risks and hold a skeptical attitude towards online training. They believe that the authenticity of online training content needs to be verified and is limited to theory and lacks practice. At the same time, most novice investors also indicate that they do not have enough time to participate in online training or activities. The survey results on the understanding of investment risks show that the proportions of those who have a very good understanding account for 11.43%, basic understanding account for 44.76%, little understanding account for 33.33%, and no understanding of investment risks account for 10.48%. The survey results on whether to participate in investment related online training or communication activities show that the proportions of those who are very willing account for 15.24%, willing to participate when they have time account for 30.48%, depending on the situation account for 38. 1%, and not very interested account for 16. 19%.

4 Conclusion and discussion

To address the lack of investment knowledge of young novice investors,investment education should be strengthened to provide systematic training on investment knowledge to help them establish correct investment concepts and risk awareness. Second,optimize the content of online training. In view of the negative attitude of young novice investors towards online investment training, the content of online training should be optimized to improve the practicality and relevance of the content, and at the same time increase the practical aspects to enhance the participation and interest of learners.

Universities and institutions should educate young investors on how to recognize the authenticity of investment information to avoid being misled or falling into investment traps. Second, promote intelligent investment tools. Utilizing artificial intelligence and other technologies,more intelligent investment tools suitable for young investors should be developed to help them better manage their investment portfolios and reduce investment risks.

One is to guide rational investment. In view of the polarization trend in the investment tendency of young novice investors, they should be guided to invest rationally and avoid blindly pursuing high returns while ignoring risks; they should also be encouraged to try diversified investment portfolios to reduce investment risks. Second, strengthen market regulation.Strengthen the regulation of the investment market, combat illegal investment activities and protect

the legitimate rights and interests of investors; also strengthen information disclosure and risk tips for investment products to help investors better understand the risks and returns of investment products. (Muhtar Sapiri, 2023)

For our upcoming research, we would like to employ questionnaires to collect substantial data for an extensive study. The objectives include integrating the latest technical findings, ensuring the timeliness and accuracy of information related to investment strategy for young investors, a thorough analysis of existing models and identifying any potential areas for improvement. We will keep vigilant about monitoring changes in the stock market and the behavior of young novice investors. By dynamically refining, we aim to elevate the robustness of the strategy and model, bringing a higher level of impact in the real finance market.

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Construction of Financial Industry Agglomeration Index System

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Abstract

The rapid development of the regional economy can result in the formation of economic center with a radiation effect in the region. The formation of economic centers is usually accompanied by influx of capital, thus forming a financial center. It will produce a clustering effect which can providing a strong impetus for the high-quality development of the region's economy by gather a sufficient number of financial institutions, financial talents, financial capital and other resources. The essence of financial industry agglomeration is the agglomeration of financial resources. In this paper, we will take financial institutions, financial talents and financial capital as the first-level indicators and select a number of second-level indicators to construct a comprehensive indicator system for financial industry agglomeration. Each indicator will be weighted with the AHP-Fuzzy Comprehensive Evaluation method. An empirical test, together with a spatial heterogeneity analysis, will be provided using the proposed financial agglomeration index.

Keywords: Financial Industry Agglomeration, Agglomeration Index, AHP, Fuzzy Comprehensive Evaluation

Opportunities and Challenges for Currency Digitalization

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Abstract

This paper provides a comprehensive analysis of the opportunities and challenges associated with currency digitalization. The study focuses on the implications for financial risk management and the dual-tier operational model, exploring how digital currencies can revolutionize financial transactions and promote financial inclusivity. The examination delves into market and technological competition, scrutinizing business applications, financial stability, and market penetration. The research indicates that currency digitalization plays a key role in digital transformation, offering significant improvements in transaction transparency and efficiency, particularly in supply chain finance and international trade.

Furthermore, this paper critically evaluates the secondary market performance of digital currencies through a thorough financial prospect analysis. Our findings suggest that digital currencies, supported by robust regulatory frameworks and advanced technological infrastructures, are well-positioned to enhance financial stability and market penetration. This analysis underscores the importance of digital currency ecosystems in the broader context of global financial systems, emphasizing their potential to drive future financial innovation and economic growth.

Keywords: Currency Digitalization, Digital Currency Ecosystem, Risk Management, Cross-Border Transactions, Financial Security, Market Penetration

1. Instruction

The theoretical framework for this study integrates poverty alleviation theories and digital currency adoption models, including the Capability Approach, Diffusion of Innovations Theory, Institutional Theory, and the Financial Inclusion Framework. The Capability Approach, developed by Amartya Sen, focuses on expanding the freedoms and capabilities of individuals to improve their well-being, which is relevant for assessing how e-RMB can enhance financial inclusion for impoverished communities [1]. The Diffusion of Innovations Theory, proposed by Everett Rogers, examines how innovations are adopted within a population, helping to understand the factors influencing e-RMB adoption among different socio-economic groups [2]. Institutional Theory explores how institutions impact individual and organizational behavior, examining how regulatory frameworks influence e-RMB implementation and effectiveness in poverty alleviation. The Financial Inclusion Framework assesses access to and usage of financial services by underserved populations, providing a basis for evaluating the role of e-RMB in improving financial inclusion and economic participation [3].

The chosen methodologies are justified by their ability to comprehensively address the research questions and objectives. Conducting an extensive literature review ensures a thorough understanding of existing knowledge and gaps, laying a strong foundation for the research. Selecting relevant case studies, such as e-RMB pilot programs, provides practical insights and real-world data for an in-depth examination of e-RMB implementation. Using both primary and secondary data collection methods enhances the study's reliability and validity. Employing advanced statistical tools ensures rigorous and objective assessment of trends and correlations, which is crucial for drawing meaningful conclusions about e-RMB's impact on poverty alleviation. Real-time monitoring and anomaly detection systems enhance transaction security and integrity. Conducting a thorough impact assessment provides a comprehensive evaluation of e-RMB's effectiveness in poverty alleviation. Adopting an iterative and adaptive research design allows flexibility and responsiveness to emerging challenges and opportunities, ensuring the research remains relevant and incorporates new insights.

In designing this research, the author undertook preparation and planning to establish a solid foundation for

the study. This phase involved defining the research objectives, identifying key stakeholders, and developing a detailed research plan. Collaborations with relevant institutions and experts in digital currency and poverty alleviation were arranged during this period. An extensive literature review was conducted to gather existing knowledge and insights on digital currencies and poverty alleviation. Relevant case studies were selected to provide valuable data and insights, including pilot programs related to e-RMB implementation [4].

Data collection involved gathering primary data through field studies and surveys in regions with e-RMB pilot programs, and secondary data from government reports, policy documents, and historical records. This comprehensive approach provided a thorough understanding of the policy framework and historical context. The collected data was analyzed using statistical tools to identify trends and correlations, helping to understand e-RMB's impact on poverty alleviation and verify the accuracy of biometric and real-name authentication systems. Real-time monitoring and anomaly detection systems using big data analytics were implemented to ensure continuous oversight and detect irregularities. Following data analysis, a thorough evaluation of the pilot programs was conducted to assess e-RMB's effectiveness in poverty alleviation. An impact assessment measured socio-economic changes in targeted communities, including changes in income levels, financial inclusion, and access to essential services.

In our efforts to explore the potential of the digital renminbi (e-RMB) for poverty alleviation, we developed a new research model that integrates elements from traditional poverty alleviation policy analysis and digital currency implementation studies. This innovative approach combines policy-focused methodologies with technological and operational assessments, providing a comprehensive framework to evaluate the effectiveness of e-RMB in reducing poverty. The new research model consists of several key components: Policy and Historical Context Analysis, Pilot Program Evaluations, Real-time Monitoring and Anomaly Detection, Biometric and Real-name Authentication Systems, and Impact Assessment on Poverty Alleviation.

The rationale for using this fusion model is multifaceted. It provides a holistic perspective by combining policy analysis, pilot program evaluations, real-time monitoring, biometric authentication, and impact assessment to offer a broad and deep understanding of the e-RMB ecosystem and its implications for poverty alleviation. This model ensures recommendations are grounded in real-world applications by analyzing both theoretical and practical aspects of e-RMB [5]. Additionally, focusing on regulatory environments and real-time monitoring addresses compliance and security, which are crucial for the success of digital currencies in poverty alleviation [6]. Examining technological innovations and biometric authentication systems highlights the importance of advanced solutions in gaining user trust and ensuring the efficient operation of e-RMB [7]. Moreover, the fusion model allows for the adaptability of research methods as the study progresses, addressing emerging challenges and opportunities promptly [8].

Our research journey includes several key strategies to ensure a thorough and comprehensive study. We continue to deepen policy analysis, expand pilot program evaluations, advance technological innovations, enhance real-time monitoring, and develop user education and training programs. While significant progress has been made, there is still much to be done. Each phase builds on previous findings, ensuring a well-rounded and in-depth understanding of e-RMB and its potential impact on poverty alleviation.

The research methodology adopted for this study on the digital renminbi (e-RMB) and its potential for poverty alleviation demonstrates methodological rigor through several key practices. An extensive literature review was conducted to gather existing knowledge and insights on digital currencies and poverty alleviation. Relevant case studies were meticulously selected to provide valuable data and insights. Multiple data collection methods, including primary data from field studies and surveys and secondary data from government reports and historical records, ensured the reliability and validity of the data collected. Advanced statistical tools were used to analyze the data, ensuring rigorous assessment of trends and correlations. Real-time monitoring and anomaly detection systems enhanced transaction security and integrity. A thorough evaluation of pilot programs and an impact assessment were conducted to measure socio-economic changes in targeted communities.

The research methodology allowed for iterative adjustments and adaptations based on emerging challenges and opportunities, ensuring the research remained relevant. Collaboration with relevant institutions and experts provided additional expertise and perspectives, enhancing the overall quality and credibility of the research. Ethical considerations were paramount, with informed consent obtained from all participants and data privacy maintained. The research findings were subjected to peer review and validation by experts in the field, ensuring accuracy and reliability. By adhering to these rigorous methodological practices, the research ensures a high level of reliability, validity, and credibility, allowing for robust conclusions and actionable recommendations regarding the potential of e-RMB in poverty alleviation.

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Financial Innovation Impacts on Carbon-Intensive Industries

--Evidence from China

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ABSTRACT

In response to China's resource and environmental challenges, there is an urgent need to explore the path towards upgrading carbon-intensive industries. Financial innovation plays a crucial role in supporting the transition towards greener and more sustainable industrial development. This paper focuses on the impact of financial innovation on carbon-intensive industries and provides recommendations for their transformation and upgrading.

This paper takes the carbon emissions of 308 carbon-intensive enterprises in Shanghai and Shenzhen A-shares from 2012 to 2021 as the benchmark data, and empirically examines the impact of financial innovation on China's carbon-intensive industries by adopting the two-way fixed effect model, and the results of the study show that: (1) financial innovation helps to reduce the carbon emissions of carbon-intensive industries and realize the optimization of low-carbon structure. (2) There are differences in the effect of financial innovation on carbon emissions of carbon intensive industries in different marketized regions, and the effect of financial innovation on carbon emissions of carbon intensive industries in low market level regions is more significant. In this regard, carbon-intensive industries should introduce digital technology and utilize financial product innovation to improve industrial production efficiency and reduce transaction costs; the government should intensify its efforts in financial science and technology innovation, promote the in-depth integration of financial institutions and carbon-intensive industries, and formulate relevant financial innovation policies, so as to promote the upgrading of carbon-intensive industries.

Keywords: Financial innovation, Carbon-intensive industries, Industrial upgrading paths

Presumed Guilty, Not Innocent: Earnings Management and CEO Turnover

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Presumed Guilty, Not Innocent: Earnings Management and CEO Turnover

Abstract

We are the first paper in literature that shows Chief Executive Officer (CEO) forced turnover is contagious in the year of and after Securities Class Act (SCA) litigation. We are also among the first to use Cox Proportional Hazard Model in accounting literature analyzing CEO turnover. SCA firms are firms that have SCA litigations. Peer firms are firms in the same industry as the SCA firms in the year SCA litigation is filed. Besides SCA firms, we find that peer firms have significantly higher CEO forced turnover in the year of SCA litigation and we call this CEO turnover contagion. Up to five years before SCA litigation, both SCA and peer firms have significantly higher stock return, sales growth and earning management than the market and we show that the higher stock return are positively correlated with the higher sales growth and earning management. But accounting performance measured in terms of ROA, ROE and net income to sales fail to follow the higher sales growth and in the year of SCA litigation, stock return of SCA firms collapses and this is the reason for the much higher CEO turnover of SCA firms. Board of directors of peer firms use pre-emptive tactics to fire their CEO to signal to the market that they are different from the SCA firms and will avoid the SCA litigation and this result in CEO turnover contagion.

1. Introduction

The revelation about Securities Class Act (SCA) litigation of one firm may provoke tumultuous market reaction: board of directors of peer firms may be confronted with CEO dismissal decisions to differentiate their firms from SCA firms and avoid potential SCA litigation; CEOs of peer firms, innocent or not, tend to be negatively impacted in terms of dismissal; shareholders of the peer firms may feel skeptical about the trustworthiness of the peer firms' accounting information and scared of the potential infectious effect on peer firm stock performance; other investors may exploit the common part of information (i.e. shared directors and shared auditing firms) among SCA and peer firms.

The ensuing impact of SCA litigation roots in agency problems.

Prior literature show that CEOs are more likely to be dismissed when stock performance is poor than when it is good (Murphy and Zimmerman 1993; Denis and Denis 1995; Brickley 2003; Coughlan and Schmidt 1985). In addition, Warner et al. (1988) show inverse relation between stock performance and the ensuing probability of top management changes. To keep their positions, CEOs are incentivzed to take advantage of their inside information and extract rent from firms (Evans et al. 2014; Laux, 2008). Based on their insider information in terms of assets quality and firm operational alternatives, CEOs may manage earnings to make financial statement look nice (Cohen et al. 2008; Ali and Zhang, 2015; Evans et al. 2010).

Although in short run, accounting targets can be met and stock prices may be boosted up, building such illusive image of superior firm performance through overstating earnings cannot eliminate the chance of CEO turnover, for accruals will ultimately reverse. In contrast, earnings management may increase their probability of turnover. Allen et al. (2013) show the negative influence of accrual reversal on future stock prices. Hazarika et al. (2012) demonstrate that the probability of CEO turnover tends to be driven up by earnings management in the previous year.

Arthaud-Day et al. (2006) find that when firms are subject to material changes of financial statements, the probability of their CEOs and CFOs turnover are more than twice that of their counterparts in control group.

Moreover, the fraud/lawsuit revelations following earnings management are found to be positively related to CEO turnover and have negative influence on stock prices (Aharony et al., 2015; Hennes et al., 2008; Persons, 2006). In order to repair firm reputation, the boards tend to make forced CEO turnover decision. It is shown that the probability of forced top management turnover is increased significantly after major decline in operating performance, and after the turnover, the performance rebounds (Denis and Denis, 1995). Hazarika et al. (2012) argue that it is highly probable that the boards proactively monitor managers' earnings management and take actions before the overly aggressive behaviour are known publicly. They find that the degree of earnings management is positively related to the probability of forced CEO turnover and this relation is invariant of firm performance and the direction of accruals and conclude that the overly aggressive earnings management behaviour of CEOs can lead to CEO turnover before being detected externally.

Except for CEO dismissal, to restore investor confidence, external auditors and CFOs are subject to termination. It is found by Hennes et al. (2014) that firms with lower switching cost and more external auditor choices are more likely to dismiss their external auditors following accounting restatements. The Board of Directors regard CFO turnover and auditor turnover as complementary reaction to restatements, which is indicated by the significantly positive relationship between CFO turnover and auditor turnover. They also find that investor confidence is restored by auditor termination following restatements, especially severe restatements.

Meanwhile, existing literature presents that firm bad news tend to have negative impact on other firms in the same industries. Negative externalities are found to be spread from event firms to peer firms in the extensive literature on stock price contagion effect. External shocks, accounting restatements, management earnings forecast, bankruptcy announcements and common directors/external auditors can all have contagious influence on stock performance. Jenter and Kanaan (2015) document that following bad industry performance and bad market performance, CEOs who underperform the industry average are more vulnerable to turnover since they suffer from the peer performance effect, while the outperformers are much less affected. They argue that it is due to the board's failure to filter out beyond-CEO-control factors. Ramnath (2002) find that there are contagion effects between forecast errors of first-announcing firms and that of subsequent peer firms. Pyo and Lustgarten (1990) argue that the direction and degree of the influence of management earnings forecasts on intra-industry information transfers are determined by firm-by-firm covariance to variance of earnings. The logic is that if the two industry members are competing directly with each other, the management earnings forecasts of one firm may influence the other. Lang and Stulz (1992) find that contagion effect is moderate on average and is strong when the peer firms have high leverage. Docking et al. (1997) document that contagion effects are triggered by regional banks' Loan-Loss Reserve (LLR) announcements, for the release of LLR announcements by regional banks invokes value drops in money-center banks and nonannouncing regional banks. Gleason et al. (2008) find the negative shareholder wealth effect in both restating firm and non-restating peers in the same industry. They find that the effect to be more pronounced when the non-restating firms with high earnings and accruals share the same external auditor with the restating firms. Chiu et al. (2013) studied the network influence of the board over firms with shared CEOs and find that earnings management is more contagious among firms with common

directors, especially when the directors have leadership or take the accounting-related position on the board. This phenomenon is called the board contagion effect and this effect is still significant after controlling for other endogenous factors. We show consistent evidence that the stock returns are negatively related to shared common directors between SCA firms and the other firms.

Though there is a large body of literature on CEO turnover and stock price contagion effect, there is a glaring lack of studies on CEO turnover contagion. The rich array of market reactions in and following the year of SCA litigation revelation, the vital role of CEOs in firm investment and financing decision making, and the stock price contagion effect shape our core research question: whether peer firms CEO forced turnover is influenced by the revelation of SCA litigation (which we call CEO turnover contagion effect). To unveil the rationale behind this effect from the aspects of operational, accounting, and stock performance of SCA and peer firms, as well as common director ratio, we are going to answer the following questions: Do SCA and peer firms have significantly higher CEO forced turnover ratios than Non-related firms? What's the relation between their CEO turnover and stock return, earning management, and profits, respectively? Does common director ratio play a role in our CEO turnover contagious effect? By demonstrating that CEO turnover is contagious in the year of and after Securities Class Act (SCA) litigation, and show the potential interpretation of the effect, our paper adds a new twist to the existing literature by establishing a link among CEO turnover, contagion effect and SCA litigation.

This study aims to explore the impact of SCA litigation on both SCA firms and peer firms. Our research is based on SCA data manully collected from Stanford University Law School Security Class Action Clearinghouse, and other related data downloaded from CRSP, COMPUSTAT and Riskmetrics. We define SCA firms as firms have SCA litigations, peer firms as those in the same industry as the SCA firms in the year SCA litigation is filed. We employed

Cox Proportional Hazard Model in the research which is new in accounting literature analyzing CEO turnover.

Our analysis contributes to the literature in three main respects. First, our results indicate that CEO forced turnover is contagious in the year of and after SCA litigation, which we call CEO turnover contagion effect. SCA firms are more than four times as likely to fire their CEOs as non-related firms. Most importantly, Peer firms which are in the same industries as SCA firms are more likely to be fired than non-related firms, even though these peer firms actually have no litigation. This may be resulted from that the peer-firm board aims to differentiate their firms from SCA litigation firms by firing CEOs and to avoid potential SCA litigation.

Second, we show that high CEO forced turnover in the year of litigation for both SCA and peer firms may be caused by the revelation of performance manipulation. Up to five years before SCA litigation, both SCA and peer firms have significantly higher sales growth, earning management, and stock return than the market. While the higher stock return is positively correlated with the higher sales growth and earning management, however, the accounting performance (ie., ROA, ROE and net income to sales) fail to match with the higher sales growth. In the year of SCA litigation, stock return of SCA firm collapses and this is the reason of notable higher CEO turnover of SCA and peer firms.

2. Data and Measures

We collect CEO turnover data from Compustat ExecuComp and group turnovers into forced turnover and voluntary turnover according to Parrino (1997). We then combine CEO turnover data with return data from CRSP, accounting performance data from Compustat, director data from Riskmetrics and SCA data from Stanford University Law School Security Class Action

Clearinghouse. Totally, there are 1556 CEO turnovers between 1997 and 2012[1], of which 370 are identified as forced turnover and 1186 are identified as voluntary turnover (see Table 1 Panel A). Table 1 Panel A also shows that forced turnover ratio is 0.032, voluntary turnover ratio is 0.103, and the total turnover ratio is 0.135, which are consistent with the literature, e.g., see Jenter and Kanaan (2015) and Lee et al. (2012).

[Insert Table 1 Panel A around here.]

In each year, we divide all firm-year observations (a total of 11537) into three groups. First, if a company has an SCA litigation in a year, we label this company as an SCA firm. Second, 'Peer' firms are those that share the same Compustat Global Industry Classification Standard (GICS) code[2] as SCA stocks in the same year. Third, the remaining firms in the same year are in 'Non-related' group. Table 1 Panel A reveals that the number of SCA lawsuits varies from a minimum of 10 in 2010 to a maximum of 43 in 1999. Table 1 Panel B shows the summary statistics for financial performance, accounting performance, earnings management, common director ratio and other control variables in year -1 (year of filing of lawsuit reported in SCA litigation database is denoted year 0)[3]. For financial performance, in addition to unadjusted stock return we include industry adjusted stock return, stock return bottom decile dummy, stock return momentum loser and winner dummies. Table 1 Panel C shows the number of SCA firms, Peer firms and Non-related firms each year in year 04. The total number of SCA firms, Peer firms and Non-related firms are

[1] Our SCA data is from 1996 to 2012. We need to regress CEO turnover on previous 1-year financial performance, accounting performance, earnings management and also common director ratio so CEO turnover has to start from 1997.

[2] We follow Gleason et al. (2008) in using GICS instead of the Standard Industry Classification (SIC) code in classifying Peer firms. Gleason et al. (2008) discusses why GICS is a better measure. We use GICS also because it will be easier to compare our results with that of Gleason et al. (2008).

[3] In our Cox proportional hazard rate model and logistic model, we regress year t CEO forced turnover on year t-1 financial performance and other variables where t= -5 to +5. Year of filing of lawsuit reported in SCA litigation database is denoted year 0

[4] Year of filing of lawsuit reported in SCA litigation database is denoted year 0. Years -1 to -5 are previous 1 to 5 years before year 0 and years 1 to 5 are next 1 to 5 years after year 0.

345, 4201 and 6991 respectively. Each group has a large enough sample size for Cox proportional hazard rate and logistic analysis later on.

The definitions of variables in Table 1 Panel B are as follows.

Jenter and Kanaan (2015) discuss why Strong-form relative performance test is preferred over Weak-form test though we provide both the Weak-form and Strong-firm tests in this paper. To do the Strong-form relative performance test, we need a two-stage regression approach. Following Jenter and Kanaan (2015), in the first stage, we derive industry adjusted stock return:

$$\text{First Stage: } r_{j,Y-1} = \alpha_0 + \alpha_1 r_{\text{industry group, Y-1}} + u_{j,Y-1} \quad (1)$$

Where r j,Y-1 is unadjusted annual stock return of firm j in year Y-1 (Y=1996 to 2012), r industry group, Y-1 is mean unadjusted annual stock return of industry groups[5] in year Y-1 and uj, Y-1, the residual, is industry adjusted annual stock return of firm j in year Y-1.

$$\text{Second Stage: Prob (CEO forced turnover}_{Y,j,t}) = \beta_{0,t} + \beta_{1,t} u_{Y-1,j,t} + \beta_{2,t} * \text{other variables}_{Y-1,j,t} + v_{Y,j,t} \quad (2)$$

where Y=1996 to 2012, t= -5 to +5 and t=0 denotes year of filing of lawsuit.

u Y,j, t-1, the residual in equation (1) is the industry adjusted annual stock return. Instead of following Jenter and Kanaan (2015) in adding the estimated exogenous component of firm performance in equation (2), we put the annual stock return bottom decile dummy, the momentum loser and winner dummies in equation 2. In each year, we divide all stock available in CRSP by unadjusted annual stock return into 10 groups. If a stock's unadjusted annual stock return is in the bottom decile, then it has an annual stock return bottom decile dummy of 1, otherwise 0. This decile dummy shows the relative performance of a stock to the market. Similarly, for every year, we divided all stocks in CRSP in year -2 (2 year before) into three groups by unadjusted annual

[5] To be consistent with Gleason et al. (2008) we again use GICS to divide all stocks into industry groups.

stock return. For stocks in the bottom 1/3, we further divide them into three groups by unadjusted annual stock return in year -1. For stocks in the bottom 1/3 in both years -1 and -2, we call them unadjusted annual stock return momentum loser and they have an unadjusted annual stock return momentum loser dummy of 1, otherwise 0. Similarly, for stocks in the top 1/3 in both years -2 and -1, we call them unadjusted annual stock return momentum winner and they have an unadjusted annual stock return momentum winner dummy of 1, otherwise 0. The momentum loser and winner dummies show the relative performance of a stock in two consecutive years and reveal the relative performance of a stock in a dynamic fashion.

One of the most important variables in equation (2) is earnings management. To be consistent with Jenter and Kanaan (2015), earnings management needs to be industry adjusted too. For this industry adjustment requirement, we follow Hazarika et al. (2012) in obtaining the earnings management variable for each of the GICS industry groups:

$$\text{Total accrual}_{j,Y} = (\Delta CA_{j,Y} - \Delta CL_{j,Y} - \Delta Cash_{j,Y} - \Delta CA_{j,Y} + \Delta STDEBT_{j,Y} - DEPN_{j,Y})/Asset_{j,Y-1} \quad (3)$$

Where Y=1996 to 2012, ΔCA j, Y = change in firm assets for firm j from year Y-1 to year Y, ΔCL j, Y = change in firm current liabilities for firm j from year Y-1 to year Y, ΔCA j, Y = change in firm assets for firm j from year Y-1 to year Y, ΔCash j, Y = change in firm cash for firm j from year Y-1 to year Y, ΔSTDEBT j, Y = change in firm debt in current liabilities for firm j from year Y-1 to year Y, DEPN j, Y = change in firm depreciation and amortization for firm j from year Y-1 to year Y and Asset j, Y = book value of asset for firm j from in year Y.

The abnormal accrual of firm j in year Y is obtained from the residual in the following equation:

$$\text{Total accrual}_{j,Y} = \beta_{0\,j} + \beta_{1\,j}(1/Asset_{j,Y-1}) + \beta_{2\,j}(\Delta Rev_{j,Y} - \Delta AR_{j,Y}) + \beta_{3\,j}(PPE_{j,Y}) + \beta_{4\,j}(ROA_{j,Y-1}) + w_{j,Y} \quad (4)$$

Where $\Delta Rev_{j, Y}$ = change in revenue for firm j from year Y-1 to year Y divided by $Asset_{j, Y-1}$, $\Delta AR_{j, Y}$= change in account receivables for firm j from year Y-1 to year t divided by $Asset_{j, Y-1}$, $PPE_{j, Y}$= gross value of property, plant and equipment for firm j in year Y divided by $Asset_{j, Y-1}$, and $ROA_{j, Y-1}$= return on asset for firm j in year Y-1 to year Y. Earnings management of firm j in year Y is the absolute value of $w_{j, Y.}$

For accounting performance measures, we include ROA[6] and sales growth. ROA is net income / total asset and sales growth is (sales in year Y/sales in year Y-1) -1. Unadjusted ROA and sales growth can be unreliable with extreme values and to be consistent with our earnings management variable, ROA and sales growth are also winsorized at 5% and 95% for each industry[7]. Common director ratio of Peer or Non-related firms each year is equal to the number of shared directors in the board of directors between SCA firm and Peer or Non-related firms each year divided by the number of directors in the Peer firms or Non-related firms in the same year respectively. Common director ratio of SCA firms is set to 0 in year 0. The other variables are:

inventory to cost of goods sold ratio (= (inventory/(cost of goods sold/365))/1000) receivable to sales ratio (= (account receivable / (sales/365))/1000)

current ratio = (current asset/current liabilities)

debt ratio = (total liabilities / total asset)

and age of CEO, tenure in years of CEO and size (natural log of total assets).

[Insert Table 1 Panel B around here.]

All of the variables in Table 1 Panel B have a total number of observation of 11537, except for CEO tenure which has only 11526 observations. Annual unadjusted stock return varies widely from -97% to 2619%, with a mean of 15% and a median of 9%. Age of CEO is from a minimum

[6] We also try ROE and results are basically the same.
[7] We also try 1% and 99%. Results are basically similar.

of 32 years to a maximum of 96 years, while CEO tenure (= number of days as CEO/365) is from 0 years (i.e., CEO tenure is less than 4 days) to 61.04 years with a mean of 7.29 years and a median of 5.25 years. ROA is from -185% to 53%, with a mean of 5% and a median of also 5%.

In Table 1 Panel C, we show the number of observations, mean, minimum, maximum and median of unadjusted stock return, industry adjusted stock return, earnings management, ROA, sales growth, common director ratio and forced turnover ratio for SCA, Peer and Non-related firms in the SCA filing year. 345 SCA filings are included in our study. The mean turnover ratio for SCA firms is 11.6%, much higher than that of Peer firms (3.7%) and Non-related firms (2.5%).

[Insert Table 1 Panel C around here.]

4. Univariate Analysis

4.1 Univariate Analysis shows that SCA firms have significantly higher CEO turnover ratio than that of Non-related firms and this is highly related to earnings management and unsustainable sales growth

Table 2 Panel A presents the mean forced turnover ratio[8] and other firm performance ratios for SCA and Non-related stocks. Five years before SCA lawsuit, the mean forced turnover ratio of SCA and Non-related groups are 0.021 and 0.027 respectively (t=0.69 for Non-related minus SCA, hereafter Non - SCA), i.e., Non-related firms have higher CEO turnover ratio. When time gets closer to SCA year, mean forced turnover ratio of SCA firms starts to be higher than the corresponding mean of Non-related firms which may be a result of information leak, but the difference is still insignificant. In the year of SCA litigation, mean forced CEO turnover ratio

[8] Forced turnover ratio for each firm each year is equal to the number of forced CEO turnover (the maximum number of forced turnover for all firms in a year is 1 except for 1 firm which is 2) in thin year. Similarly, voluntary turnover ratio for each firm each year is equal to the number of voluntary CEO turnover (the maximum number of voluntary turnover for all firms in a year is 1). If there is no forced or voluntary turnover for a firm in a year, then the forced or voluntary turnover ratio for that firm in thin year is 0. The total turnover ratio for each firm each year is equal to the sum of forced turnover and voluntary turnover ratios for that firm in thin year.

difference increases sharply. The mean forced turnover ratio of SCA stocks becomes as high as 0.116, whereas that of Non-related related stocks is only 0.025 (t= -5.24 for Non - SCA and mean forced turnover ratio of SCA is 364% higher than that of Non-related firms), where the difference is notably significantly negative. Moreover, the mean forced turnover ratio of SCA stocks continues to be substantially higher than that of Non-related firms for the next 1 year. Hence, these results, from both mean difference magnitude and significance, show that SCA litigation is deadly to CEO. When there is a SCA litigation, the CEO of a company is significantly more likely to be kicked out than those in Non-related companies, and this trend persists into five years after the lawsuit.

[Insert Table 2 Panel A around here.]

Table 2 Panel A also presents the mean of firm performance and other ratios. First, mean unadjusted annual return of SCA firms is significantly higher than of Non-related firms from years -5 to -2, but then becomes significantly lower than of Non-related firms in years -1 and 0. In year 0, the difference between mean unadjusted returns of SCA firms and Non-related firms reaches its peak. Mean unadjusted return of SCA firms is 30.5 percentage points lower than that of Non-related firms. Figure 1 Panel A denotes this graphically and from the figure we can notice that the difference of forced turnover ratio (SCA minus Non-related) peaks in year 0, and the difference of unadjusted return (SCA minus Non-related) reaches bottom in the same year. This indicates firm financial performance and CEO turnover move in different direction among SCA and Non-related stocks, which will be further analyzed in this work.

[Insert Figure 1 Panel A around here.]

High Sales and Asset growth of SCA firms are not sustainable

Table 2 Panel A demonstrates that the peak and bottom relationship in Figure 1 Panel A and B is not a coincidence. SCA firms have substantially higher unadjusted stock return than Non-related firms from years -5 to -2. We also observe that the mean of earnings management of SCA firms is significantly higher than that of Non-related firms in all years. Winsorized sales growth of SCA firms are much higher than its non-related counterparts, and after year 0, the sales growth of Non-related firms significantly outperform SCA firms. The bottom line of a firm's management is profit. In all years, the mean ROA of SCA firms is below that of Non-related firms. Coupled with the collapse of SCA firms' returns in year 0, compared with that of Non-related firms, a reasonable hypothesis to explain this collapse in return is that CEOs of SCA firms try to manipulate stock return by high unsustainable earnings management. SCA firms have significantly lower ROA compared to its Non-related counterparts from year 0. This reversed sign of the difference between the sales growth of SCA and Non-related firm after the SCA event year supports the results above. Thus, the inferior accounting performance of SCA firms is the prime reason that leads to a major collapse of stock return of SCA firms in year 0. This is in line with Figure 1 Panel B which clearly shows that the difference of the mean of unadjusted stock return basically moves in unison with that of ROA. Both reach the bottom in year 0. This collapse in stock return of SCA firms would then lead to the significantly higher forced turnover ratio for SCA firms.

[Insert Figure 1 Panel B around here.]

Sales not generating profit for SCA firms

Intriguingly, from Table 2 Panel A, we can observe that ROA is not following the substantially higher sales growth for SCA firms. After year 0, the ROA of SCA firms are significantly lower than that of Non-related firms, which is consistent with the significantly lower sales growth of SCA firms. However, before year 0 when sales growth of SCA firms significantly

outperform Non-related firms, the ROA of SCA firms is insignificantly lower than that of Non-related counterparts in year -5 and year -1 and is insignificantly higher in year -2.

[Insert Table 2 Panel A around here.]

Similarly, from Table 2 Panel B, we can see that sales growth, total asset growth rate, and property, plant and equipment growth rate of SCA firms are substantially higher than that of Non-related firms before year 0, while ROA, operating profit to sales ratio, and net income to sales ratio of SCA firms are basically lower before and including year 0. The relationship is also shown graphically in Figure 1 Panel C.

[Insert Table 2 Panel B around here.]

Figure 1 Panel C depicts the difference of mean unadjusted annual return and accounting performance of SCA and Non-related firms. We also observe that most measures end the increasing trend and become negative in the year of SCA lawsuit filing. From year 1 on, they reverse again and move towards 0. Unsustainable earnings management and the interference from Board of Directors and new CEOs may explain these trends. As is reflected by the negative Operating Income before Depreciation/Sales and Net Income to Sales ratio, and other weak financial performance and accounting measures, the outperformance of firms in stock return with persistent lower income is not sustainable. In addition, after the lawsuit, the firms have to reveal more reliable accounting information and may focus more on operating performance, making their financial and accounting performance approach normal level.

[Insert Figure 1 Panel C around here.]

Forced turnover ratio sorted by financial and accounting performance and earnings management

Table 2 Panel C summarizes the accounting information of SCA and Non-related firms. In the event year, SCA firms are subject to significantly higher total and voluntary CEO turnover ratio than Non-related firms, accompanied by significantly worse financial performance (i.e., SCA firms are more likely to be in momentum loser group and less likely to be in momentum winner group), worse accounting performance (i.e., SCA firms have higher Receivable to Sales Ratio and higher Receivable to Sales Ratio), younger CEO, and larger firm size (higher log of Total Asset).

[Insert Table 2 Panel C around here.]

Table 2 Panel D sorts forced turnover ratio by financial and accounting performance and earnings management into 3 groups (Low, Medium and High) from years -5 to 5 to show more clearly the relationship among forced turnover ratio, financial performance, accounting performance, and earnings management.[9] We also observe that CEO forced turnover is negatively and significantly correlated with financial and accounting performance and positively and significantly correlated with earnings management. For every year, mean forced turnover ratio of firms with lowest unadjusted return, ROA and Net income to sales ratio are significantly higher than that of firms with highest performance measures. For earnings management, mean forced turnover ratio of firms with highest earnings management are significantly higher than that of firms with lowest measures.

[Insert Table 2 Panel D around here.]

Forced turnover ratio sorted by financial and accounting performance and earnings management for SCA, Peer and Non-related firms

[9] For space reasons, only years -5, -2 to 2 and 5 are shown. Other years are available upon request.

We further analyze the relationship among CEO forced turnover ratio, financial performance, accounting performance, and earnings management by firm groups (SCA, Peer, and Non-related). Analogously, for each firm group from years -5 to 5. As Table 2 Panel E shows, CEO forced turnover is negatively and significantly correlated with financial and accounting performance in most of the years for the Peer and Non-related firms. For SCA firms, the relationship is mostly negative but only significant around year 0 (from year -1 to year 1). CEO forced turnover is positively and significantly correlated with earnings management in most of the years for Peer and Non-related firms. For SCA firms, CEO forced turnover is positively correlated with earnings management in year 0 but not significant.

[Insert Table 2 Panel E around here.]

Results using industry adjusted return

In Figure 1 Panel D and Panel E, we show the relationship between industry adjusted return and forced turnover ratio and the relationship between industry adjusted return and ROA respectively. The basic trends are similar to that in Figure 1 Panel A and Panel D respectively. Thus, the above results indicate that our findings are not influenced by industry effect.

[Insert Figure 1 Panel D around here.]

[Insert Figure 1 Panel E around here.]

4.2 SCA firms are contagious in CEO turnover and Peer firms have significantly higher CEO turnover ratio than that of Non-related firms and this is also significantly related to earnings management and unsustainable sales growth

Table 3 Panel A shows forced turnover ratio and firm performance for Peer and Non-related stocks. We demonstrate that Non-related firms tend to have lower forced turnover ratio than peer firms, and this is significant from year -2 to 2. In addition, the difference of mean forced turnover ratio between Peer and Non-related firms (Non-related minus Peer, hereafter Non-Peer) tend to be larger when it is closer to SCA lawsuit filling year. One year after the event year, the difference reaches its 10-year-high. These results imply that when there is an SCA litigation, the CEO of a Peer firm is significantly more likely to be kicked out than those in Non-related companies. This trend is strongest one year after the lawsuit and persists into at least two years after the event year. This is in accordance with our hypothesis that SCA CEO turnover is contagious to Peer firms.

[Insert Table 3 Panel A around here.]

Figure 2 Panel A describes the relationship between annual return and forced turnover ratio graphically. From the figure we can observe that from year -5 to year 0, the difference of forced turnover ratio (Peer minus Non-related, hereafter Peer - Non) has an increasing trend, while the difference of unadjusted return between Peer and Non-related has a decreasing trend and the difference of forced turnover ratio and the difference of annual return are above 0. That is, peer firms tend to have increasingly higher forced turnover ratio and decreasingly higher annual return than Non-related firms when it comes closer to the event year. This is consistent with Table 3 Panel A results which supports the contagious effect.

[Insert Figure 2 Panel A around here.]

Firm performance shown in Table 3 Panel A provides further insights into the phenomenon. We can observe that peer firms have higher unadjusted stock return than Non-related firms in most years, and the difference is significant in years -5, -2, and 1. Though the higher sales growth seem to support the better stock performance, the earnings management of Peer firms is also much higher, and in all years except year -5, mean ROA of Peer firms is below that of Non-related firms. One year before the event year, the better stock performance of peer firms become insignificant, which is mainly driven by the significantly worse ROA performance of Peer firms compared to Non-related firms, which is also depicted in Figure 2 Panel B. This indicates that earnings management is unsustainable, which is the same as the previous discussion on the relationship between SCA and Non-related firms. In addition, difference of annual return and ROA of peer and Non-related firms move toward 0 after year 0. This indicates that after SCA lawsuit, like SCA firms, peer firms also tend to reveal more reliable information, which pushes them back to normal performance level.

[Insert Figure 2 Panel B around here.]

Figure 2 Panel C demonstrates graphically the details of financial and accounting performance between Peer and Non-related firms. The relationship is the same as that between SCA and Non-related firms: unadjusted return and accounting performance reach the bottom at around year 0 and the difference approaches 0 thereafter.

[Insert Figure 2 Panel C around here.]

Figure 2 Panels D and E show the relationship between industry adjusted return and forced turnover ratio or ROA. Again, the basic trend is similar to that in Figure 1 Panel D and E. Therefore, our findings above are not influenced by industry effect.

[Insert Figure 2 Panel D around here.]

[Insert Figure 2 Panel E around here.]

Table 3 Panel B presents the difference of unadjusted return and accounting performance between Peer and Non-relate firms from year -5 to year 5. We observe that Peer firms have lower Net income, Operating Income and ROA than Non-related firms. However, the total asset growth rate and total property, plant and equipment growth rate are higher. Before the year of SCA lawsuit filling, peer firms have higher unadjusted return, and this is reversed in the event year and 3 to 5 years after the event year.

[Insert Table 3 Panel B around here.]

As is in Table 3 Panel C, from year -5 to year 5, Peer firms tend to have more experienced CEOs, higher inventory, more receivables, less total asset, and less debt. The unadjusted return of Peer firms is substantially higher than that of Non-related firms in and before the SCA lawsuit filling year and this trend become much weaker thereafter. In the SCA lawsuit filling year, Peer firms have significantly more CEO total turnover than Non-related firms and insignificantly less voluntary turnover, which implies that it is the forced turnover that gives rise to the total turnover difference. In addition, in thin year, Peer firms are more likely to be in momentum loser deciles in the past one or two years and less likely to be in momentum winner deciles in the past two years.

This may be explained by worse accounting performance in the long term of Peer firms in terms of inventory COGS Ratio and more receivables.

[Insert Table 3 Panel C around here.]

5. Regression Analysis

Cox Proportional Hazard Regression VS Logistic regression

Cox Proportional Hazard Regression is a more suitable model for the purpose of this work compared to logistic regression. Hazard rate, which is the probability of CEO forced turnover given the fact that the CEO has been retained to a specific time point, is adopted in Cox model as the independent variable. In this work, it is the comparison between the risk of forced CEO turnover for event/peer firms and the Non-related firms.

Vittinghoff et al. (2012) compare the advantage of Cox model over Logistic model in biology and health context. They argue that the binary indicator of mortality used in Logistic regression hides the information behind the wide range of the follow-up length. In addition, if the follow-up length is not constant, the relationship between event risk and duration will be unnecessarily assumed. Furthermore, unlike Logistic model which assumes the relationship between response variables (independent variables) and outcome variable (dependent variable), Cox proportional hazard model do not have such assumptions. But it contains the efficiency and favorable features of fully parametric models.

In our context, as is discussed in Campbell et al. (2011), unlike Logistic model which use cumulative incidence of forced CEO turnover, Cox model tolerates the case that CEOs are retained though there is risk of forced turnover in a given time unit. In addition, when estimating the hazard

ratio of forced CEO turnover, Cox model incorporates time-varying variables. Furthermore, Cox Proportional Hazard Regression do not assume the shape of survival distribution.

6. Strong-form relative performance test

To do the strong-form relative performance test, we first use equation 2 to do the first-stage test to derive the industry adjusted values for stock return and other measures. Results are in Table 4 Panel A. Consistent with Jenter and Fanaan (2015), the parameter for the industry mean is 1.00 but our adjusted R^2 is much higher than theirs.

[Insert Table 4 around here]

Table 4 Panel B presents the results of second-stage cox proportional hazard regression of forced CEO turnover on industry adjusted stock return and other industry adjusted ratios. The dependent variable is CEO forced turnover dummy in year t where t= -5 to +5 and t=0 means year of filing of lawsuit. The independent variables are values at previous 1 year except for the SCA and Peer dummies which are always values at t=0. P-values are provided.

Consistent with univariate results in Section 4, Peer and SCA dummies are positive and significant at t=0 and 1, i.e. Peer and SCA firms have significantly higher forced CEO turnover than Non-related firms in year of filing of lawsuit and also 1 year after the filing. This lends further support to our hypothesis in a multivariate setting that SCA firms have significantly higher CEO forced turnovers than Non-related firms and CEO forced turnover of SCA firms is contagious to Peer firms.

In addition, we find that the CEO forced turnover contagious effect is strongest one year after lawsuit filling year. SCA dummy parameter reaches its peak in year 0 whereas Peer Dummy reaches its peak in year 1. The combined results of SCA and Peer Dummies are highest in year 0.

We include four measures in financial performance: industry adjusted stock return, industry adjusted bottom decile dummy, industry adjusted momentum loser dummy and industry adjusted momentum winner dummy. The coefficient of Industry adjusted stock return is negative and significant at 1% in all years which is consistent with the literature on the causal relationship between firm performance and CEO turnover. This illustrates that one major concern for board of directors in deciding CEO turnover is stock performance. This is obvious because a top objective for investors for investing in a company is stock return. Higher stock return usually implies that shareholders are more satisfied, which in turn puts less pressure on the board to remove the CEO. The bottom decile dummy, which shows whether the company's stock return is in the bottom 1/10 of all stocks available in CRSP is not significant in any year. We follow Jenter and Kanaan (2015) in providing the momentum loser and winner measures.[10] The momentum loser dummy, which shows whether a company's stock return is consistently in the bottom 1/3 of all stocks in CRSP both in previous 1 and 2 years before t, is positive and significant in years -2, -1, 0, 1 and 5. The momentum winner dummy, which shows whether a company's stock return is consistently in the top 1/3 of all stocks in CRSP both in previous 1 and 2 years before t, is not significant in any year. These three measures are complementary to the stock return measure because they measure the relative performance of a company's return to the market. When we compare the bottom decile dummy with the momentum loser dummy, we find that the board of directors is more concerned if a company's stock return was consistently in the bottom 1/3 in both previous 1 and 2 years than when the stock's return is in the bottom 1/10 in the past 1 year. That is, persistent firm underperformance is more likely to trigger CEO dismissal procedure of the board. If we compare the momentum loser dummy with the momentum winner dummy, the insignificance of the

[10] Jenter and Kanaan (2015) used 90th percentile while we use top and bottom 1/3

momentum winner results shows that when considering forcing a CEO out, consistent poor performance of a company is more important than consistent good performance. This is consistent with the findings of Jenter and Kannan (2015) that CEOs of industry loser firms are more likely to be dismissed and CEOs of industry winner firms are much less affected by stock and accounting performance.

For accounting performance, we include industry adjusted ROA and industry adjusted sales growth. Both are negative and significant at 1% in most of the year, especially in year 0. Our results show that board of directors, in deciding whether to force a CEO out, are very interested in the measures of ROA and sales growth. ROA and sales growth are major drivers of a company's stock return as ROA is a measure of the profitability of a company and sales growth is one of the factors that will determine whether a company's profit is sustainable. Our results show that when a company's ROA and sales growth are good, it is less likely that the CEO will be forced out.

Our earnings management variable is negative but not significant before t=0. It is positive starting from year 0 until year 5 but is only significant in year 0. It seems that the board of directors accepts the earnings management of the company's CEO before year 0. But earnings management is not sustainable, as can be seen from the deteriorating stock return, ROA and net income to sales of both SCA and Peer firms relative to Non-related firms in Tables 2 and 3 though sales growth of both SCA and Peer firms are persistently above that of Non-related firms before year 0. Our results show that a firm's CEO, through manipulating the earnings management and sales growth measures, may be able to fool both the board of directors, shareholders and the market for a few years, but in year 0, when the company is being sued, stock return collapses. This leads to higher CEO forced turnover for both SCA and Peer firms as both firms have higher earnings management than Non-related firms in year 0.

In addition, as is indicated in Table 4 Panel B, SCA lawsuit is deadly to SCA firms, and contagious to Peer firms. In year 0, Peer dummy and SCA dummy variables are highly significant and positive, supporting the univariate analysis that CEOs in SCA and Peer companies are more likely to be fired than Non-related firms. The positive and significant Peer dummy also supports our hypothesis that SCA CEO turnover is contagious to Peer firms. This relationship extends into year 1. The parameter estimate of SCA dummy is 1.349 (Prob =0.000)[11] in year 0 which is extremely high. Moreover, the influence of SCA litigation not only stays in the SCA firm, but also spread to the related companies. The relation between Peer dummy and forced turnover dummy is the most significantly in the SCA filing year, and gradually decreases afterwards. In year 0, the parameter estimate of Peer dummy is as high as 0.230 (Prob =0.041), and it increases to 0.337 (Prob =0.005). These results indicate that SCA lawsuit is a disaster to the CEO in Peer firms as well, and CEOs are more likely to be fired once an SCA lawsuit takes place in the industry.

Furthermore, we present that market adjusted common director ratio has positive but insignificant impact on CEO forced turnover. Since common director ratio is defined as the proportion of the shared directors between SCA firms and Peer or Non-related firms, it is surprising that it has no significant impact on forced CEO turnover. We will take a further look at it in Table 11.

5.3 Robustness Check

We have done robustness check by replacing control variables in Table 5-7, conducting the weak form Cox Proportional Hazard Regression of in Table 8, and doing Logistic regression in Table 9-10 .

[11] Prob>=Chi Square statistics.

5.3.1 Replacing control variables

Table 5 use market-adjusted measures for robustness check and the results are consistent with industry-adjusted measures in Table 4. Market adjusted Bottom Decile (past one-year loser) is not significantly related to Forced Turnover Dummy, whereas Market adjusted Momentum Loser (past two-year loser) is positively significantly related to Forced Turnover Dummy. This indicates that the board of the directors can accept that their past one-year stock return is ranked as loser, however, they will consider replacing the CEO if the firm is ranked as loser for past two years. The negative relationship between market adjusted momentum winner dummy (past two-year winner) and forced turnover dummy is insignificant over year -5 to 5 (except year 0 which is significant at 10% level), which implies that forced CEOs turnover is not significantly correlated with the momentum winner status of a firm. This is in line with Jenter and Kannan (2015) that CEOs of loser firms are more likely to be dismissed and CEOs of winner firms are much less affected by stock and accounting performance.

[Insert Table 5 around here.]

Table 5 also presents the impact of the other accounting measures on forced CEO turnover. Throughout year -5 to year 2, the market adjusted ROA ratio and market adjusted sales growth are negatively and significantly related to forced CEO turnover. This implies that good firm accounting performance decreases the likelihood of CEO being fired. Also, the table presents the negative relation between CEO age and forced CEO turnover over the whole sample period, which indicates that senior CEOs are less likely to be fired than junior CEOs. Moreover, the log of total asset is negatively and significantly related to forced CEO turnover, demonstrating that large firms are less likely to dismiss CEOs in the event year, which may be out of firm reputation concern.

Table 4 shows the relation between industry-adjusted performance and CEO turnover while Table 5 shows the relation between market-adjusted performance and CEO turnover. We also show that in the event year, industry adjusted momentum loser dummy (0.324 with Prob=0.089) has stronger impact than market adjusted momentum loser dummy (0.424 with Prob=0.014). In addition, around the event year, this observation also holds. Thus, a comparison between Table 4 and Table 5 shows that the impact of being market-wide loser on CEO turnover is stronger than the impact of being industry-side loser on CEO turnover.

If we compare Table 4 with Table 7 and Table 5 with Table 6, we can find that after replacing industry adjusted returns with market adjusted returns, industry adjusted momentum loser dummy and market adjusted momentum loser dummy becomes insignificant. This indicates that the impact of market adjusted returns on CEO forced turnover dominates the impact of industry adjusted momentum loser dummy and market adjusted momentum loser dummy. In other words, as long as the firm relative-to-market return is good, the CEO is not likely to be dismissed even though the stock is industry loser. This is consistent with the previous observation from the comparison between Table 4 and 5 that the impact of being market-wide loser on CEO turnover is stronger than the impact of being industry-side loser on CEO turnover.

[Insert Table 6 around here.]

[Insert Table 7 around here.]

5.3.2 Weak-form performance test

Table 8 demonstrates the weak form Cox Proportional Hazard Regression of Forced CEO Turnover on Unadjusted Stock Return, Unadjusted Firm Financial Performance Measures, Unadjusted Firm Accounting Performance Measures and Control Variables. Overall, the results are consistent with Strong form relative performance test.

[Insert Table 8 around here.]

5.3.3 Logistic regression

We also have done robustness check by using logistic regression in Tables 9 to 10. All results show that SCA litigation increases the risk of CEO being fired. Both SCA dummy and Peer dummy are significantly positively related to forced turnover dummy, and the relation is the strongest in the SCA year for SCA Dummy and one year after SCA year for Peer dummy.

[Insert Table 9 around here.]

[Insert Table 10 around here.]

5.4 Common director ratio

Though in Table 4 Panel B, market adjusted common director ratio has positive but insignificant impact on CEO forced turnover. We shall show that there is a significant relationship between the two below. Table 11 demonstrates that common director ratio has negative impact on stock performance. Intriguingly, this negative influence is inconspicuous in the event year and one year after, as is indicated by the insignificant negative impact in year 0 and year 1. One potential explanation is that in order to differentiate themselves from SCA firms, board of directors of peer and non-related firms tend to dismiss their CEOs when their firms have shared common directors with SCA firms in a pre-emptive fashion, to prevent the problem of earnings management and

weak accounting and financial performance ratios to go out of control. In contrast, ROA have significantly positive impact on stock returns all the years. This indicates that stock performance strongly reflects firm profitability.

5.5 Univariate Analysis of Difference of Means for Firms With and Without (W/O) Forced CEO Turnover

Table 12 presents the difference among the firms with forced CEO turnover at year 0 and firms without forced CEO turnover at year 0 (i.e., we divide all firms into 2 groups by considering whether they have CEO forced turnover in year 0). For each group, we further divide them into groups of SCA Firms, Non-related Firms, and Peer Firms. For SCA firms (Panel A), we observe that one year before SCA lawsuit filling year, SCA firms without forced CEO turnover in year 0 have on average 4.3% more forced CEO turnover than firms with forced CEO turnover in year 0 at 1% significance level. Likewise, for Peer firms (Panel C), 2 years before the event year, firms with forced CEO turnover in year 0 experience much higher CEO forced turnover than the firms with forced CEO turnover at 10% significance level and this trend is weaker in all other years. This implies that SCA and peer firms tend to take the precaution of CEO dismissal to avoid SCA litigation. The precaution is not observed in Non-related firms group (Panel B). In both years 0 and 1, Non-related firms with forced turnover in year 0 experience much higher forced CEO turnover than Non-related firms without forced turnover in year 0.

In the event year, SCA firms with forced CEO turnover generate materially more negative annual returns than the firms without forced CEO turnover. This is more significant after adjusting for industry effect. Similar phenomenon can be observed in Non-related and peer firm group one year before the event year.

In most of the years reported, SCA firms with forced CEO turnover have lower sales growth compared to SCA firms without forced CEO turnover the difference becomes significant in year 0 and year 1. This phenomenon is much weaker for Non-related firm group but more conspicuous for peer firm group.

In terms of winsorized ROA and common director ratio in most of the years, there is no conspicuous difference between firms with and without forced CEO turnover in SCA firm group. This is consistent with our previous explanation that the board of directors tend to take pre-emptive tactics to control earnings management and other accounting performance. However, peer firms with forced CEO turnover in year 0 have materially more absolute accrual and lower winsorized ROA than peer firms without forced CEO turnover and this is also observed in Non-related firms group.

In all three firm groups, common director ratio makes trivial difference in most of the years between with and without forced CEO turnover group.

5. Conclusion

CEO turnover contagion effect in the year of and after Securities Class Act (SCA) litigation is first documented in our work. By adopting Cox proportional hazard model, logistic model, strong and weak form relative performance test, we observe that in the year of litigation, except for SCA firms, peer firms also have materially higher forced CEO turnover compared to Non-related firms. This is accompanied by earnings management and unsustainable sales growth. Board of directors of peer firms tend to use pre-emptive tactics of CEO dismissal to distinguish from the SCA firms and avoid the SCA litigation, giving rise to CEO turnover contagion.

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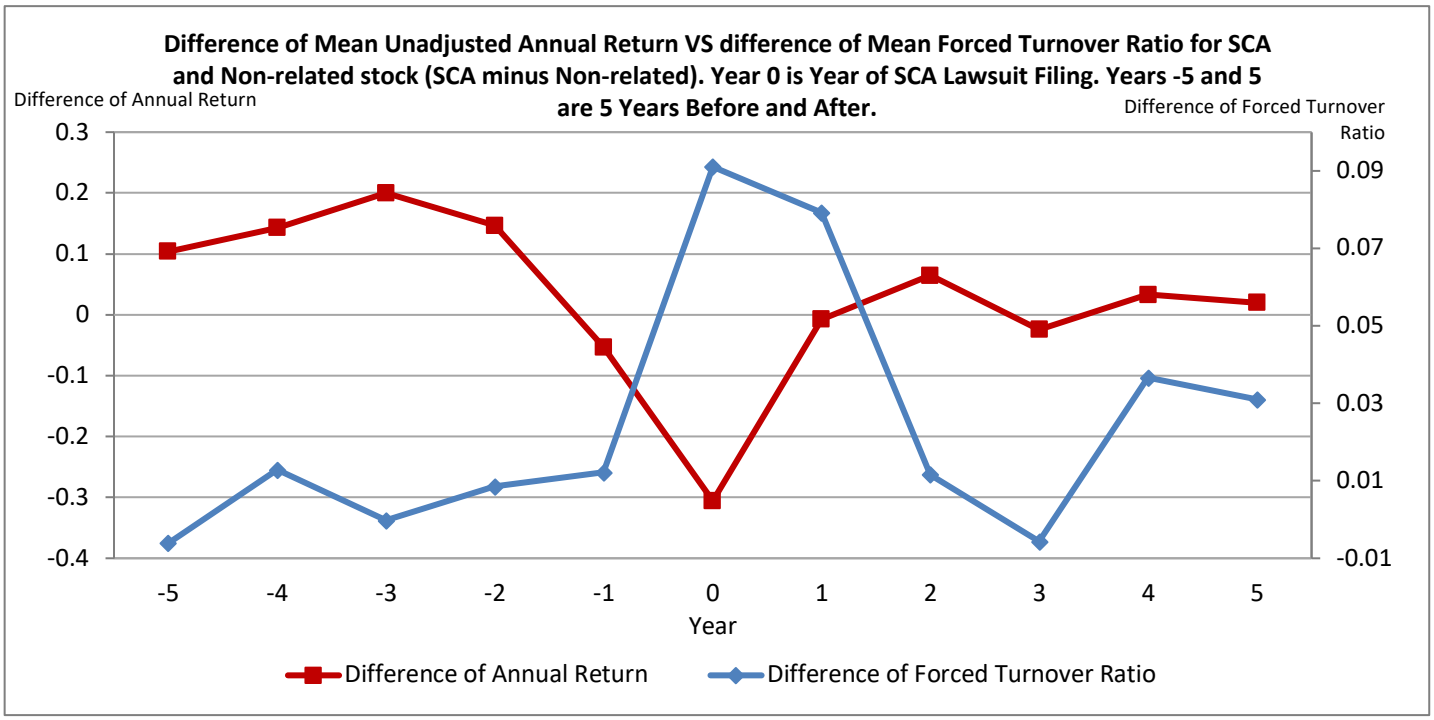
Figure 1 Panel A



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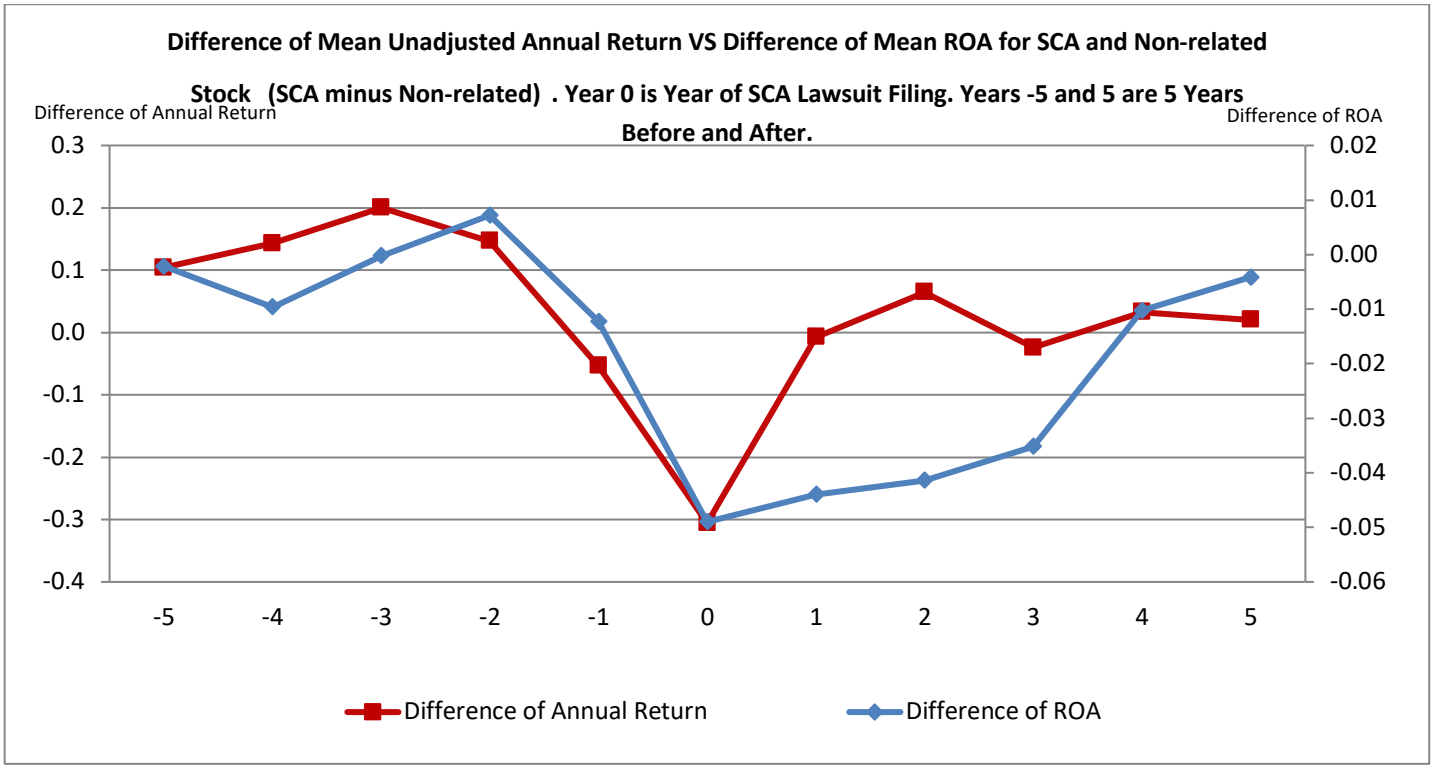

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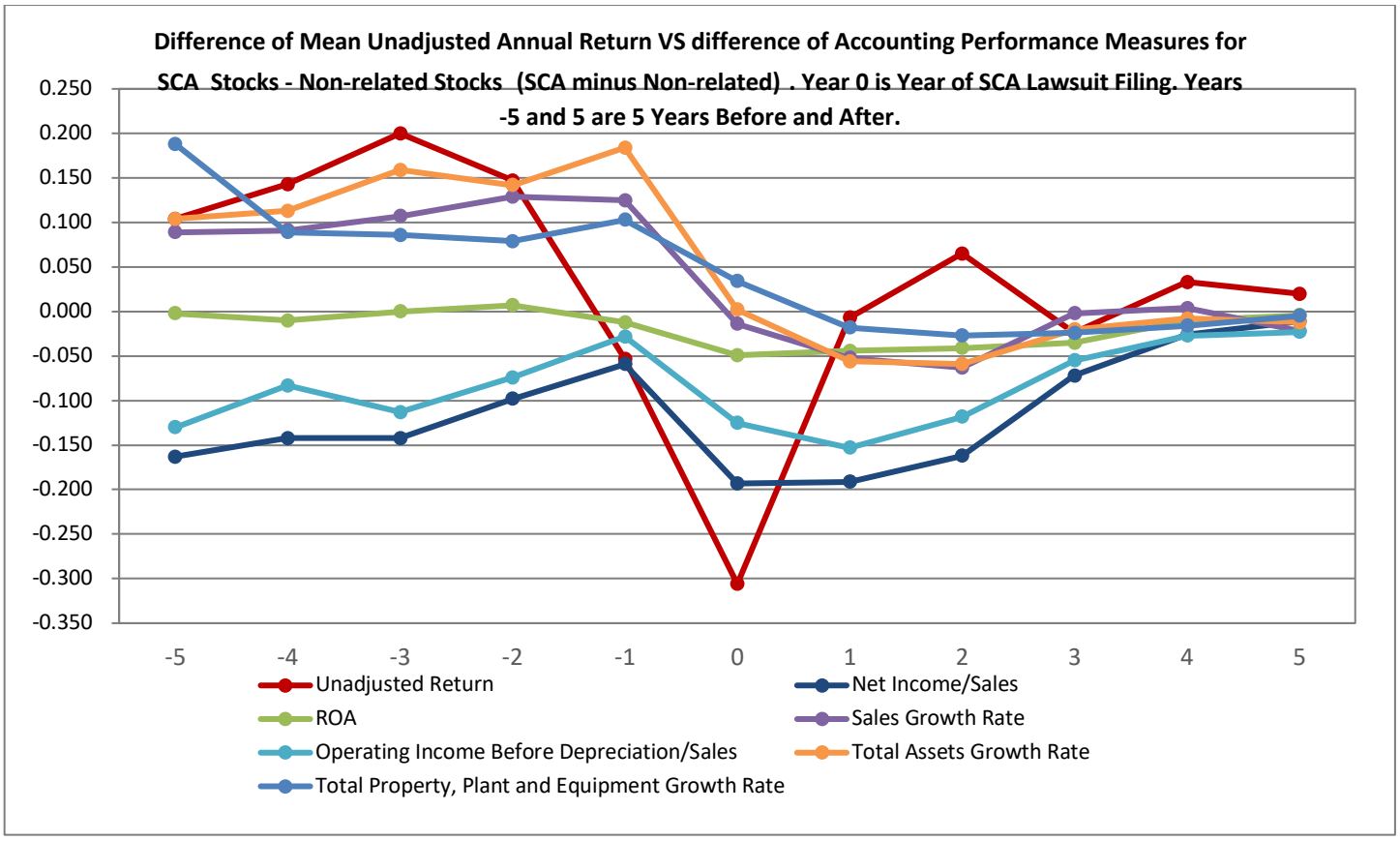

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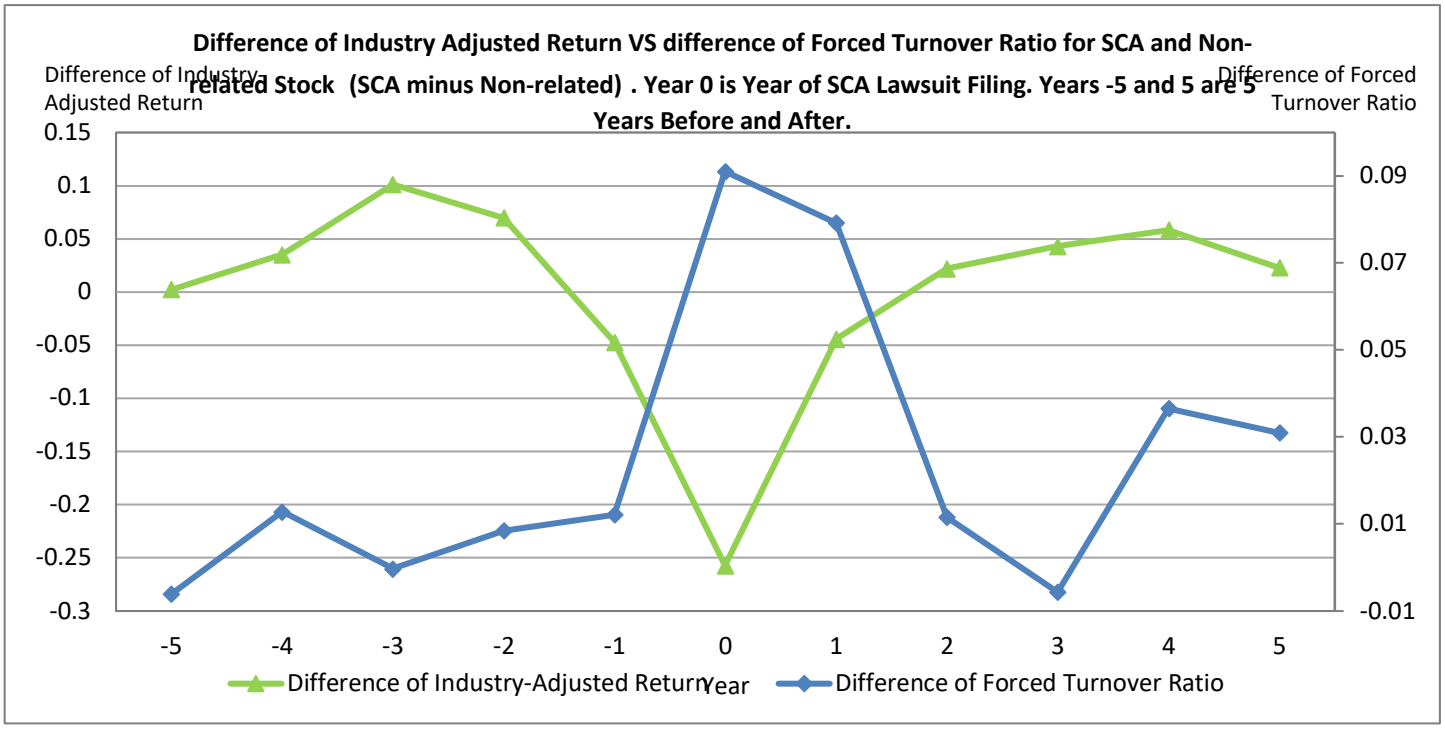

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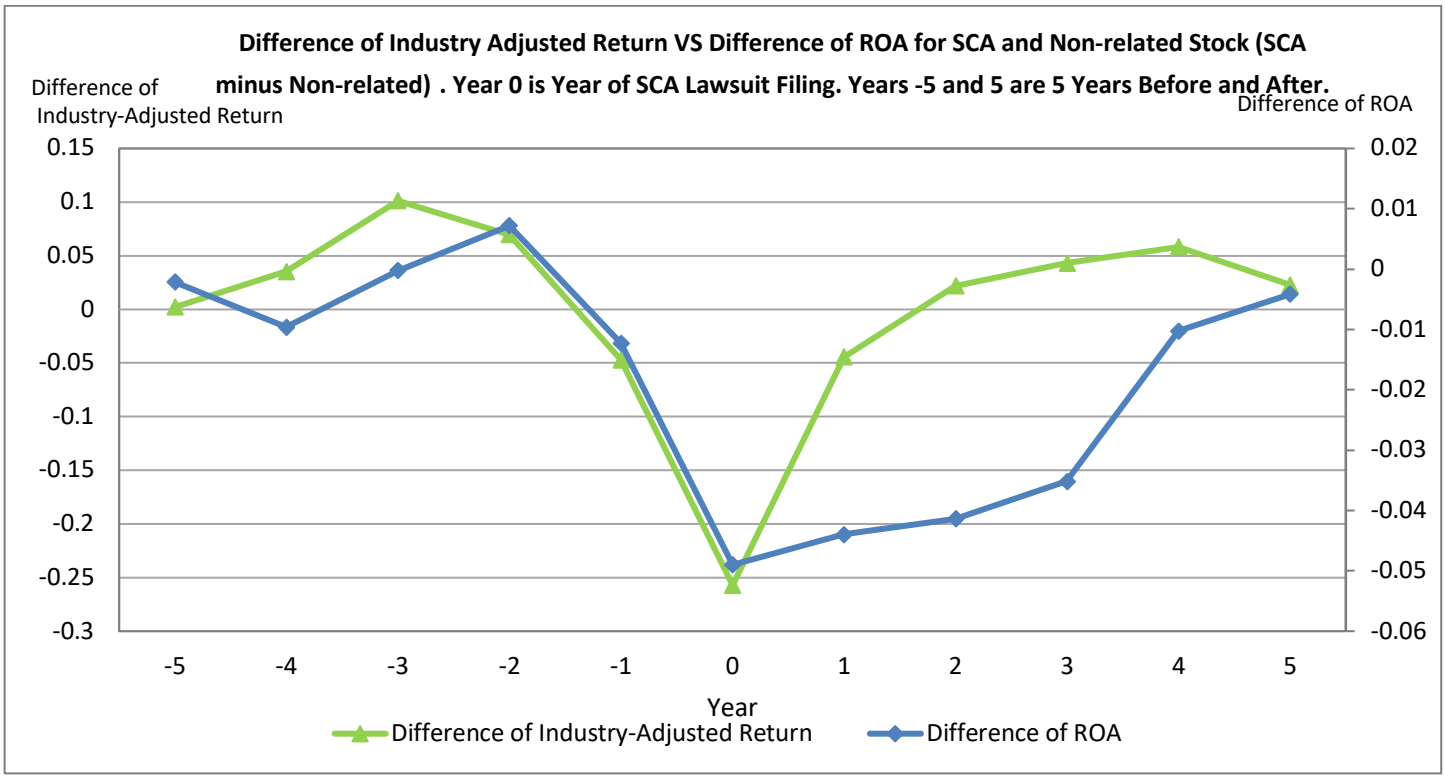
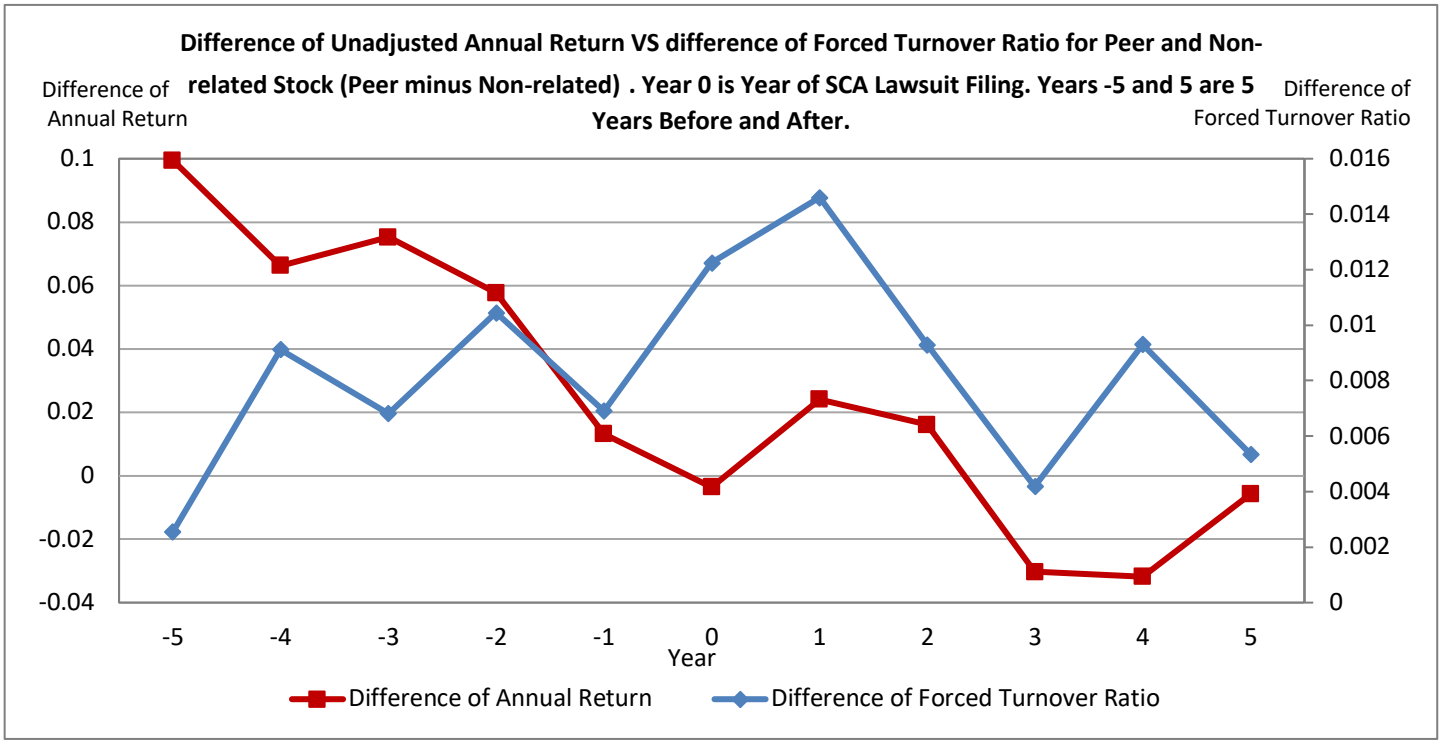


Figure 2 Panel A



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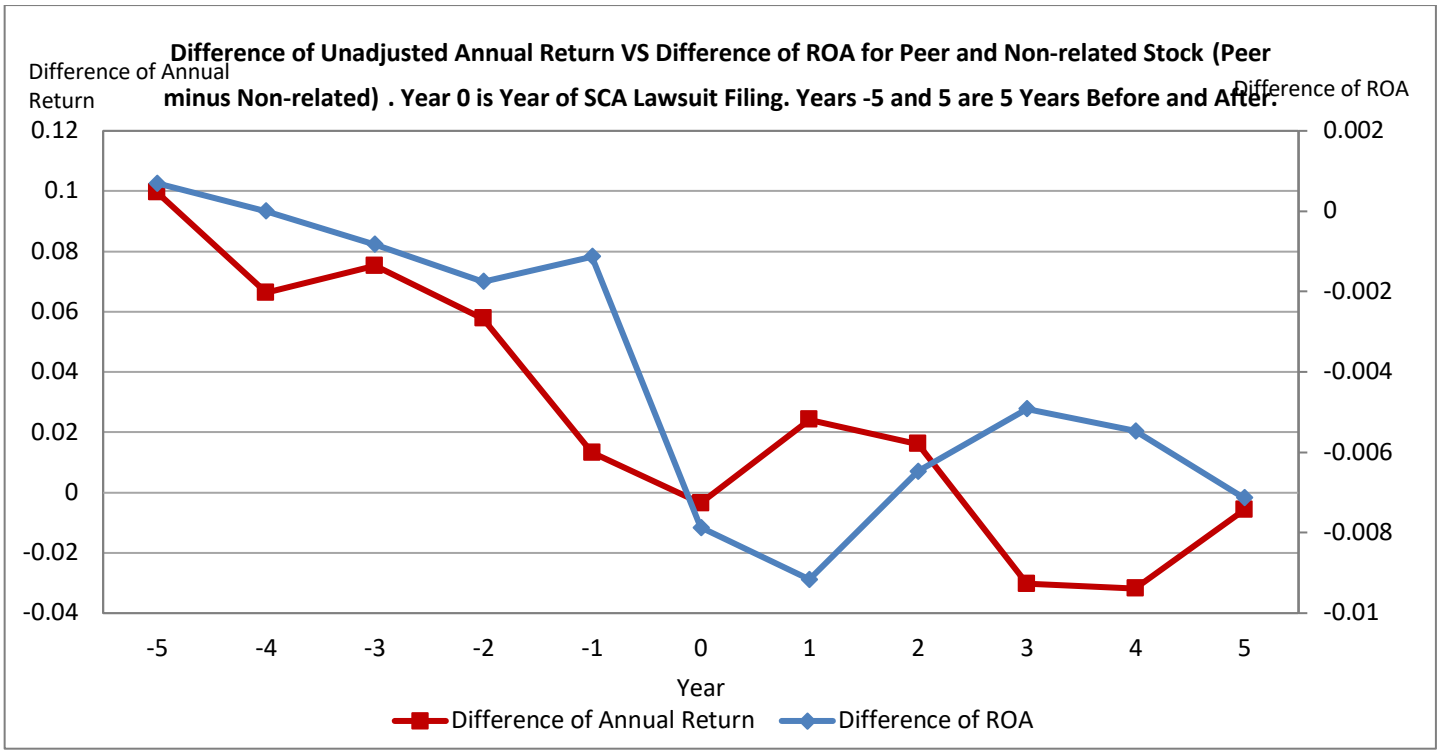

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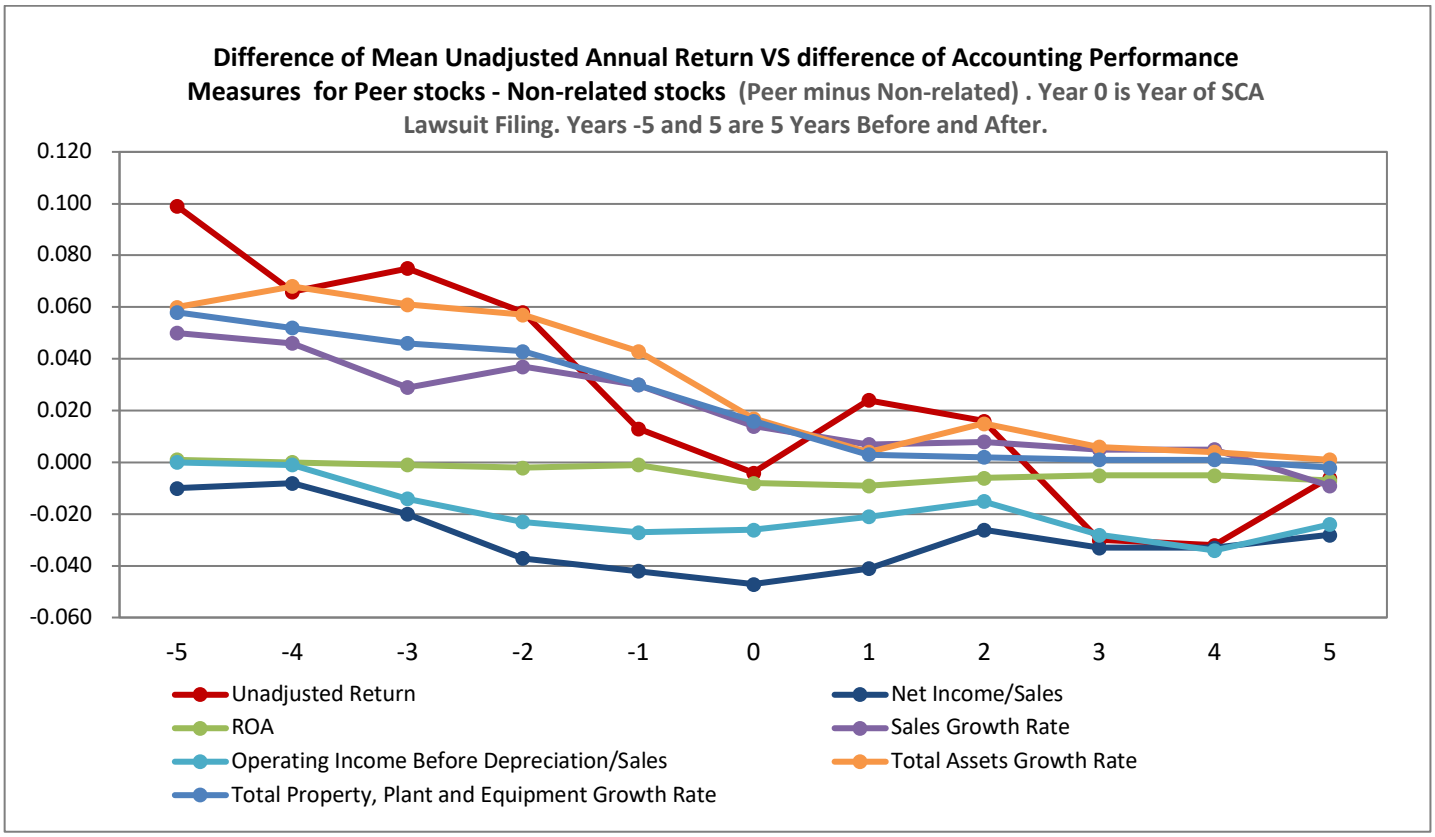

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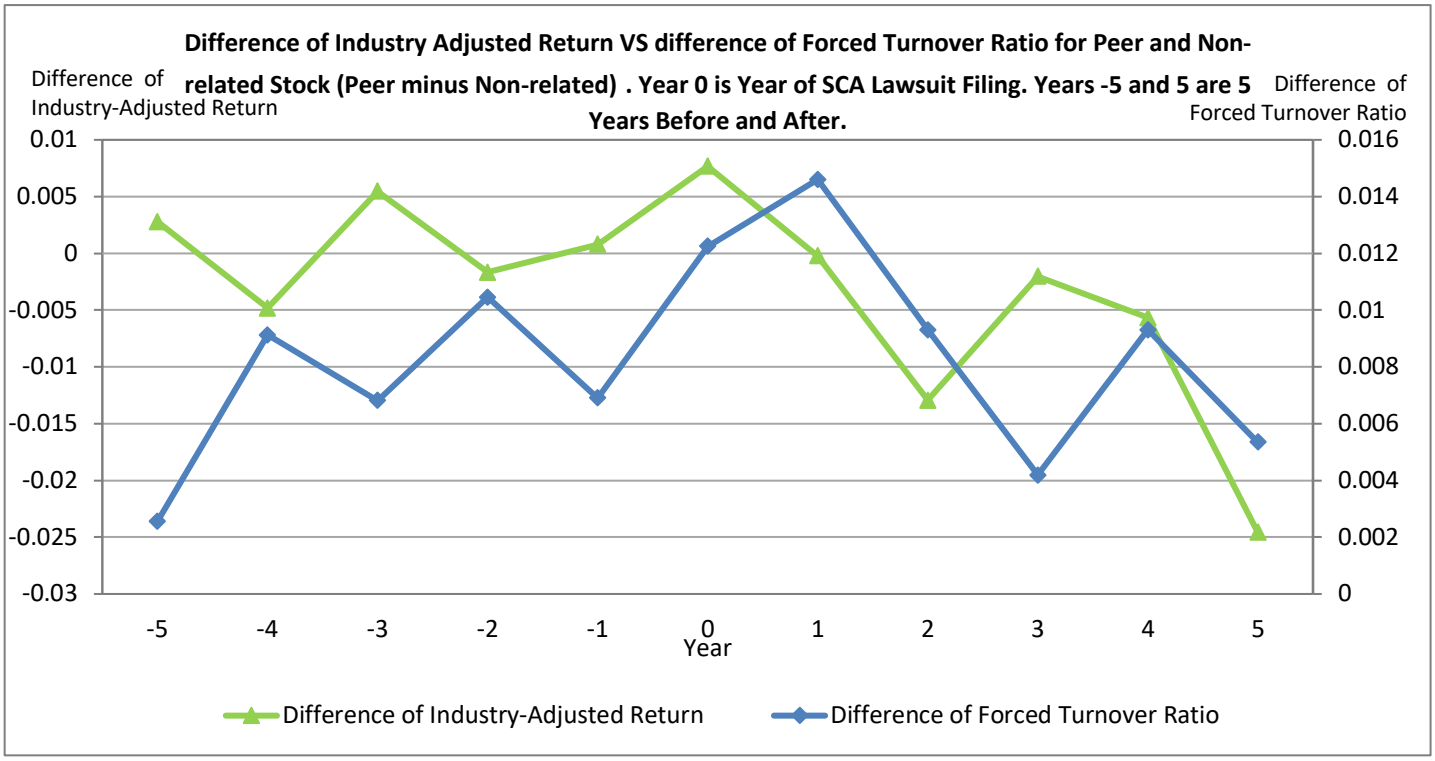

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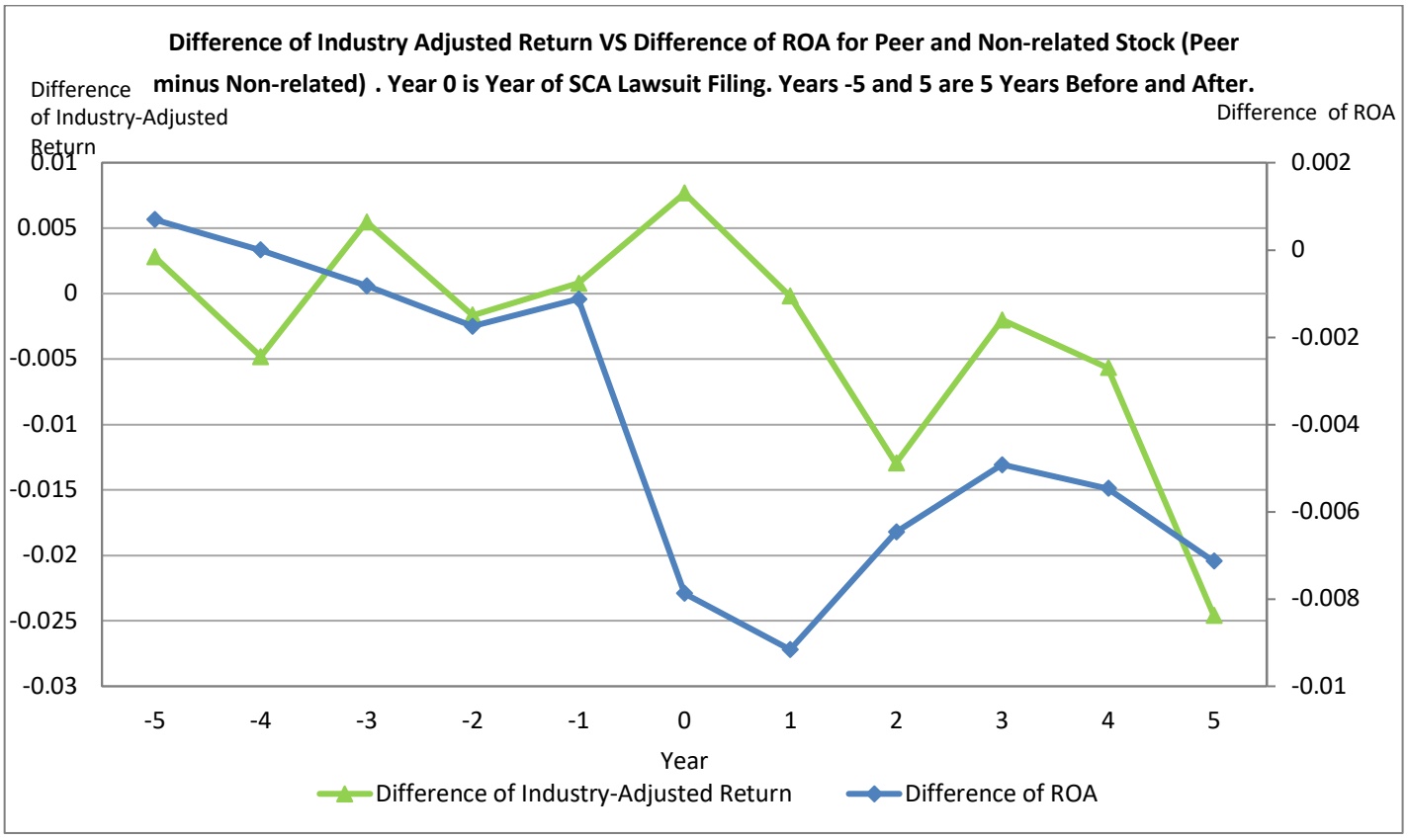

Table 1 Summary Statistics

Panel A: CEO Turnover

Year	No. of Forced Turnover	No. of Voluntary Turnover	Number of Firm Years	Forced Turnover Ratio	Voluntary Turnover Ratio	Total Turnover Ratio
1997	25	53	546	0.046	0.097	0.143
1998	26	76	692	0.038	0.110	0.147
1999	43	103	756	0.057	0.136	0.193
2000	36	96	774	0.047	0.124	0.171
2001	23	91	818	0.028	0.111	0.139
2002	22	84	790	0.028	0.106	0.134
2003	22	64	774	0.028	0.083	0.111
2004	33	69	787	0.042	0.088	0.130
2005	29	94	763	0.038	0.123	0.161
2006	26	70	745	0.035	0.094	0.129
2007	17	49	556	0.031	0.088	0.119
2008	14	55	569	0.025	0.097	0.121
2009	13	62	739	0.018	0.084	0.101
2010	10	60	745	0.013	0.081	0.094
2011	19	82	717	0.026	0.114	0.141
2012	12	78	766	0.016	0.102	0.117
Total	370	1186	11537	0.032	0.103	0.135

Panel B: Descriptive Statistics for All Stocks

Variable	N	Min	Max	Mean	Median
Unadjusted Annul Stock Return	11537	-0.97	26.19	0.15	0.09
Industry-Adjusted Stock Return	11537	-2.94	23.60	0.00	-0.03
Bottom Decile Dummy	11537	0.00	1.00	0.03	0.00
Momentum Loser Dummy	11537	0.00	1.00	0.05	0.00
Momentum Winner Dummy	11537	0.00	1.00	0.13	0.00
Current Ratio	11537	0.20	57.61	2.25	1.80
Earning Management	11537	0.00	1.49	0.06	0.04
Inventory COGS ratio	11537	0.00	1.29	0.07	0.05
Receivable to Sales ratio	11537	0.00	0.67	0.05	0.05
Debt Ratio	11537	0.02	2.16	0.52	0.53
ROA	11537	-1.85	0.53	0.05	0.05
Sales Growth	11537	-0.87	5.25	0.11	0.08
Age	11537	32.00	96.00	56.07	56.00
Tenure	11526	0.00	61.04	7.29	5.25
Log of Total Assets	11537	3.04	12.71	7.56	7.42
Ratio of Common Directors	11537	0.00	0.73	0.02	0.00

Panel C Descriptive Statistics for Different Groups of Firms

Firm Type	Type	Unadjusted Annul Stock Return	Adjusted Annul Stock Return	Earning Management	ROA	Sales Growth	Ratio of Common Directors	Forced Turnover Ratio
SCA	N	345	345	345	345	345	345	345
	Mean	0.094	-0.049	0.080	0.036	0.216	0.022	0.116
	Min	-0.878	-2.227	0.000	-1.099	-0.705	0.000	0.000
	Max	3.240	3.183	1.488	0.356	5.248	0.250	1.000
	Median	0.006	-0.104	0.051	0.049	0.127	0.000	0.000
Non-related	N	6991	6991	6991	6991	6991	6991	6991
	Mean	0.147	-0.002	0.049	0.048	0.092	0.015	0.025
	Min	-0.966	-2.182	0.000	-1.845	-0.590	0.000	0.000
	Max	6.492	4.956	1.094	0.531	3.837	0.727	2.000#
	Median	0.101	-0.026	0.032	0.052	0.072	0.000	0.000
Peer	N	4201	4201	4201	4201	4201	4201	4201
	Mean	0.161	-0.001	0.070	0.047	0.122	0.015	0.037
	Min	-0.885	-2.942	0.000	-1.749	-0.875	0.000	0.000
	Max	26.194	23.601	1.330	0.282	2.980	0.571	1.000
	Median	0.091	-0.038	0.042	0.059	0.088	0.000	0.000

One company has 2 forced turnovers in the same year, so the forced turnover ratio is 2. 345+6991+4201=11537 in Table 1 Panel A.

Table 2 Panel A Summary of Forced Turnover Ratio and Firm Performance for SCA and Non-related Stock

This panel presents the mean values of six variables for SCA and Non groups (t-stat is for SCA minus Non-related and in bracket). The definitions of the variables are explained in the appendix. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After. For space reasons, only some of the years are shown.

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	SCA	Obs	284	335	345	345	324	313	232
		Mean	0.021	0.036	0.038	0.116	0.105	0.042	0.056
	Non	Obs	5,879	6,886	6,983	6,991	6,760	6,513	4,668
		Mean	0.027	0.027	0.025	0.025	0.026	0.030	0.025
	SCA - Non	t-stat	[0.69]	[-0.82]	[-1.17]	[-5.24***]	[-4.61***]	[-1.01]	[-2.02**]
Unadjusted Annual Return	SCA	Obs	330	345	345	345	343	332	263
		Mean	0.291	0.300	0.094	-0.159	0.127	0.196	0.156
	Non	Obs	6,807	6,991	6,991	6,991	6,987	6,815	5,297
		Mean	0.187	0.153	0.147	0.146	0.134	0.131	0.135
	SCA - Non	t-stat	[-2.15**]	[-3.41***]	[1.76*]	[12.43***]	[0.21]	[-1.68*]	[-0.38]
Industry-Adjusted Return	SCA	Obs	222	345	345	287	260	225	151
		Mean	0.017	0.073	-0.049	-0.265	-0.057	0.009	0.017
	Non	Obs	4,604	6,976	6,991	5,992	5,232	4,482	2,945
		Mean	0.014	0.004	-0.001	-0.008	-0.013	-0.013	-0.006
	SCA - Non	t-stat	[-0.08]	[-2.02**]	[1.77*]	[11.18***]	[1.56]	[-0.57]	[-0.89]
Earning Management	SCA	Obs	310	343	345	345	331	320	239
		Mean	0.081	0.078	0.080	0.065	0.060	0.064	0.065
	Non	Obs	6,345	6,943	6,991	6,991	6,791	6,554	4,758
		Mean	0.060	0.052	0.049	0.049	0.047	0.044	0.042
	SCA - Non	t-stat	[-3.74***]	[-4.15***]	[-4.95***]	[-3.99***]	[-3.64***]	[-4.60***]	[-4.32***]
ROA	SCA	Obs	341	345	345	345	332	326	245
		Mean	0.055	0.057	0.036	-0.001	0.002	0.002	0.040
	Non	Obs	6,951	6,991	6,991	6,991	6,854	6,660	4,882
		Mean	0.057	0.049	0.048	0.048	0.046	0.044	0.045
	SCA - Non	t-stat	[0.34]	[-0.96]	[1.58]	[3.37***]	[4.24***]	[4.64***]	[0.62]
Common Director Ratio	SCA	Obs	193	293	345	345	283	254	162
		Mean	0.018	0.023	0.022	0	0.024	0.033	0.020
	Non	Obs	4,126	5,984	6,991	6,991	5,975	5,258	3,457
		Mean	0.016	0.014	0.015	0.014	0.015	0.015	0.015
	SCA-Non	t-stat	[-0.65]	[-2.45**]	[-2.64***]	[26.93***]	[-2.57**]	[-3.69***]	[-1.27]
Winsorized Sales Growth	SCA	Obs	335	345	345	345	332	325	244
		Mean	0.233	0.227	0.216	0.074	0.032	0.013	0.047
	Non	Obs	6,878	6,990	6,991	6,991	6,854	6,652	4,879
		Mean	0.147	0.098	0.092	0.088	0.083	0.076	0.069
	SCA-Non	t-stat	[-4.26***]	[-5.92***]	[-4.69***]	[0.93]	[4.75***]	[6.58***]	[1.75*]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 2 Panel B Difference of Mean Unadjusted Return and Accounting Measures between SCA and Non-related groups (SCA minus Non-related). Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

Year	Unadjusted Return	Net Income/Sales	ROA	Sales Growth Rate	Operating Income Before Depreciation /Sales	Total Assets Growth Rate	Total Property, Plant and Equipment Growth Rate
-5	0.104	-0.163	-0.002	0.089	-0.130	0.104	0.188
-4	0.143	-0.142	-0.010	0.091	-0.083	0.113	0.089
-3	0.200	-0.142	0.000	0.107	-0.113	0.159	0.086
-2	0.147	-0.098	0.007	0.129	-0.074	0.142	0.079
-1	-0.053	-0.059	-0.012	0.125	-0.028	0.184	0.103
0	-0.306	-0.193	-0.049	-0.014	-0.125	0.002	0.034
1	-0.007	-0.191	-0.044	-0.052	-0.153	-0.056	-0.018
2	0.065	-0.162	-0.041	-0.063	-0.118	-0.059	-0.027
3	-0.024	-0.072	-0.035	-0.002	-0.055	-0.020	-0.024
4	0.033	-0.026	-0.010	0.004	-0.027	-0.008	-0.016
5	0.020	-0.011	-0.004	-0.022	-0.023	-0.012	-0.005

Table 2 Panel C Mean of Firm Performance for SCA and Non-related Stock (t stat is for SCA minus Non-related and in bracket). Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After. For space reason, only Years -5, 0 and +5 are shown.

Year		-5	0	5
Total Turnover Ratio	SCA	0.123	0.264	0.138
	Non	0.121	0.127	0.124
	SCA-Non	[-0.10]	[-5.25***]	[-0.59]
Voluntary Turnover Ratio	SCA	0.102	0.148	0.082
	Non	0.094	0.102	0.099
	SCA-Non	[-0.45]	[-2.27**]	[0.86]
Dummy of Unadjusted Annual Return in Bottom Decile	SCA	0.040	0.058	0.072
	Non	0.025	0.022	0.041
	SCA-Non	[-1.40]	[-2.85***]	[-1.93*]
Momentum Loser Dummy	SCA	0.065	0.209	0.072
	Non	0.033	0.048	0.058
	SCA-Non	[-2.26**]	[-7.30***]	[-0.81]
Momentum Winner Dummy	SCA	0.191	0.029	0.140
	Non	0.129	0.134	0.127
	SCA-Non	[-2.79***]	[10.51***]	[-0.56]
Current Ratio	SCA	2.484	2.060	2.011
	Non	2.109	2.062	2.042
	SCA-Non	[-2.40**]	[0.02]	[0.31]
Inventory COGS Ratio	SCA	0.070	0.072	0.075
	Non	0.064	0.063	0.063
	SCA-Non	[-1.49]	[-1.71*]	[-1.59]
Receivable to Sales Ratio	SCA	0.066	0.066	0.057
	Non	0.055	0.052	0.051
	SCA-Non	[-4.21***]	[-3.52***]	[-2.32**]
CEO Age	SCA	55.736	54.957	55.391
	Non	56.687	56.416	56.481
	SCA-Non	[2.22**]	[3.61***]	[2.57**]
Tenure	SCA	7.616	7.350	6.038
	Non	7.585	7.220	6.999
	SCA-Non	[-0.07]	[-0.32]	[2.56**]
Debt Ratio	SCA	0.523	0.573	0.582
	Non	0.532	0.550	0.570
	SCA-Non	[0.68]	[-1.32]	[-0.77]
Log of Total Asset	SCA	7.388	8.155	8.397
	Non	7.265	7.712	7.984
	SCA-Non	[-1.19]	[-4.80***]	[-3.70***]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 2 Panel D Mean of Forced Turnover Ratio of All Stocks by Low and High Financial and Accounting Performance and Earning Management for Year -5 to -1. T-stat is for Low Minus High and in bracket. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

Year		Unadjusted Return		ROA		Net Income to Sales		Earning Management	
		Low	High	Low	High	Low	High	Low	High
-5	Turnover Ratio	0.04	0.018	0.045	0.02	0.043	0.022	0.021	0.038
	N	3267	3036	3078	3251	3038	3271	3173	2885
	t-stat	[5.17***]		[5.61***]		[4.59***]		[-3.71***]	
-2	Turnover Ratio	0.046	0.022	0.053	0.022	0.051	0.022	0.026	0.039
	N	3792	3768	3780	3774	3780	3788	3762	3742
	t-stat	[5.69***]		[7.00***]		[6.56***]		[-3.02***]	
-1	Turnover Ratio	0.039	0.021	0.047	0.018	0.046	0.018	0.023	0.034
	N	3843	3841	3838	3844	3839	3845	3841	3842
	t-stat	[4.59***]		[7.21***]		[6.84***]		[-2.80***]	
0	Turnover Ratio	0.047	0.025	0.056	0.021	0.055	0.02	0.026	0.037
	N	3845	3846	3845	3846	3845	3846	3845	3846
	t-stat	[5.34***]		[8.22***]		[8.08***]		[-2.61***]	
1	Turnover Ratio	0.052	0.024	0.06	0.021	0.059	0.019	0.027	0.039
	N	3762	3679	3681	3737	3692	3732	3698	3690
	t-stat	[6.24***]		[8.44***]		[9.03***]		[-3.01***]	
2	Turnover Ratio	0.048	0.028	0.061	0.02	0.062	0.018	0.029	0.039
	N	3625	3544	3514	3613	3531	3602	3542	3526
	t-stat	[4.58***]		[8.70***]		[9.43***]		[-2.53**]	
5	Turnover Ratio	0.039	0.025	0.051	0.018	0.049	0.016	0.024	0.031
	N	2540	2686	2539	2637	2552	2624	2539	2541
	t-stat	[2.79***]		[6.51***]		[6.62***]		[-1.71*]	

*, ** and *** denote significance at 10%, 5% and 1% respectively.
In every year, we sort all firms into three groups: low, medium and high. Only the comparison between low and high is presented here

Table 2 Panel E Mean of Forced Turnover Ratio For Each Group of Stocks (SCA, Peer and Non-related) by Low and High Financial and Accounting Performance and Earning Management. T-stat is for Low Minus High and in bracket. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

Year	Firms		Unadjusted Return		ROA		Net Income to Sales		Earning Management	
			Low	High	Low	High	Low	High	Low	High
-5	SCA	Forced Turnover	0.033	0.022	0.032	0.02	0.033	0.011	0.011	0.034
		N	92	92	94	98	92	93	88	89
		t-stat	[0.45]		[0.50]		[1.02]		[-1.00]	
	Non	Forced Turnover	0.038	0.017	0.039	0.022	0.038	0.026	0.026	0.032
		N	2005	1877	1889	1990	1873	2024	1949	1805
		t-stat	[4.00***]		[3.07***]		[2.23**]		[-0.99]	
	Peer	Forced Turnover	0.044	0.017	0.055	0.018	0.049	0.018	0.014	0.048
		N	1169	1079	1083	1161	1065	1176	1134	1008
		t-stat	[3.87***]		[4.61***]		[3.99***]		[-4.35***]	
-2	SCA	Forced Turnover	0.045	0.036	0.036	0.044	0.056	0.035	0.027	0.064
		N	112	110	110	114	108	115	112	109
		t-stat	[0.31]		[-0.28]		[0.74]		[-1.33]	
	Non	Forced Turnover	0.04	0.018	0.043	0.022	0.042	0.021	0.027	0.031
		N	2304	2281	2286	2293	2285	2299	2282	2270
		t-stat	[4.34***]		[3.94***]		[4.08***]		[-0.91]	
	Peer	Forced Turnover	0.054	0.026	0.07	0.02	0.063	0.018	0.027	0.048
		N	1377	1375	1385	1374	1388	1375	1363	1360
		t-stat	[3.70***]		[6.39***]		[5.94***]		[-2.81***]	
-1	SCA	Forced Turnover	0.07	0.017	0.061	0.009	0.061	0.035	0.043	0.035
		N	115	115	115	115	115	115	115	115
		t-stat	[1.95*]		[2.17**]		[0.92]		[0.34]	
	Non	Forced Turnover	0.036	0.018	0.043	0.018	0.043	0.017	0.021	0.028
		N	2328	2328	2323	2329	2325	2329	2327	2327
		t-stat	[3.62***]		[4.87***]		[5.17***]		[-1.42]	
	Peer	Forced Turnover	0.041	0.026	0.053	0.019	0.049	0.017	0.026	0.045
		N	1400	1397	1400	1400	1399	1400	1398	1399
		t-stat	[2.21**]		[4.78***]		[4.77***]		[-2.76***]	
0	SCA	Forced Turnover	0.174	0.087	0.183	0.087	0.183	0.07	0.096	0.113
		N	115	115	115	115	115	115	115	115
		t-stat	[1.97**]		[2.14**]		[2.61***]		[-0.43]	
	Non	Forced Turnover	0.034	0.021	0.041	0.018	0.041	0.016	0.02	0.027
		N	2330	2330	2330	2330	2330	2330	2330	2330
		t-stat	[2.87***]		[4.78***]		[5.16***]		[-1.65*]	
	Peer	Forced Turnover	0.053	0.03	0.067	0.02	0.065	0.019	0.032	0.046
		N	1400	1400	1400	1400	1400	1400	1400	1400
		t-stat	[3.04***]		[6.15***]		[6.06***]		[-1.95*]	
1	SCA	Forced Turnover	0.164	0.075	0.204	0.047	0.204	0.019	0.102	0.131
		N	110	107	108	106	108	105	108	107
		t-stat	[2.03**]		[3.55***]		[4.48***]		[-0.66]	
	Non	Forced Turnover	0.039	0.021	0.047	0.017	0.046	0.017	0.021	0.029
		N	2283	2233	2233	2267	2241	2263	2241	2242
		t-stat	[3.51***]		[5.62***]		[5.59***]		[-1.62]	
	Peer	Forced Turnover	0.064	0.025	0.070	0.026	0.069	0.019	0.032	0.048
		N	1370	1340	1340	1362	1342	1366	1349	1341
		t-stat	[4.85***]		[5.43***]		[6.40***]		[-2.19**]	
2	SCA	Forced Turnover	0.019	0.057	0.051	0.028	0.061	0.019	0.039	0.058
		N	103	106	99	107	99	106	102	103
		t-stat	[-1.41]		[0.82]		[1.52]		[-0.63]	
	Non	Forced Turnover	0.046	0.024	0.054	0.017	0.055	0.016	0.023	0.040
		N	2197	2156	2139	2195	2145	2189	2144	2135
		t-stat	[4.03***]		[6.65***]		[6.98***]		[-3.09***]	
	Peer	Forced Turnover	0.054	0.033	0.071	0.024	0.072	0.017	0.040	0.043
		N	1324	1283	1278	1313	1285	1314	1293	1288
		t-stat	[2.63***]		[5.71***]		[6.91***]		[-0.32]	
5	SCA	Forced Turnover	0.093	0.037	0.092	0.051	0.079	0.013	0.013	0.065
		N	75	82	76	78	76	77	76	77
		t-stat	[1.43]		[0.98]		[1.96*]		[-1.66*]	
	Non	Forced Turnover	0.032	0.023	0.042	0.016	0.042	0.015	0.022	0.033
		N	1492	1630	1518	1579	1523	1567	1520	1523
		t-stat	[1.50]		[4.23***]		[4.53***]		[-1.88*]	
	Peer	Forced Turnover	0.048	0.027	0.061	0.016	0.058	0.016	0.031	0.027
		N	967	973	944	980	951	983	948	943
		t-stat	[2.43**]		[5.12***]		[4.84***]		[0.53]	

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 3 Panel A: Mean of Forced Turnover Ratio and Firm Performance for Peer and Non-related Stock (t stat is for Peer minus Non-related and in bracket). Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After. For space reasons, only some of the years is shown.

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	Peer	Obs	3,393	4,132	4,198	4,201	4,065	3,899	2,893
		Mean	0.030	0.038	0.032	0.037	0.040	0.039	0.030
	Non	Obs	5,879	6,886	6,983	6,991	6,760	6,513	4,668
		Mean	0.027	0.027	0.025	0.025	0.026	0.030	0.025
	Peer-Non	t-stat	[-0.70]	[-2.91***]	[-2.08**]	[-3.53***]	[-4.01***]	[-2.47**]	[-1.36]
Unadjusted Annual Return	Peer	Obs	4,046	4,201	4,201	4,201	4,198	4,087	3,188
		Mean	0.286	0.211	0.161	0.143	0.158	0.147	0.130
	Non	Obs	6,807	6,991	6,991	6,991	6,987	6,815	5,297
		Mean	0.187	0.153	0.147	0.146	0.134	0.131	0.135
	Peer-Non	t-stat	[-6.90***]	[-4.46***]	[-1.09]	[0.30]	[-2.06**]	[-1.50]	[0.52]
Industry-Adjusted Return	Peer	Obs	2,718	4,201	4,201	3,625	3,188	2,843	1,965
		Mean	0.017	0.002	-0.001	-0.000	-0.013	-0.026	-0.030
	Non	Obs	4,604	6,976	6,991	5,992	5,232	4,482	2,945
		Mean	0.014	0.004	-0.002	-0.008	-0.013	-0.013	-0.006
	Peer-Non	t-stat	[-0.19]	[0.15]	[-0.08]	[-0.69]	[0.02]	[1.36]	[2.61***]
Earning Management	Peer	Obs	3,793	4,165	4,201	4,201	4,093	3,945	2,968
		Mean	0.082	0.074	0.070	0.065	0.061	0.060	0.054
	Non	Obs	6,345	6,943	6,991	6,991	6,791	6,554	4,758
		Mean	0.060	0.052	0.049	0.049	0.047	0.044	0.042
	Peer-Non	t-stat	[-10.84***]	[-13.08***]	[-13.13***]	[-11.44***]	[-10.79***]	[-12.18***]	[-8.93***]
ROA	Peer	Obs	4,170	4,201	4,201	4,201	4,120	3,996	3,029
		Mean	0.058	0.048	0.047	0.040	0.037	0.037	0.038
	Non	Obs	6,951	6,991	6,991	6,991	6,854	6,660	4,882
		Mean	0.057	0.049	0.048	0.048	0.046	0.044	0.045
	Peer-Non	t-stat	[-0.38]	[0.81]	[0.56]	[3.52***]	[3.88***]	[2.64***]	[2.68***]
Common Director Ratio	Peer	Obs	2,309	3,513	4,201	4,201	3,517	3,117	2,196
		Mean	0.015	0.016	0.015	0.017	0.015	0.017	0.016
	Non	Obs	4,126	5,984	6,991	6,991	5,975	5,258	3,457
		Mean	0.016	0.014	0.015	0.014	0.015	0.015	0.015
	Peer-Non	t-stat	[0.83]	[-1.77*]	[-0.91]	[-2.59***]	[-0.23]	[-2.33**]	[-0.59]
Winsorized Sales Growth	Peer	Obs	4,121	4,200	4,201	4,201	4,120	3,996	3,024
		Mean	0.194	0.134	0.122	0.102	0.090	0.085	0.060
	Non	Obs	6,878	6,990	6,991	6,991	6,854	6,652	4,879
		Mean	0.144	0.098	0.092	0.088	0.083	0.076	0.069
	Peer-Non	t-stat	[-6.43***]	[-7.20***]	[-6.24***]	[-3.11***]	[-1.50]	[-1.98**]	[2.10**]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 3 Panel B Difference of Mean of Unadjusted Return and Accounting Measures (Peer minus Non-related). Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.							
Year	**Unadjusted Return**	**Net Income/Sales**	**ROA**	**Sales Growth Rate**	**Operating Income Before Depreciation /Sales**	**Total Assets Growth Rate**	**Total Property, Plant and Equipment Growth Rate**
-5	0.099	-0.010	0.001	0.050	0.000	0.060	0.058
-4	0.066	-0.008	0.000	0.046	-0.001	0.068	0.052
-3	0.075	-0.020	-0.001	0.029	-0.014	0.061	0.046
-2	0.058	-0.037	-0.002	0.037	-0.023	0.057	0.043
-1	0.013	-0.042	-0.001	0.030	-0.027	0.043	0.030
0	-0.004	-0.047	-0.008	0.014	-0.026	0.017	0.016
1	0.024	-0.041	-0.009	0.007	-0.021	0.004	0.003
2	0.016	-0.026	-0.006	0.008	-0.015	0.015	0.002
3	-0.030	-0.033	-0.005	0.005	-0.028	0.006	0.001
4	-0.032	-0.033	-0.005	0.005	-0.034	0.004	0.001
5	-0.006	-0.028	-0.007	-0.009	-0.024	0.001	-0.002

Table 3 Panel C Mean of Firm Performance Measures for Peer and Non-related Stock (t-stat is for Peer minus Non-related and in bracket). Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After. For space reason, only Years -5, 0 and +5 are shown.

Year		-5	0	5
Total Turnover Ratio	Peer	0.111	0.138	0.128
	Non	0.121	0.127	0.124
	Peer-Non	[1.37]	[-1.69*]	[-0.46]
Voluntary Turnover Ratio	Peer	0.082	0.101	0.097
	Non	0.094	0.102	0.099
	Peer-Non	[2.00**]	[0.13]	[0.23]
Unadjusted Annual Return in Bottom Decile	Peer	0.031	0.040	0.046
	Non	0.025	0.022	0.041
	Peer-Non	[-1.84*]	[-5.23***]	[-1.23]
Momentum Loser Dummy	Peer	0.046	0.067	0.068
	Non	0.033	0.048	0.058
	Peer-Non	[-3.19***]	[-4.20***]	[-1.71*]
Momentum Winner Dummy	Peer	0.169	0.118	0.119
	Non	0.129	0.134	0.127
	Peer-Non	[-5.59***]	[2.35**]	[0.98]
Current Ratio	Peer	2.553	2.504	2.507
	Non	2.109	2.062	2.042
	Peer-Non	[-10.64***]	[-11.01***]	[-4.38***]
Inventory COGS Ratio	Peer	0.075	0.073	0.073
	Non	0.064	0.063	0.063
	Peer-Non	[-5.78***]	[-6.66***]	[-5.74***]
Receivable to Sales Ratio	Peer	0.061	0.058	0.055
	Non	0.055	0.052	0.051
	Peer-Non	[-7.40***]	[-7.53***]	[-4.78***]
CEO Age	Peer	55.698	55.503	55.882
	Non	56.687	56.416	56.481
	Peer-Non	[6.06***]	[6.43***]	[3.71***]
Tenure	Peer	7.579	7.227	7.027
	Non	7.585	7.220	6.999
	Peer-Non	[0.04]	[-0.06]	[-0.20]
Debt Ratio	Peer	0.471	0.485	0.509
	Non	0.532	0.550	0.570
	Peer-Non	[15.04***]	[16.18***]	[11.59***]
Log of Total Asset	Peer	6.875	7.475	7.780
	Non	7.265	7.712	7.984
	Peer-Non	[12.56***]	[8.19***]	[5.76***]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 4 Two-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Financial Performance, Accounting Performance and Earning Management.

In the first-stage regressions, we follow Jenter and Kanaan (2015) in using industry mean to obtain industry adjusted variables for the following variables: unadjusted annual stock return, return in bottom decile, momentum loser dummy, momentum winner dummy, ROA, sales growth, receivable to sales ratio, current ratio, inventory to cost ratio, debt ratio and net income to sales ratio. In the second-stage we use Cox proportional hazard regression to predict CEO forced turnover using financial and accounting performance, earning management and other variables in the previous year, except the Peer and SCA dummy, which is always value at year 0.

Panel A: First-Stage Regression

Dependent Variable	Intercept	t-stat	Industry Mean	t-stat	R^2
Annual Return	0.00	[0.00]	1.00	[73.00***]	0.32
Bottom Decile	0.00	[0.00]	1.00	[40.47***]	0.12
Momentum Loser	0.00	[0.00]	1.00	[41.51***]	0.13
Momentum Winner	0.00	[0.00]	1.00	[49.27***]	0.17
ROA	0.00	[0.00]	1.00	[54.63***]	0.21
Sales Growth	0.00	[0.00]	1.00	[67.68***]	0.28
Current Ratio	0.00	[0.00]	1.00	[73.44***]	0.32
Receivable to Sales	0.00	[0.00]	1.00	[75.13***]	0.33
Debt Ratio	0.00	[0.00]	1.00	[73.79***]	0.32
Inventory to COGS Ratio	0.00	[0.00]	1.00	[99.77***]	0.46
Net Income to Sales Ratio	0.00	[0.00]	1.00	[82.80***]	0.37

*** denotes significance at 1%.

Panel B: Second-Stage Cox Proportional Hazard Regression Using Industry Adjusted Measures

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Peer Dummy				0.230	0.337	0.175	-0.018
				[0.041**]	[0.005***]	[0.190]	[0.926]
SCA Dummy				1.349	0.883	0.175	1.049
				[0.000***]	[0.000***]	[0.618]	[0.008***]
Financial Performance							
Industry Adjusted Return	-0.806	-0.891	-0.948	-0.880	-0.881	-0.995	-1.507
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Ind Adj Bottom Decile Dummy	0.337	0.104	0.158	-0.099	-0.135	-0.331	-0.891
	[0.440]	[0.762]	[0.612]	[0.729]	[0.688]	[0.396]	[0.154]
Ind Adj Momentum Loser Dummy	0.120	0.377	0.500	0.324	0.408	0.261	0.504
	[0.732]	[0.091*]	[0.013**]	[0.089*]	[0.039**]	[0.274]	[0.098*]
Ind Adj Momentum Winner Dummy	0.333	0.287	0.065	-0.169	0.043	-0.026	-0.031
	[0.199]	[0.157]	[0.758]	[0.411]	[0.848]	[0.916]	[0.934]
Accounting Performance							
Industry Adjusted ROA	-0.933	-1.295	-1.444	-1.692	-1.781	-1.582	-3.906
	[0.195]	[0.001***]	[0.000***]	[0.000***]	[0.000***]	[0.003***]	[0.000***]
Industry Adjusted Sales Growth	-0.618	-0.439	-0.644	-0.499	-0.516	-0.819	-0.247
	[0.057*]	[0.062*]	[0.001***]	[0.007***]	[0.017**]	[0.001***]	[0.663]
Earning Management							
Ind Adj Earning management	-0.304	-0.156	-0.012	0.985	0.146	0.664	0.137
	[0.748]	[0.821]	[0.985]	[0.055*]	[0.844]	[0.401]	[0.924]
Market Adj Common Director Ratio				2.383	2.482	2.940	-1.522
				[0.447]	[0.444]	[0.371]	[0.772]
Other Ratios							
Ind Adj Receivable Sales Ratio	1.672	0.570	-0.784	0.204	0.478	0.133	-3.473
	[0.374]	[0.693]	[0.550]	[0.877]	[0.729]	[0.946]	[0.306]
Ind Adj Current Ratio	-0.019	0.039	0.035	0.017	0.040	0.027	0.063
	[0.709]	[0.100*]	[0.120]	[0.417]	[0.067*]	[0.322]	[0.020**]
Ind Adj Inventory Cost Ratio	4.320	3.200	3.154	3.056	3.136	3.483	3.864
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.002***]
Industry Adjusted Debt Ratio	0.447	0.818	0.688	0.685	0.750	0.468	0.211
	[0.292]	[0.005***]	[0.018**]	[0.015**]	[0.015**]	[0.230]	[0.708]
Age	-0.107	-0.094	-0.081	-0.082	-0.086	-0.090	-0.080
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Log of Total Asset	0.040	-0.003	-0.053	-0.086	-0.032	-0.006	-0.051
	[0.471]	[0.948]	[0.202]	[0.028**]	[0.458]	[0.903]	[0.470]
N	6278	9586	11168	11525	9856	8162	5328

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.
Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 5 Second-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Industry Adjusted Stock Return, Market Adjusted Firm Financial Performance Measures, Market Adjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Peer Dummy				0.273	0.369	0.184	-0.009
				[0.017**]	[0.002***]	[0.173]	[0.964]
SCA Dummy				1.384	0.858	0.207	0.943
				[0.000***]	[0.000***]	[0.557]	[0.020**]
Financial Performance							
Industry Adjusted Return	-0.713	-0.809	-0.887	-0.857	-0.870	-0.987	-1.456
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Market Adj Bottom Decile Dummy	0.125	0.125	0.101	-0.230	-0.111	-0.402	-0.904
	[0.771]	[0.685]	[0.727]	[0.422]	[0.731]	[0.300]	[0.167]
Market Adj Momentum Loser Dummy	0.363	0.518	0.562	0.424	0.462	0.318	0.644
	[0.224]	[0.008***]	[0.002***]	[0.014**]	[0.010***]	[0.142]	[0.019**]
Market Adj Momentum Winner Dummy	-0.050	-0.048	-0.306	-0.392	-0.212	-0.283	-0.547
	[0.842]	[0.814]	[0.175]	[0.063*]	[0.351]	[0.271]	[0.201]
Accounting Performance							
Market Adjusted ROA	-0.490	-1.035	-1.085	-1.154	-1.144	-1.038	-2.630
	[0.534]	[0.002***]	[0.001***]	[0.001***]	[0.001***]	[0.040**]	[0.001***]
Market Adjusted Sales Growth	-0.783	-0.520	-0.862	-0.463	-0.510	-0.678	0.478
	[0.031**]	[0.046**]	[0.001***]	[0.022**]	[0.041**]	[0.030**]	[0.254]
Earning Management							
Ind Adj Earning management	-0.072	-0.047	0.299	1.003	0.182	0.563	-1.098
	[0.941]	[0.947]	[0.651]	[0.062*]	[0.807]	[0.485]	[0.440]
Market Adj Common Director Ratio				2.483	2.518	2.990	-1.558
				[0.424]	[0.432]	[0.361]	[0.767]
Other Ratios							
Market Adj Receivable Sales Ratio	1.228	0.684	-1.218	-0.002	0.570	-0.270	-0.729
	[0.480]	[0.607]	[0.419]	[0.999]	[0.659]	[0.875]	[0.772]
Market Adj Current Ratio	-0.013	0.029	0.026	0.008	0.024	0.024	0.052
	[0.767]	[0.181]	[0.211]	[0.699]	[0.298]	[0.350]	[0.031**]
Market Adj Inventory Cost Ratio	3.335	1.903	2.236	1.947	1.992	2.237	1.379
	[0.000***]	[0.003***]	[0.000***]	[0.001***]	[0.001***]	[0.002***]	[0.222]
Market Adjusted Debt Ratio	0.184	0.653	0.618	0.767	0.933	0.600	0.418
	[0.650]	[0.013**]	[0.018**]	[0.002***]	[0.001***]	[0.075*]	[0.401]
Age	-0.110	-0.094	-0.082	-0.085	-0.088	-0.092	-0.078
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Log of Total Asset	0.053	-0.001	-0.054	-0.102	-0.051	-0.018	-0.074
	[0.360]	[0.978]	[0.195]	[0.011**]	[0.245]	[0.713]	[0.297]
N	6278	9586	11168	11525	9856	8162	5328

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 6 Second-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Market Adjusted Stock Return, Market Adjusted Firm Financial Performance Measures, Market Adjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Peer Dummy				0.271	0.334	0.215	0.019
				[0.018**]	[0.003***]	[0.080*]	[0.913]
SCA Dummy				1.346	0.938	0.229	0.823
				[0.000***]	[0.000***]	[0.481]	[0.027**]
Financial Performance							
Market Adjusted Return	-1.006	-1.045	-1.186	-1.078	-1.321	-1.521	-2.129
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Market Adj Bottom Decile Dummy	0.175	0.169	0.188	-0.140	-0.228	-0.239	-0.388
	[0.631]	[0.556]	[0.521]	[0.627]	[0.443]	[0.481]	[0.441]
Market Adj Momentum Loser Dummy	0.283	0.464	0.382	0.275	0.393	0.189	0.403
	[0.290]	[0.014**]	[0.039**]	[0.121]	[0.016**]	[0.333]	[0.097*]
Market Adj Momentum Winner Dummy	0.153	0.080	-0.041	-0.171	-0.073	-0.113	-0.417
	[0.541]	[0.703]	[0.861]	[0.438]	[0.751]	[0.664]	[0.347]
Accounting Performance							
Market Adjusted ROA	-0.442	-0.940	-1.008	-1.125	-0.621	-0.388	-1.954
	[0.514]	[0.004***]	[0.001***]	[0.001***]	[0.021**]	[0.383]	[0.005***]
Market Adjusted Sales Growth	-0.558	-0.314	-0.811	-0.417	-0.255	-0.496	0.361
	[0.071*]	[0.163]	[0.002***]	[0.041**]	[0.270]	[0.090*]	[0.370]
Earning Management							
Ind Adj Earning management	0.353	0.302	0.330	1.034	0.297	0.750	-0.172
	[0.663]	[0.625]	[0.615]	[0.059*]	[0.676]	[0.324]	[0.890]
Market Adj Common Director Ratio				2.080	0.235	0.554	-1.325
				[0.498]	[0.935]	[0.852]	[0.789]
Other Ratios							
Market Adj Receivable Sales Ratio	2.012	1.316	-0.858	0.125	0.460	-0.372	-0.373
	[0.166]	[0.291]	[0.574]	[0.924]	[0.728]	[0.817]	[0.868]
Market Adj Current Ratio	-0.042	0.015	0.024	0.006	-0.002	0.009	0.032
	[0.322]	[0.499]	[0.239]	[0.759]	[0.931]	[0.731]	[0.194]
Market Adj Inventory Cost Ratio	3.199	1.664	2.205	1.938	1.620	1.769	1.091
	[0.000***]	[0.010***]	[0.001***]	[0.001***]	[0.010**]	[0.012**]	[0.303]
Market Adjusted Debt Ratio	0.112	0.624	0.600	0.703	0.610	0.570	0.627
	[0.765]	[0.012**]	[0.023**]	[0.006***]	[0.002***]	[0.061*]	[0.139]
Age	-0.106	-0.094	-0.083	-0.084	-0.079	-0.084	-0.071
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Log of Total Asset	0.047	-0.023	-0.059	-0.104	-0.067	-0.051	-0.106
	[0.353]	[0.576]	[0.163]	[0.010***]	[0.091*]	[0.263]	[0.091*]
N	7962	10730	11183	11525	11105	9249	6137

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 7 Second-Stage Cox Proportional Hazard Regression of Forced CEO Turnover on Market Adjusted Stock Return, Industry Adjusted Firm Financial Performance Measures, Industry Adjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Peer Dummy				0.224	0.345	0.225	-0.002
				[0.046**]	[0.004***]	[0.090*]	[0.990]
SCA Dummy				1.319	0.875	0.122	1.182
				[0.000***]	[0.000***]	[0.730]	[0.002***]
Financial Performance							
Market Adjusted Return	-1.054	-1.118	-1.263	-1.126	-1.181	-1.369	-2.049
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Ind Adj Bottom Decile Dummy	0.385	0.106	0.182	-0.061	-0.080	-0.302	-0.922
	[0.386]	[0.761]	[0.565]	[0.834]	[0.814]	[0.444]	[0.156]
Ind Adj Momentum Loser Dummy	0.062	0.277	0.351	0.203	0.267	0.120	0.418
	[0.856]	[0.211]	[0.079*]	[0.283]	[0.175]	[0.611]	[0.157]
Ind Adj Momentum Winner Dummy	0.444	0.344	0.092	-0.162	0.064	0.006	-0.059
	[0.109]	[0.111]	[0.687]	[0.460]	[0.790]	[0.983]	[0.888]
Accounting Performance							
Industry Adjusted ROA	-0.702	-1.142	-1.251	-1.561	-1.743	-1.355	-3.577
	[0.333]	[0.002***]	[0.000***]	[0.000***]	[0.000***]	[0.013**]	[0.000***]
Industry Adjusted Sales Growth	-0.673	-0.401	-0.561	-0.463	-0.507	-0.918	-0.276
	[0.035**]	[0.053*]	[0.001***]	[0.007***]	[0.008***]	[0.000***]	[0.630]
Earning Management							
Ind Adj Earning management	-0.229	-0.073	0.058	1.089	0.217	0.646	0.050
	[0.809]	[0.915]	[0.928]	[0.038**]	[0.771]	[0.429]	[0.972]
Market Adj Common Director Ratio				2.017	2.013	2.254	-1.416
				[0.512]	[0.533]	[0.490]	[0.790]
Other Ratios							
Ind Adj Receivable Sales Ratio	1.472	0.629	-1.019	-0.005	0.628	0.163	-3.627
	[0.440]	[0.685]	[0.489]	[0.997]	[0.672]	[0.935]	[0.295]
Ind Adj Current Ratio	-0.019	0.037	0.033	0.016	0.039	0.026	0.053
	[0.705]	[0.108]	[0.141]	[0.456]	[0.066*]	[0.329]	[0.043**]
Ind Adj Inventory Cost Ratio	4.286	3.265	3.082	3.138	3.183	3.556	4.076
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000**]	[0.000***]	[0.002***]
Industry Adjusted Debt Ratio	0.501	0.867	0.763	0.708	0.726	0.450	0.159
	[0.231]	[0.003***]	[0.008***]	[0.012**]	[0.020**]	[0.243]	[0.777]
Age	-0.108	-0.094	-0.081	-0.082	-0.086	-0.090	-0.077
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Log of Total Asset	0.043	-0.009	-0.060	-0.091	-0.028	-0.005	-0.060
	[0.441]	[0.837]	[0.148]	[0.020**]	[0.522]	[0.922]	[0.390]
N	6278	9586	11168	11525	9856	8162	5328

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 8 Weak-form Cox Proportional Hazard Regression of Forced CEO Turnover on Unadjusted Stock Return, Unadjusted Firm Financial Performance Measures, Unadjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Peer Dummy				0.280	0.313	0.203	-0.018
				[0.014**]	[0.005***]	[0.100*]	[0.918]
SCA Dummy				1.367	0.974	0.245	0.960
				[0.000***]	[0.000***]	[0.449]	[0.009***]
Financial Performance							
Unadjusted Return	-0.743	-0.723	-0.870	-0.740	-0.950	-1.044	-1.044
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Unadjusted Bottom Decile Dummy	0.124	0.088	0.096	-0.217	-0.296	-0.313	-0.433
	[0.730]	[0.757]	[0.740]	[0.454]	[0.318]	[0.352]	[0.362]
Unadjusted Momentum Loser Dummy	0.405	0.611	0.517	0.422	0.541	0.391	0.753
	[0.125]	[0.001***]	[0.005***]	[0.017**]	[0.001***]	[0.043**]	[0.001***]
Unadjusted Momentum Winner Dummy	0.038	-0.095	-0.218	-0.328	-0.219	-0.342	-0.993
	[0.877]	[0.637]	[0.337]	[0.120]	[0.322]	[0.175]	[0.031**]
Accounting Performance							
Unadjusted ROA	-0.291	-0.850	-0.926	-0.978	-0.513	-0.201	-2.023
	[0.684]	[0.011**]	[0.004***]	[0.005***]	[0.067*]	[0.646]	[0.003***]
Unadjusted Sales Growth	-0.523	-0.092	-0.541	-0.253	-0.089	-0.364	0.598
	[0.088*]	[0.660]	[0.030**]	[0.178]	[0.683]	[0.195]	[0.068*]
Earning Management							
Ind adjusted Earning management	0.479	0.209	0.316	1.029	0.311	0.905	-0.381
	[0.557]	[0.740]	[0.635]	[0.062*]	[0.662]	[0.234]	[0.759]
Market Adj Common Director Ratio				0.830	-0.379	0.106	-0.574
				[0.453]	[0.757]	[0.932]	[0.756]
Other Ratios							
Unadjusted Receivable Sales Ratio	2.040	1.497	-0.927	0.321	0.000	-0.754	-1.531
	[0.160]	[0.227]	[0.545]	[0.804]	[1.000]	[0.651]	[0.526]
Unadjusted Current Ratio	-0.050	0.013	0.021	0.001	-0.006	0.004	0.038
	[0.250]	[0.558]	[0.319]	[0.946]	[0.812]	[0.873]	[0.117]
Unadjusted Inventory Cost Ratio	3.318	1.710	2.195	1.984	1.656	1.757	1.069
	[0.000***]	[0.007***]	[0.001***]	[0.000***]	[0.008**]	[0.013**]	[0.306]
Unadjusted Debt Ratio	0.138	0.602	0.627	0.710	0.619	0.584	0.569
	[0.710]	[0.015**]	[0.016**]	[0.005***]	[0.001***]	[0.051*]	[0.184]
Age	-0.106	-0.094	-0.081	-0.084	-0.078	-0.083	-0.071
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Log of Total Asset	0.041	-0.036	-0.084	-0.126	-0.080	-0.065	-0.105
	[0.422]	[0.375]	[0.046**]	[0.002***]	[0.045**]	[0.157]	[0.106]
N	7962	10730	11183	11525	11105	9249	6137

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 9 Second-Stage Logistic Regression of Forced CEO Turnover on Industry Adjusted Stock Return, Industry Adjusted Firm Financial Performance Measures, Industry Adjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Intercept	0.233	-0.136	-0.809	0.227	-0.417	-0.987	-1.630
	[0.736]	[0.799]	[0.123]	[0.655]	[0.465]	[0.137]	[0.089*]
Peer Dummy				0.138	0.206	0.099	-0.001
				[0.017**]	[0.001***]	[0.150]	[0.994]
SCA Dummy				0.766	0.458	0.096	0.426
				[0.000***]	[0.000***]	[0.587]	[0.033**]
Financial Performance							
Industry Adjusted Return	-0.849	-0.946	-0.981	-0.880	-0.901	-0.994	-1.715
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Ind Adj Bottom Decile Dummy	0.316	0.034	0.005	-0.121	-0.146	-0.331	-0.577
	[0.507]	[0.927]	[0.987]	[0.689]	[0.681]	[0.412]	[0.372]
Ind Adj Momentum Loser Dummy	0.077	0.3899	0.524	0.326	0.497	0.360	0.534
	[0.831]	[0.097*]	[0.014**]	[0.108]	[0.017**]	[0.143]	[0.100*
Ind Adj Momentum Winner Dummy	0.309	0.256	0.039	-0.160	0.020	-0.042	-0.096
	[0.251]	[0.224]	[0.861]	[0.451]	[0.932]	[0.869]	[0.802]
Accounting Performance							
Industry Adjusted ROA	-0.651	-1.115	-1.240	-1.262	-1.162	-1.432	-2.564
	[0.442]	[0.012**]	[0.001***]	[0.002***]	[0.009***]	[0.016**]	[0.002***]
Industry Adjusted Sales Growth	-0.141	0.016	-0.337	-0.338	-0.317	-0.654	-0.018
	[0.686]	[0.950]	[0.169]	[0.098*]	[0.205]	[0.028**]	[0.973]
Earning Management							
Ind Adj Earning management	0.381	0.438	0.585	1.114	0.368	1.058	0.880
	[0.686]	[0.535]	[0.388]	[0.055*]	[0.631]	[0.218]	[0.548]
Market Adj Common Director Ratio				2.776	3.121	3.469	-0.068
				[0.369]	[0.335]	[0.304]	[0.990]
Other Ratios							
Ind Adj Receivable Sales Ratio	1.697	0.077	-1.966	-0.424	-0.658	-0.181	-3.470
	[0.390]	[0.962]	[0.217]	[0.785]	[0.678]	[0.929]	[0.331]
Ind Adj Current Ratio	-0.016	0.055	0.057	0.041	0.064	0.052	0.083
	[0.760]	[0.034**]	[0.017**]	[0.070*]	[0.011**]	[0.082*]	[0.017**]
Ind Adj Inventory Cost Ratio	3.464	2.205	2.160	2.334	2.183	3.126	2.642
	[0.001***]	[0.009***]	[0.013**]	[0.003***]	[0.012**]	[0.002***]	[0.070*]
Industry Adjusted Debt Ratio	0.572	0.907	0.708	0.730	0.831	0.518	0.331
	[0.229]	[0.006***]	[0.030**]	[0.019**]	[0.015**]	[0.202]	[0.566]
Age	-0.062	-0.050	-0.036	-0.037	-0.038	-0.040	-0.023
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.115]
Log of Total Asset	-0.021	-0.052	-0.094	-0.121	-0.058	-0.027	-0.068
	[0.703]	[0.228]	[0.026**]	[0.003***]	[0.184]	[0.591]	[0.330]
Tenure	-0.041	-0.045	-0.035	-0.034	-0.033	-0.030	-0.024
	[0.012**]	[0.001***]	[0.003***]	[0.002***]	[0.007***]	[0.030**]	[0.200]
N	6278	9586	11168	11526	9857	8162	5328

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Number of observations in year 0 is 11525 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 10 Second-Stage Logistic Regression of Forced CEO Turnover on Industry Adjusted Stock Return, Market Adjusted Firm Financial Performance Measures, Market Adjusted Firm Accounting Performance Measures and Control Variables. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

	Year t						
	-5	**-2**	**-1**	**0**	**1**	**2**	**5**
	Dependent Variable: CEO Forced Turnover Dummy at year t						
Intercept	0.200	0.222	-0.875	0.301	-0.656	-1.161	-1.757
	[0.748]	[0.664]	[0.109]	[0.568]	[0.220]	[0.066*]	[0.048**]
Peer Dummy				0.142	0.202	0.109	0.000
				[0.015**]	[0.000***]	[0.083*]	[1.000]
SCA Dummy				0.756	0.473	0.099	0.381
				[0.000***]	[0.000***]	[0.554]	[0.041**]
Financial Performance							
Industry Adjusted Return	-1.070	-1.102	-1.270	-1.175	-1.419	-1.619	-2.250
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]
Market Adj Bottom Decile Dummy	0.397	0.197	0.109	-0.215	-0.259	-0.257	-0.276
	[0.293]	[0.516]	[0.723]	[0.476]	[0.408]	[0.460]	[0.596]
Market Adj Momentum Loser Dummy	0.244	0.470	0.443	0.274	0.479	0.270	0.408
	[0.378]	[0.018**]	[0.022**]	[0.145]	[0.004***]	[0.175]	[0.112]
Market Adj Momentum Winner Dummy	0.130	0.055	-0.032	-0.112	-0.044	-0.084	-0.451
	[0.611]	[0.796]	[0.894]	[0.617]	[0.850]	[0.749]	[0.314]
Accounting Performance							
Market Adjusted ROA	-0.169	-0.806	-0.867	-0.955	-0.387	-0.726	-1.234
	[0.814]	[0.032**]	[0.013**]	[0.009***]	[0.234]	[0.126]	[0.085*]
Market Adjusted Sales Growth	-0.046	0.093	-0.427	-0.291	-0.047	-0.196	0.367
	[0.871]	[0.665]	[0.096*]	[0.138]	[0.835]	[0.472]	[0.272]
Earning Management							
Ind Adj Earning management	0.717	0.779	0.697	1.239	0.461	1.039	0.598
	[0.365]	[0.224]	[0.315]	[0.040**]	[0.537]	[0.201]	[0.653]
Market Adj Common Director Ratio				2.609	2.589	2.916	0.950
				[0.390]	[0.381]	[0.348]	[0.846]
Other Ratios							
Market Adj Receivable Sales Ratio	2.073	1.234	-1.450	-0.428	-0.581	-0.969	-0.614
	[0.183]	[0.332]	[0.340]	[0.763]	[0.668]	[0.570]	[0.795]
Market Adj Current Ratio	-0.029	0.035	0.049	0.031	0.027	0.027	0.046
	[0.525]	[0.124]	[0.022**]	[0.150]	[0.273]	[0.333]	[0.129]
Market Adj Inventory Cost Ratio	2.420	1.095	1.657	1.544	1.183	1.524	0.103
	[0.003***]	[0.107]	[0.015**]	[0.015**]	[0.076*]	[0.049**]	[0.931]
Market Adjusted Debt Ratio	-0.079	0.596	0.512	0.617	0.583	0.389	0.391
	[0.849]	[0.036**]	[0.082*]	[0.026**]	[0.024**]	[0.224]	[0.371]
Age	-0.066	-0.055	-0.037	-0.038	-0.030	-0.033	-0.015
	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.000***]	[0.242]
Log of Total Asset	0.008	-0.066	-0.093	-0.129	-0.093	-0.062	-0.117
	[0.880]	[0.112]	[0.033**]	[0.002***]	[0.020**]	[0.176]	[0.065*]
Tenure	-0.039	-0.045	-0.035	-0.035	-0.026	-0.026	-0.020
	[0.006***]	[0.000***]	[0.003***]	[0.002***]	[0.017**]	[0.032**]	[0.226]
N	7962	10730	11183	11526	11106	9249	6137

All independent variables are at year t-1 except SCA and Peer dummies which are always at year 0. Prob>=Chi square statistics in brackets are provided. Ind Adj= Industry Adjusted. For space reason we provide results for t=-5, -2 to 2 and 5. Results for years -4,-3, 3 and 4 are available upon request.
*, ** and *** denote significance at 10%, 5% and 1% respectively.
Number of observations in year 0 is 11526 which is less than 11537 in Table 1 Panel A because dependent variable forced turnover dummy is in year 0 but all independent variables except SCA and Peer dummies are all in year -1. Similarly for year -5 to +5.

Table 11 Regression of Unadjusted Annual Return on ROA and Common Director Ratio for All Stocks

Unadjusted Annual Return $_{Yjt}$= a + b_1* ROA$_{Y\,jt}$ + b_3*Common Director Ratio$_{Y\,jt}$ +ε_{Yjt} for Firm j in Year t in Period Y. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After. Period Y is from 1996 to 2012.

Dependent Variable	stock return in year -5	stock return in year -2	stock return in year -1	stock return in year 0	stock return in year 1	stock return in year 2	stock return in year 5
Intercept	0.161	0.160	0.135	0.121	0.114	0.111	0.131
	[17.31***]	[23.46***]	[22.29***]	[21.42***]	[18.30***]	[19.25***]	[20.66***]
ROA	0.474	0.321	0.396	0.380	0.517	0.419	0.134
	[5.09***]	[5.41***]	[7.60***]	[8.58***]	[9.68***]	[8.29***]	[2.19**]
Common Director Ratio	-0.231	-0.316	-0.189	-0.105	-0.163	-0.312	-0.405
	[-1.53]	[-2.51**]	[-1.65*]	[-0.93]	[-1.38]	[-2.92***]	[-3.45***]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Table 12 Univariate Analysis of Difference of Means for Firms With and Without (W/O) Forced CEO Turnover. Year 0 is Year of SCA Lawsuit Filing. Years -5 and 5 are 5 Years Before and After.

Panel A: SCA Firms

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	W/O	Obs	255	299	305	305	285	251	165
		Mean	0.020	0.033	0.043	0.000	0.109	0.040	0.042
	With	Obs	29	36	40	40	39	62	67
		Mean	0.034	0.056	0.000	1.000	0.077	0.048	0.090
	W/O-With	t-stat	[-0.42]	[-0.55]	[3.68***]	ratio does not exist#	[0.68]	[-0.28]	[-1.22]
Unadjusted Annual Return	W/O	Obs	294	305	305	305	303	262	190
		Mean	0.299	0.307	0.105	-0.140	0.121	0.218	0.165
	With	Obs	36	40	40	40	40	70	73
		Mean	0.224	0.244	0.015	-0.306	0.166	0.114	0.131
	W/O-With	t-stat	[0.84]	[0.60]	[1.24]	[2.22**]	[-0.45]	[1.17]	[0.40]
Industry-Adjusted Return	W/O	Obs	201	305	305	251	225	180	110
		Mean	0.026	0.070	-0.032	-0.235	-0.050	0.001	0.006
	With	Obs	21	40	40	36	35	45	41
		Mean	-0.072	0.100	-0.174	-0.473	-0.099	0.041	0.047
	W/O-With	t-stat	[1.79*]	[-0.34]	[1.74*]	[3.38***]	[0.49]	[-0.46]	[-0.76]
Absolute Accrual	W/O	Obs	278	304	305	305	291	253	173
		Mean	0.084	0.078	0.080	0.064	0.060	0.061	0.068
	With	Obs	32	39	40	40	40	67	66
		Mean	0.052	0.073	0.078	0.065	0.062	0.075	0.060
	W/O-With	t-stat	[2.95***]	[0.36]	[0.11]	[-0.06]	[-0.21]	[-1.13]	[0.67]
Winsorized ROA	W/O	Obs	302	305	305	305	292	257	177
		Mean	0.054	0.058	0.038	0.004	0.005	0.011	0.044
	With	Obs	39	40	40	40	40	69	68
		Mean	0.064	0.048	0.018	-0.043	-0.023	-0.032	0.031
	W/O-With	t-stat	[-0.78]	[0.53]	[0.68]	[1.16]	[0.96]	[1.58]	[1.01]
Winsorized Sales Growth	W/O	Obs	298	305	305	305	292	256	176
		Mean	0.231	0.227	0.218	0.082	0.039	0.021	0.054
	With	Obs	37	40	40	40	40	69	68
		Mean	0.246	0.230	0.204	0.012	-0.022	-0.017	0.030
	W/O-With	t-stat	[-0.28]	[0.04]	[0.18]	[1.71*]	[2.88***]	[1.79*]	[1.01]
Common Direct Ratio	W/O	Obs	178	260	305	305	246	200	118
		Mean	0.019	0.023	0.022	0.000	0.022	0.030	0.021
	With	Obs	15	33	40	40	37	54	44
		Mean	0.007	0.023	0.022	0.000	0.040	0.041	0.016
	W/O-With	t-stat	[1.54]	[-0.01]	[-0.06]	Ratio does not exist##	[-1.54]	[-0.75]	[0.64]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

#: All firms with CEO being forced out have a forced turnover ratio of 1. The standard deviation of the ratio does not exist. As we use the formula for samples of different standard deviation to calculate the t-statistics, so the t-statistics does not exist.

##: In year 0, common director ratio of all SCA firms is set to 0, so similar to # above, t-statistics does not exist.

Panel B: Non-related Firms

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	W/O	Obs	5,749	6,715	6,810	6,818	6,593	6,208	4,105
		Mean	0.027	0.027	0.025	0.000	0.025	0.029	0.024
	With	Obs	130	171	173	173	167	305	563
		Mean	0.046	0.041	0.040	1.006	0.060	0.043	0.032
	W/O-With	t-stat	[-1.04]	[-0.91]	[-1.01]	[-174.0***]	[-1.72*]	[-1.05]	[-0.96]
Annual Return	W/O	Obs	6,639	6,818	6,818	6,818	6,814	6,486	4,667
		Mean	0.186	0.152	0.153	0.148	0.132	0.134	0.142
	With	Obs	168	173	173	173	173	329	630
		Mean	0.217	0.186	-0.058	0.076	0.193	0.085	0.085
	W/O-With	t-stat	[-0.60]	[-0.90]	[6.79***]	[1.52]	[-1.00]	[1.47]	[3.08***]
Industry-Adjusted Return	W/O	Obs	4,503	6,803	6,818	5,844	5,110	4,279	2,606
		Mean	0.013	0.004	0.003	-0.005	-0.016	-0.013	-0.006
	With	Obs	101	173	173	148	122	203	339
		Mean	0.083	0.005	-0.191	-0.106	0.117	-0.012	-0.005
	W/O-With	t-stat	[-1.00]	[-0.02]	[7.03***]	[2.22**]	[-1.83*]	[-0.03]	[-0.04]
Absolute Accrual	W/O	Obs	6,194	6,770	6,818	6,818	6,622	6,237	4,186
		Mean	0.059	0.051	0.049	0.048	0.046	0.044	0.041
	With	Obs	151	173	173	173	169	317	572
		Mean	0.083	0.071	0.069	0.061	0.063	0.059	0.052
	W/O-With	t-stat	[-2.02**]	[-3.21***]	[-3.22***]	[-1.93*]	[-2.96***]	[-3.81***]	[-4.34***]
Winsorized ROA	W/O	Obs	6,778	6,818	6,818	6,818	6,683	6,338	4,297
		Mean	0.057	0.050	0.049	0.049	0.047	0.046	0.048
	With	Obs	173	173	173	173	171	322	585
		Mean	0.048	0.028	-0.004	-0.007	0.003	-0.012	0.017
	W/O-With	t-stat	[1.52]	[2.32**]	[3.92***]	[5.19***]	[4.66***]	[5.57***]	[4.77***]
Winsorized Sales Growth	W/O	Obs	6,707	6,817	6,818	6,818	6,683	6,330	4,294
		Mean	0.143	0.096	0.092	0.088	0.084	0.078	0.071
	With	Obs	171	173	173	173	171	322	585
		Mean	0.173	0.150	0.084	0.070	0.063	0.043	0.055
	W/O-With	t-stat	[-1.12]	[-1.84*]	[0.37]	[0.82]	[1.06]	[2.51**]	[1.72*]
Common Direct Ratio	W/O	Obs	4,052	5,849	6,818	6,818	5,827	5,017	3,050
		Mean	0.016	0.014	0.015	0.014	0.015	0.015	0.015
	With	Obs	74	135	173	173	148	241	407
		Mean	0.005	0.013	0.018	0.011	0.016	0.014	0.015
	W/O-With	t-stat	[4.36***]	[0.31]	[-0.98]	[1.26]	[-0.32]	[0.29]	[0.00]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Panel C: Peer Firms

			Year						
			-5	**-2**	**-1**	**0**	**1**	**2**	**5**
Forced Turnover Ratio	W/O	Obs	3,273	3,978	4,042	4,045	3,920	3,611	2,428
		Mean	0.029	0.036	0.032	0.000	0.040	0.038	0.028
	With	Obs	120	154	156	156	145	288	465
		Mean	0.058	0.078	0.051	1.000	0.041	0.056	0.043
	W/O-With	t-stat	[-1.37]	[-1.91*]	[-1.09]	[.]	[-0.06]	[-1.27]	[-1.50]
Annual Return	W/O	Obs	3,896	4,045	4,045	4,045	4,042	3,786	2,667
		Mean	0.287	0.210	0.168	0.147	0.160	0.146	0.123
	With	Obs	150	156	156	156	156	301	521
		Mean	0.262	0.237	-0.035	0.035	0.112	0.158	0.161
	W/O-With	t-stat	[0.49]	[-0.36]	[5.49***]	[2.51**]	[0.92]	[-0.28]	[-1.34]
Industry-Adjusted Return	W/O	Obs	2,620	4,045	4,045	3,497	3,075	2,641	1,676
		Mean	0.020	0.004	0.006	0.004	-0.015	-0.028	-0.031
	With	Obs	98	156	156	128	113	202	289
		Mean	-0.061	-0.053	-0.168	-0.122	0.054	0.006	-0.028
	W/O-With	t-stat	[1.60]	[0.84]	[5.67***]	[2.83***]	[-1.61]	[-0.85]	[-0.14]
Absolute Accrual	W/O	Obs	3,654	4,011	4,045	4,045	3,942	3,653	2,494
		Mean	0.081	0.074	0.069	0.064	0.061	0.060	0.052
	With	Obs	139	154	156	156	151	292	474
		Mean	0.114	0.096	0.085	0.076	0.082	0.070	0.064
	W/O-With	t-stat	[-2.39**]	[-2.26**]	[-1.60]	[-1.81*]	[-2.53**]	[-2.18**]	[-2.92***]
Winsorized ROA	W/O	Obs	4,016	4,045	4,045	4,045	3,967	3,700	2,549
		Mean	0.058	0.049	0.048	0.043	0.039	0.041	0.046
	With	Obs	154	156	156	156	153	296	480
		Mean	0.034	0.014	0.021	-0.028	-0.022	-0.007	-0.005
	W/O-With	t-stat	[1.50]	[2.55**]	[2.08**]	[4.39***]	[3.99***]	[4.70***]	[5.30***]
Winsorized Sales Growth	W/O	Obs	3,967	4,044	4,045	4,045	3,967	3,700	2,544
		Mean	0.190	0.134	0.122	0.105	0.093	0.088	0.063
	With	Obs	154	156	156	156	153	296	480
		Mean	0.284	0.132	0.107	0.032	0.025	0.047	0.045
	W/O-With	t-stat	[-0.93]	[0.08]	[0.57]	[4.08***]	[3.05***]	[2.77***]	[2.02**]
Common Direct Ratio	W/O	Obs	2,226	3,386	4,045	4,045	3,392	2,890	1,857
		Mean	0.015	0.016	0.016	0.017	0.015	0.017	0.016
	With	Obs	83	127	156	156	125	227	339
		Mean	0.025	0.018	0.010	0.013	0.016	0.019	0.015
	W/O-With	t-stat	[-1.58]	[-0.33]	[1.56]	[1.01]	[-0.26]	[-0.51]	[0.32]

*, ** and *** denote significance at 10%, 5% and 1% respectively.

Appendix

Year	Year of SCA lawsuit filing date in the Stanford University Law School database is *year 0*. We study from years -5 to years +5, totally 11 years.
Forced Turnover Ratio	Number of forced CEO turnover in a year for that firm
Forced Turnover Dummy	Equals 1 if there is a forced CEO turnover in that year, otherwise 0.
Total Turnover Ratio	Number of total CEO turnover in a year for that firm. It equals the sum of forced turnover ratio and voluntary turnover ratio.
Voluntary Turnover Ratio	Number of voluntary CEO turnover in a year for that firm
SCA Dummy	Equals 1 if a firm has SCA lawsuit filing in that year, otherwise 0. A company is a SCA firm in a year if it has SCA lawsuit filing in that year.
Peer Dummy	Equals 1 if a firm has the same 8-digit GICS (with SCA firm in the same year, Otherwise 0. We use GICS to classify stocks into industries as Gleason et al (2008) use GICS for industry classifications.
Stock Return	Unadjusted annul stock return
Bottom Decile Dummy	Equals 1 if stock return in the bottom 1/10 of all stocks in CRSP in a year, otherwise 0
Momentum Loser Dummy	Equals 1 if stock return in the bottom 1/3 of all stocks in CRSP in both previous 1 and 2 years, otherwise 0
Momentum Winner Dummy	Equals 1 if stock return in the top 1/3 of all stocks in CRSP in both previous 1 and 2 years, otherwise 0
Earning Management (Accrual)	Absolute value of winsorized earnings management accrual, according to Hazarika, et al. (2012). Hazarika, et al. (2012) use 5th and 95th percentile to winsorize, we use the same percentiles throughout the paper for consistency.
Inventory COGS ratio	(Inventory/(Cost Of Goods Sold/365))/1000
Receivable to Sales ratio	(Account Receivable/(Sales/365))/1000
Debt Ratio	Total Liability/ Total Asset
ROA	Winsorized ROA[12]
Market-Adjusted Ratio	The ratio of the firm less the mean of the ratios of all firms in the CEO sample in that year. For example, Market Adjusted Stock Return = annual return of the stock in a year - mean of annual return of all firms in the CEO sample in the same year
Industry-Adjusted Stock Return and other measures	We compute industry-adjusted stock return and other measures based on Jenter and Kanaan (2015). We use GICS to classify stocks into industries as Gleason et al (2008) use GICS for industry classifications. Jenter and Kanaan (2015) has 48 industries, to be compatible, we use 6-digit GICS which has 73 industries from 1996 to 2012.

[12] at 5% and 95%

The Association Between Financial Performance and Corporate Governance of Technology Companies

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Abstract

The aim of the study is to investigate the relationship between corporate governance and financial performance in technology companies. The thesis can be divided into five parts. The first part introduces the basic information of the study. The second part is about literature review. The third part explains the research method. The fourth part concludes data analysis. The fifth part is discussion, and the last part is conclusion.

Based on a comprehensive literature review, the theoretical foundations and the relationship between corporate governance and financial performance of companies were determined, which led to the formulation of research hypotheses. Using an empirical research methodology, data was collected and analysed using descriptive statistics, correlation analysis and regression analysis to confirm the hypotheses.

In conclusion, financial performance of companies is affected by the governance system; nonetheless, the impact of each variable varies on components of financial performance of technology companies. The results showed that corporate governance has a significant impact on financial performance. This study not only advances the relevant theories, but also provides practical guidance for companies to optimise their governance structures and improve their financial performance. However, the study still has some limitations and future research can expand the scope of the study and deepen the methods of analysis.

***Keywords**:* Technology Companies, Financial Performance, Corporate Governance

1.Introduction

1.1 Background of the study

Corporate governance (CG) can be defined as the systems of processes, practices and rules through which companies are controlled and directed. Fundamentally, it balances the interest of various stakeholders of the firm such as financiers, customers, shareholders, community and senior management executives etc[1].. In this regard, it has been argued that effective corporate governance ensures the growth and long-term development of the business. It is because weak corporate governance results in scandals and frauds in the businesses which in turn significantly impact the return and market share prices of companies [2]. For example, Nikola, Wirecard and WorldCom recorded the high-profile corporate scandals which highlighted the role and need of CG. Apart from this, privacy concern in the US IT companies such as Facebook and Alphabet reflects the poor corporate governance which affected the return of the businesses to a great extent [3][4]. Moreover, in the US, Securities and Exchange Commission (SEC) has charged many technology companies with fine for indulging in frauds and poor governance. For example, in 2022, SEC fined Oracle Corporation with more than $23 million for violating anti-bribery and internal control provisions of FCPA and it fined ABB, an automation company with $147 million for similar charges [5]. Thus, it is interesting to study how corporate governance affects the financial performance of the technology companies in the US.

Besides above, the role of transparent governance and diverse board of directors affects the performance of companies to a great extent which has been witnessed in many studies [2][6]. Further, Bhagat and Bolton [2]

argued that self-serving CEO behaviour due to misaligned compensation has resulted in poor governance practices and significant losses to shareholders. Therefore, the current research has been carried out to assess the association of CG with financial performance of US technology firms by discussing the relationship measured by different variables such as CEO duality, board size and board gender.

1.2 Research rationale

The issues in corporate governance affect the reputation of the businesses and result in the loss of trust of investors which ruins the overall progress of companies in the long-term. Nonetheless, it has been argued that effective governance leads to better financial performance and attract more investors towards the brand [7]. On this note, based on many corporate scandals as discussed in the background sections, the US technology firms need to revise their corporate governance policies in order to ensure effective governance and avoid payment of fines and scrutiny. However, it is unknown whether corporate governance can affect the financial performance of US technology firms or not; therefore, the current research is of interest to know about the selected companies. Apart from this, technology companies are prone to security and privacy breaches which leads to ineffective governance. This may provide long-term negative impact on the financial performance of companies [4]. Also, the tech companies have huge scope post Covid-19; therefore, issue of corporate governance may threaten the important sector of any country. Owing to this, study about the topic seems important from practical perspective.

1.3 Research aim and question

The main aim of this research is to investigate the relationship between corporate governance and financial performance of technology companies of US. To achieve the overarching research aim, below specific research questions have been developed, which are also informed by detailed literature review.

Research questions

- What is association between financial performance of US technology companies and board size?
- What is association between financial performance of US technology companies and CEO duality?
- What is association between financial performance of US technology companies and board gender diversity?

1.4 Significance of the study

The findings of the current research are helpful for both policy makers and entire IT sector of any particular nation. Although, many studies are available on this topic but studies about US technology firms are less available; therefore, findings will guide policy makers about what aspects of corporate governance affect the financial performance of companies [8][9]. Moreover, these insights will be valuable for entire sector in order to improve the corporate governance of the firms.

Besides, existing literature on corporate governance and firm performance is largely focused on the developing countries [6][10][11][12]. Particularly, this research makes significant contribution to the existing literature by examining individual relationship of key aspects of corporate governance, namely, board size, CEO duality and board gender diversity with that of financial performance, in the particular context of US technology companies from developed country.

2 Literature Review

2.1 Introduction

This literature review chapter contains a thorough review of the existing research available to assess the link between financial performance of the businesses and their corporate governance. Based on the same, a literature gap and variables suitable for the current study have been found. At last, conceptual framework of this study is developed based on the research gap identified.

2.2 CG and financial performance of companies

Corporate governance mainly aims to ensure smooth operation of businesses with timely dissemination of important information among all important stakeholders and effective governance of business operations. On another note, financial performance refers to the accounting measures of how efficiently a business can generate revenues and profits by utilising its capital or assets [13]. However, in effective management of the business, the board of directors play an important role and ensure fair and transparent operations. Due to this, efficient operations with the assurance of effective corporate governance have a significant link and the same view has been supported by many researchers [13][14][15].

The market performance of businesses however could be adversely affected if the directors work for their own sake benefit and ignore the efficient utilisation of the assets of the business by creating agency problem. Nevertheless, the core principles of corporate governance such as transparency and fairness enable the companies to achieve effective corporate governance [16]. In the present context, corporate governance has been examined in terms of CEO duality, size of the board and gender diversity. On the other side, financial performance has been quantified using return on equity (ROE) and ROA (return on assets). The rationale behind choosing these variables is that these variables are largely operationalised by authors in previous studies in corporate governance literature [1][13][17].

2.3 Theoretical foundation

The agency theory explains the link between principals (shareholders) and agents (managers) and the conflict of interests arising in this relationship. The agency theory emphasises on the matching of demands and interests of both parties to assure positive and rapid growth of the business. In this regard, separating the role of managerial positions that are CEO and the Chairman is prominent to ensure quality decision-making and fair operations. Thus, the agency theory is suitable in the present context because this explains the role of directors on the board to maximise and enhance the performance of the organisation through governance mechanisms [11][17].

An agency problem nevertheless takes place in case where both positions are held by the same person and the person works to promote his/her interest. This happens due to varied perceptions, interest conflicts and personal greed of people holding both the positions. Also, the cost involved in agency may go high due to poor corporate governance mechanisms which ultimately results in ineffective financial performance [13]. However, the board of directors play an important role in ensuring effective corporate governance wherein gender diversity is being assured and different opinions are being framed for better decision-making through larger size of board [18]. Therefore, the agency theory is significant to explain the link between corporate governance in business and financial performance and thus, can be used in this study to explain the results.

2.4 Influence of CG on financial performance

Marinova, Plantenga and Remery [27] argued that the impact of corporate governance depends on the size of the firms. This is because large businesses get more advantages from the size of the board due to diversity and heterogeneity in the decision-making by the board and the members of the board provide creative solutions to the business. Further, Topal and Dogan [19] stated that a larger board size comprises of a large number of people wherein various people come with different talents and skills which is quite effective to fight the challenges in managing effective and efficient operations. Also, different skills of people bring various solutions to the problems in the management and effective utilisation of the assets of the business. Alabdullah, Ahmed and Yahya [14] revealed that there is no effective link between the size of the board and the performance of the firms. According to the authors, the ultimate financial performance and growth of the business is an outcome of dedication, efficient management and overall efforts of the members of the board. Thus, mixed findings revealed that the board size plays a crucial role in the case of the relationship between the financial performance of the firm and corporate governance.

In a similar context, Hassan [15] asserted that the diverse board brings high-time devotion, dedication and efforts and manages the overall operations systematically. Yet, the ROE has been found as positively associated with the diversity of gender and on the other side, the ROA was negatively associated. Likewise, Maji and Saha [20] revealed that there is a positive and noteworthy association between financial performance and CG of firms. The diverse board bring unique and innovative ideas which could lead to rapid and drastic changes in the firm's performance of the organisation and provides rapid profits, returns and growth. Similarly, Kilic and Kuzey [10]

based on the regression analysis in the case of the Turkish economy revealed that a board of a great number of organisations are dominated by male members. Yet, the female directors on the board seem to enhance the ROE and ROA of the organisations. Thus, the majority of the studies revealed that the highly diverse board assures effective outcomes and good economic results.

Vo and Nguyen [28] based on the research conducted for the period from 2008 to 2012 on the relevance of the 177 listed companies from Vietnam revealed that CEO duality has a positive association with return of companies. This is because the CEO duality has rarely influenced by the stock value and other aspects of the market. In this relevance, the CEO the place of the chairperson tends to facilitate informed decision-making and serves a better understanding for the whole organisation. However, Bhagat and Bolton [16] stated that the separate roles of the CEO and chairperson are essential to make correct decisions and assures the quality of the decisions. On this note, the dual role of CEO and chairperson tends to increase the workload and change the focus of the key personnel from systematic management and strategic planning and divert the same to routine tasks. In a similar vein, Fooladi [21] based on the 30 firms from Malaysia from the year 2007 argued that CEO duality affects the firm's performance adversely. The rationale behind the same is that CEO duality decreases the board of directors' efficiency and the decision-making powers are affected by the personal interests of the personnel of the company. Nevertheless, Ehikioya [12] revealed that there is no significant link between financial performance and CEO duality in the business. On this note, Arora and Sharma [1] conducted research in the context of the Indian manufacturing sector for the year 2001-2010 and revealed that there is no significant link between financial performance and CEO duality. Thus, the findings are mixed and reveal scope for further review and analysis.

2.5 Hypotheses development

Based on the review of literature, key variables of this study have been identified and accordingly, below hypotheses have been developed for testing-

H01: There is no significant influence of board gender ratio on return on equity (ROE)

H02: There is no significant influence of board gender ratio on return on assets (ROA)

H03: There is no significant influence of the size of the board on return on equity (ROE)

H04: There is no significant influence of the size of the board on return on assets (ROA)

H05: There is no significant influence of CEO duality on return on equity (ROE)

H06: There is no significant influence of CEO duality on return on assets (ROA)

2.6 Literature gap

There are many studies which studied the relationship of economic indicators of and CG of companies. However, the research has been rarely undertaken in the context of developed nations as the majority of the research is limited to developing countries [1][14][22]. Therefore, the current study has extended the scope of already done literature to assess the link between financial performance and CG of technology firms in the US. Accordingly, below research model is developed to conduct this study-

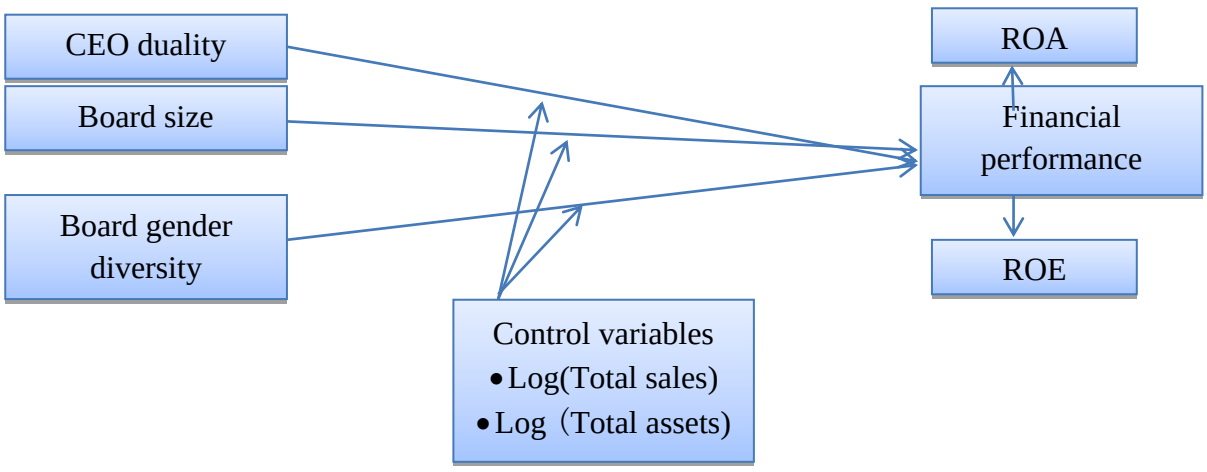

Figure 1: Conceptual framework

(Source: Created by author)

3 Research methods

3.1 Research philosophy and approach

According to Saunders et al. [23], quantitative research generally applies the positivism philosophy wherein researcher focuses on quantification of collected data in order to derive the scientific outcomes. For this purpose, statistical tools are used to interpret the data and get the generalised outcome. Using the positivism research approach, the current research tests the hypothesis which is important in the quantitative investigation. The objective interpretation of gathered information has been done to provide the law-like generalisation of the findings. Apart from this, deductive research approach has been used that helped in exploring the extant literature. It facilitated in identifying the variables for the research whereby data can be collected regarding the corporate governance and financial performance of US technology firms.

3.2 Data collection

Out of primary and secondary data collection sources, secondary sources have been found most suitable for the current research. It is because the study is about US technology firms wherein data about technology companies are to be gathered. Also, another reason is variables since variables are corporate governance and profitability of the business where existing data can better provide the idea about the topic under consideration. On this note, WRDS has been found as most suitable source to gather data about these variables. It is reliable and renowned source for extracting the database about companies. Apart from this, annual reports of firms have also been accessed to get some data regarding some variables. All numerical information available about chosen companies for nine years have been collected in the numerical form. This helps to analyse the pattern whether corporate governance affects financial performance of US technology firms or not.

3.3 Sampling design and variables of the study

The population for the current research is technology companies with largest market capitalisation. In this regard, simple random sampling method has been used whereby all companies with largest capitalisation had equal chances to be part of the research [23]. For this purpose, first 25 companies with largest market capitalisation have been considered in the current research. The data from 2012 to 2020 were collected for all 25 companies to get insight of recent scenario of US technology firms. On the other hand, mainly there are two variables including corporate governance and financial performance. The corporate governance is independent variable which has been measured by board gender diversity, CEO duality and board size. Many studies measured corporate governance by these three variables; therefore, it has been selected for the current research [20] [28] [14] [27] [15]. On the other hand, financial performance of companies which is dependent variable has been measured by return on equity and return on assets. Lastly, control variables including natural log of total sales and assets were chosen since they affect the size of the business.

Broadly, based on the research question, following variables have been identified

1. **Dependent variable (Y)**: Financial performance (Return on assets and return on equity)
2. **Explanatory variable (X)**: Corporation governance (CEO duality, board gender diversity and board size)
3. **Control variables (C)**: Natural logarithm of Total sales and total assets denoting the size of the firm

3.4 Data analysis

Basically, two types of data analysis techniques including qualitative and quantitative are used wherein quantitative employs statistical tools. Apart from this, qualitative techniques generally operationalise bulk qualitative data which is not needed in the present research [24]. It is because all data related to corporate governance and financial performance are available in numbers; thus, quantitative analysis techniques have been employed. For this purpose, descriptive statistics and regression analysis have been used. The descriptive statistic facilitated in drawing common pattern from the collected data whereas regression analysis supported in identifying the influence of each variable on others. Supporting this, Saunders et al. [23] proclaimed that regression analysis calculates the extent of influence each particular variable can have on others. On this note, impact of each particular variable such as board size, CEO duality and gender diversity on the return on equity and return on assets have been calculated separately. The findings have been presented in the tabular form

which are then followed by detailed interpretation.

Continuing from above, SPSS software has been used for operationalisation of the data. It is because SPSS software is easy to use tool to conduct statistical analysis on the large dataset[25]. Likewise, data about 25 companies for five years were to be operationalised; therefore, SPSS software has been found useful tool to perform the quantitative analysis. This output has helped in testing the final hypotheses for the research and derive the conclusion to the research aim. Apart from this, findings have been compared with the literature review to offer justification regarding the rejection and acceptance of hypotheses. This is crucial in the quantitative analysis since it provides law like generalisation by deriving results in the light of extant theories or frameworks.

4 Data analysis

This section presents the analysis of data based on the statistical test results and research objectives. The results are presented along with suitable interpretation.

4.1 Descriptive statistics

The table below provides average value of data collected for sample companies with the applications of mean, mode and standard deviation.

Table 1: Descriptive statistics

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
ROA	225	.01	.44	.1775	.08741
ROE	225	-.30	2.65	.2363	.29178
Gender ratio	225	.55	1.00	.7755	.09353
Board size	225	6	17	11.49	2.169
CEO duality	225	0	1	.32	.469
Total assets ($m)	225	2.33	6.39	4.94	.57
Total sales ($m)	225	2.18	5.64	4.65	.53
Valid N (listwise)	225				

The descriptive statistics show that US technology companies maintain average 17.75% return on assets over the period of nine years. This return deviates across companies from 8.75% which implies some companies generate minimum 1% and maximum 44%. On the other hand, return on equity deviates to a great extent since the standard deviation is 29.17% in the average return on equity; 23.63% over the nine years for US technology companies. This showcase some companies incurred loss since return on equity went minimum -.30 whereas maximum was 2.65. Besides, average gender ratio was 77.55% with variation of 9.353% whereas board size remained average 11.49% throughout the selected period. In addition to this, CEO duality reflects the great degree of variation since some companies do not have CEO duality whereas some have. Lastly, major variation remains in the total assets and total sales with wide range of log values, reflecting the significant variation in the size of companies selected into the sample.

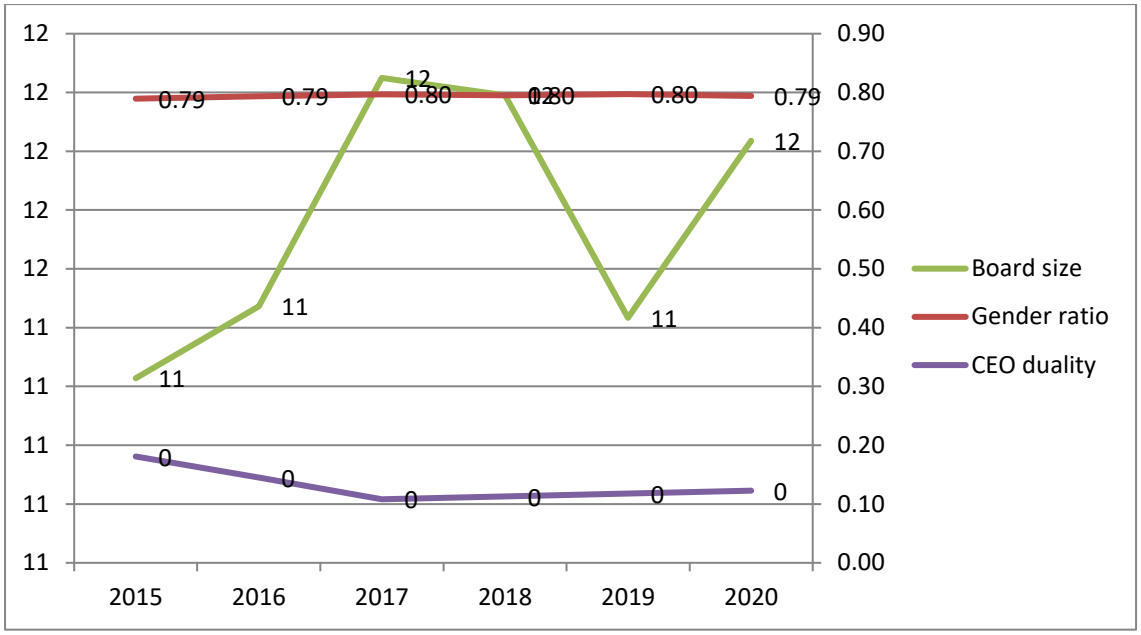

Figure 2: Corporate governance of the US companies

Figure-2 shows corporate governance performance of US companies for recent years 2015-2020. It can be seen that the US technology companies maintained average board size of 11 to 12 directors. Also, in all of the years, separate positions for CEO and Chairman are maintained. Also, gender ratio in board composition is stable around last six years with nearly 70-80% male representation.

4.2 Correlation

Table 2: Correlation between independent variables

		Gender ratio	Board size	CEO duality	Log Total assets
Gender ratio	Pearson Correlation	1	-.153*	-.022	-.023
	Sig. (2-tailed)		.022	.738	.618
	N	225	225	225	225
Board size	Pearson Correlation	-.153*	1	-.069	-.042
	Sig. (2-tailed)	.022		.304	.587
	N	225	225	225	225
CEO duality	Pearson Correlation	-.022	-.069	1	.087
	Sig. (2-tailed)	.738	.304		.368
	N	225	225	225	225
Log (Total assets)	Pearson Correlation	-.034	-.126	.087	1
	Sig. (2-tailed)	.618	.587	.368	
	N	225	225	225	225
Log (Total sales)	Pearson Correlation	.023	-.042	.117	.858**
	Sig. (2-tailed)	.731	.529	..081	.000
	N	225	225	225	225

The table above shows that all variables selected for the research are independent and do not correlate to others. It is because higher degree of correlation between independent variables leads to create the challenge of multicollinearity. It happens when the value of independent variable exceeds from +/- .070 and accordingly, no any variable from the above table is correlated [26]. Therefore, the selected data are fit to the purpose.

4.3 Regression analysis

4.3.1 ROA

Table 3: Model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.156[a]	.024	.002	.08732

The regression statistics showcase that the value of coefficient correlation is .156 which is weak and R Square is .024 which means only 2.4% change in the corporate governance can be explained by the ROA.

Table 4: ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.042	5	.008	1.091	.366[b]
	Residual	1.670	219	.008		
	Total	1.711	224			

Table 5: Regression coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.106	.085		1.248	.213
	Gender ratio	.042	.064	.045	.655	.513
	Board size	-.003	.003	-.078	-1.126	.261
	CEO duality	-.013	.013	-.079	-1.168	.244
	Total assets	0.002	.020	-.015	-.112	.911
	Total sales	0.015	.022	.089	.674	.501

From the table above, it is witnessed that CEO duality and board size have negative relationship with return on assets of the business. Nonetheless, gender ratio has the positive relationship which means increase in gender ratio into the board will positively affect the financial performance of the business. Nonetheless, the p value of the gender ratio is .513 which is greater than .050 which makes the relationship insignificant. Apart from this, beta value of board size is -.003 with p value .261 which ultimately makes the relationship negative plus insignificant since the value again exceeds from .050. Lastly, CEO duality scores -.013 whereas the p value is .244 which makes the relationship negative and insignificant. Although, overall relationship seems weak but positive. It implies the CEO can perform dual role keeping into mind the return on assets when it comes to USA companies because there seems no statistical significance between these two variables.

4.3.2 ROE

Table 6: Model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.270[a]	.073	.052	.28414

The model summary showcase that the correlation between return on equity and corporate governance of US technology firms is weak since the value of R is less than .30 whereas R square shows value worth .073. This indicates that only 7.3% of change in the return on equity of the business can be explained by the corporate governance of the business.

Table 7: ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.389	5	.278	3.441	.005[b]
	Residual	17.681	219	.081		
	Total	19.071	224			

Table 8: Regression coefficients

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.977	.277		3.528	.001
	Gender ratio	-.117	.208	-.037	-.563	.050
	Board size	-.030	.009	-.221	-3.286	.001
	CEO duality	-.017	.041	-.027	-.415	.679
	Total assets	.059	.066	.116	.890	.037
	Total sales	-.128	.071	-.233	-1.801	.017

The model is significant since the p value in case of two independent variables including gender ratio and board size is low which implies this play significant role in the return on equity. However, this relationship is negative. Apart from this, the p value of CEO duality is greater than .050 which makes the relationship insignificant. It infers that CEO duality does not leave significant impact on the return on equity of the business but other variables do. Putting it simply, the duality of CEO does not affect the return on equity of business since the relationship proves to be insignificant. Therefore, CEO can perform both roles when it comes to US context. Overall, it can be said that the model is significant because there is weak but significant relationship of majority of variables. Broadly, with the better corporate governance in terms of higher board size and greater diversity in board, financial performance is negatively affected.

Hypotheses testing

H01: There is no significant influence of board gender ratio on return on equity (ROE)=Rejected

H02: There is no significant influence of board gender ratio on return on assets (ROA)=Accepted

H03: There is no significant influence of the board on return on equity (ROE)=Rejected

H04: There is no significant influence of the board on return on assets (ROA)=Accepted

H05: There is no significant influence of CEO duality on return on equity (ROE)=Accepted

H06: There is no significant influence of CEO duality on return on assets (ROA)=Accepted

5 Discussion

The findings revealed that corporate governance significantly affect ROE of the business but the same is not significant for the return on assets. These findings are contradicted to the literature since some studies revealed that gender diversity and size of the board affect both ROE and ROA of the business [10]. On this note, some studies found positive and significant relationship whereas some found negative [15][20]. More specifically, in relation to Hassan [15], findings of the present research contradict since the current research reflects the insignificant link of gender ratio of board with ROA and negative and significant in case of ROE. However, the difference might be due to different contextual background of Hassan [15] and it may be different in case of US technology firms. This suggests that diverse board with equal male and female presentation where both male and female are provided equal opportunities to be part of the business leads to negative firm performance. The findings contradict with literature which suggests better decision-making through diverse board [18]. It can be because of cultural differences where the US tech firms' performance is affected from delay in decision-making because of diverse board. When gender ratio is too high or low, it might cause lack of gender diversity and thus a balanced diversity in board is suggested.

In relation to board size, findings are consistent to the literature it is because Alabdullah, Ahmed and Yahya [14] revealed that there is no link between larger board size and financial performance of the business which can validate the results in relation to return on equity whereas Marinova, Plantenga and Remery [27] revealed that the influence of governance in companies on financial results depends upon the size of the business. For instance, the large firm may need large board size whereas smaller firm might work with small board size and accordingly, the findings of the current research seem relevant to the literature. Considering this, it is important to the note that the size of the business control the relationship between CG and financial returns of corporates since it depends upon the size how many board members are to be employed.

In terms of CEO duality, the literature findings are consistent wherein some authors did not show the association between financial return of companies and dual roles of CEO [1][12]. Nonetheless, some studies witnessed negative relationship of duality with the economic indicators of companies since duality of CEO increases workload and restrict creativity in the business [16][21]. On this note, based on interpretation of US technology firms, it can be said that dual roles of CEO do not have significant impact on the profitability of companies. Whether CEO is holding chairmanship or not, does not matter to performance of US tech firms. This is in contradiction with agency theory which suggests that when there is lack of effective governance i.e. transparency and fairness, it leads to agency costs [16]. Also, it might be possible that companies keep dual roles of CEO in order to utilise existing expertise of CEO for better operation of the business.

6 Conclusion

The chapter above concludes that financial performance of companies is affected by the governance system; nonetheless, the impact of each variable varies on components of financial performance of US technology companies. In the first research question, "connection between return on equity and return on assets of US technology companies with CG" the study concludes that CG affects the ROE and does not affect the ROA. It is because the board gender ratio is negatively associated with the return on equity but in case of return on assets it has been found insignificant despite positive values. Coming to the next question "connection of CG with financial performance measured by ROA and ROE" it indicates that the size of board is influenced by the size of the business which means company with small size may keep limited board member but adverse case in relation to large businesses. Nonetheless, the study under consideration concludes that board size affects the return on equity but it does not affect the return on assets of the companies. This scenario may be opposite to others

studies but in case of US technology firms, the size of board seems not relevant to the return on assets of firms. Last research question about the connection of CEO duality with financial performance measured by ROE and ROA, CEO duality is not linked with the financial performance of US technology companies. In this context, the overall model of corporative governance with return on assets seems insignificant but in case of return on equity the model is significant.

6.1 Managerial implications

Drawing on the conclusion, it can be said that companies can keep large board size for companies with large size. Nonetheless, in relation to small size of firms, keeping large board size may be troublesome. Apart from this, it can be concluded that CEO duality can be kept in US technology firm when the CEO has potential to perform both roles since it does not affect the financial performance of companies.

6.2 Limitations and recommendations

The current research is restricted to the secondary data; therefore, it does not provide rich insights regarding why some variables are not related to ROA and ROE. In this context, primary research could have been added to complement the current data and get the in-depth outcome. For this purpose, the future research can be carried out by collecting primary data to get answer of unanswered questions raised in the current research. For instance, when existing studies indicate the connection between CEO duality and financial performance but the current research does not show. For this perspective, future research will be needed. Additionally, the current research findings are limited to only US technology firms; therefore, the application of findings to different industry is complicated. Also, it is complicated to apply findings to different region. Owing to this, the future research can be carried out by choosing companies from multiple countries. It will provide the diverse outcome applicable to the wider context.

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Framework for Digital Servitization in Industrial Internet of Things

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Abstract

The Industrial Internet of Things (IIoT) changes the activities and process of value creation from individual contributions to the integrations of efforts in a complex service ecosystem. Potential benefits of IIoT technology drive firms to pursue opportunities of servitization. However, there are challenges for firms to capture digital service values. Literature about the convergence of digital technology and servitization is recent, with more focus on technology than strategy. This paper proposes a framework for digital servitization in Industrial Internet of Things from a Social Network perspective. By using the theory of social capital and the social network perspective, the study develops a conceptual framework about how firms foster value in co-creation and achieve sustainable competitive advantages from network structures and relational rents. The study contributes to the integration of theory of digital servitization and social capital, the development of structural approach by visualization and appliable constructs. This conceptual framework provides mainly two aspects of contributions for future research. First, it is about how firms organize and manage networks in the digital servitization. Second, this conceptual framework reveals the dynamic features of network strategy. As the network structure evolves from early stage to late stage, social capital increases and servitization advances. Also, the diversity of industrial demands requires IIoT companies to develop different network strategies.

***Keywords*:** IIoT, Digital servitization, Social capital, Co-creation

An Explainable Federated Graph Attention Networks for Financial Fraud Detection

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Abstract

Financial institutions need effective tools for fraud detection and analysis to protect customer interests and maintain the stability of the financial system. Fraud detection is a critical challenge that necessitates robust and interpretable AI models. Collaboration among financial institutions will yield additional data for training AI models, thereby enhancing model robustness. However, these institutions frequently encounter stringent regulatory mandates regarding data sharing and privacy. Federated learning enables collaboration and model improvement without compromising data sensitivity or privacy. This paper presents Explainable Federated Graph Attention Networks (XFed-GAT) for financial fraud detection. The proposed model aims to address issues of privacy concerns, information silos, class imbalance, and interpretability in financial fraud detection. Federated learning with homomorphic encryption enables the model to be trained across multiple institutions without data sharing, thus effectively addressing privacy concerns and information silos. The graph attention mechanism, combined with weighted cross-entropy loss, enhances the model's ability to capture complex relationships and patterns within financial transaction networks, which is crucial for identifying fraudulent activities and addressing class imbalance issues. Additionally, the explainability component (Deep Lift) ensures the transparency of the model's decision-making process, allowing for the interpretation of detected fraud instances.

Keywords: Fraud detection, Federated learning, Homomorphic encryption, Explainable AI, Graph attention networks.

The Influence of Consumer Acceptance of Mobile Healthcare Technology on Quality of Life

——Taking the 'Smart Bed' as an Example

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Abstract

The development of mobile healthcare (mHealth) technology and increasing awareness of health conditions have impacted the healthcare and service industry. However, the acceptance level of these products varies among different groups, and factors influencing the use or continuous use differ across various application scenarios. It is not fully understood to what extent different consumer groups and demographic characteristics affect the acceptance and application effects of mHealth.

Objective: This research aims to study the influencing factors of different populations (elderly and non-elderly), populations with chronic and non-chronic diseases, and different demographic characteristics on the continuous use of mHealth in different application scenarios, and the difference in the influence on their technical acceptance and quality of life (QoL) after continuous use.

Method: A new healthcare acceptance model is proposed by combining different theories, including the Technology Acceptance Model (TAM), Technology Preparation (TP), Quality-Value-Satisfaction (QVS) intermediary chain, and Technology Anxiety (TA). Field investigations were conducted on actual users (234 valid investigation data) to verify the model, and multi-group partial least square path analysis was applied to the data. Result: The perceived ease of use (β=0.188, P=0.002) and usefulness (β=0.131, P=0.003) have a direct

effect on continuous use behavior. The contributing factors, inhibiting factors, and QVS chain have a significant influence on continuous use behavior (β=0.446, 0.427, 0.400, P=0.000, 0.000, 0.000) and inhibiting factors (β=-0.368, -0.388, -0.453, P=0.000, 0.000, 0.000) respectively. The QVS chain plays an intermediate role between technical preparation and continuous use behavior (β=0.338, 0.112, 0.156, P=0.000, 0.039, 0.013).

Continuous use behavior has a positive impact on users' QoL (β=0.629, P=0.000), while technology anxiety has a negative effect on the relationship between the QVS chain and continuous use behavior (β=-0.029, -0.122, -0.135, P=0.104, 0.0002, 0.0016).

Conclusion: This study combines the TAM and TP theories to investigate consumers' continuous use of mHealth from different perspectives and demographic characteristics. The results provide a theoretical and methodological basis for future research, and have practical significance for Chinese suppliers' development and promotion of mHealth systems in different countries. It also emphasizes the importance of user acceptance and use of new technologies for enterprises.

Keywords: Mobile healthcare (mHealth) technology; Internet + Smart Bed; Technology Acceptance Model (TAM), Technology Preparation (TP); Quality-Value-Satisfaction (QVS); Technology Anxiety (TA); Continuous Use Behavior (CUB); Quality of Life (QoL)

The Challenges and Solutions of Consumer Capitalism: Innovative Applications of ESG and AI

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Abstract

Consumer capitalism, a crucial component of modern economies, profoundly influences economic growth, social behaviors, and cultural values. Originating from the Industrial Revolution and maturing post-World War II, consumer capitalism has driven widespread consumption-led economic growth, particularly in developed nations. However, this economic model also exacerbates income inequality, environmental degradation, and cultural shifts towards materialism. This study investigates the characteristics, impacts, and responses to consumer capitalism through a mixed-method approach, including qualitative content analysis and interviews, alongside quantitative data analysis and comparative studies.

Grounded in theories from Marxist economics, Weber's Protestant Ethic, and Baudrillard's consumer society, this research explores consumer capitalism's influence on economic policies, market behaviors, and its socio-cultural impacts across different nations and social strata. It hypothesizes that consumer capitalism drives GDP growth while inducing economic volatility, intensifies wealth disparities, and reshapes traditional cultural values towards individualism and materialism.

The study aims to confirm the dual impacts of consumer capitalism on economic growth and stability, reveal varied responses among social groups and countries, and provide policy recommendations to balance economic benefits and social challenges. These recommendations include stringent advertising regulations, promoting responsible consumer credit use, and fostering green consumption for sustainable development.

Furthermore, the research emphasizes the role of Environmental, Social, and Governance (ESG) standards, supported by Artificial Intelligence (AI), in addressing the adverse effects of consumer capitalism. AI's capabilities in real-time monitoring, extensive data analysis, resource optimization, and decision support are highlighted as crucial in enhancing ESG implementation.

Ultimately, this study contributes to the theoretical and empirical understanding of consumer capitalism, offers practical policy insights, and demonstrates the potential of AI in achieving sustainable and equitable economic development. The integration of ESG and AI is proposed as a strategic approach to mitigate the negative impacts of consumer capitalism, promoting a more inclusive and sustainable global economy.

Keywords: Consumer Capitalism, ESG (Environmental, Social, and Governance), Artificial Intelligence (AI), Economic Growth, Environmental Sustainability, Cultural Values, Policy Recommendations

1. Instruction

The ESG-Enhanced AI-Integrated Analysis (EAIA) Model is a novel research framework created for this study by combining the ESG framework with AI-driven data analysis. The model comprises two main components: the ESG Framework and AI-Driven Data Analysis. The ESG Framework focuses on three areas: Environmental (E), which addresses resource management, sustainable production, and carbon emission reduction; Social (S), which enhances labor rights, social welfare, inclusivity, and fairness; and Governance (G), which ensures transparency, accountability, and long-term strategic planning [1]. AI-Driven Data Analysis involves real-time monitoring and reporting, predictive analytics, and resource optimization [2]. This research model implements qualitative research methods such as content analysis using AI tools to analyze media advertisements and corporate marketing strategies, and in-depth interviews with stakeholders using AI-powered transcription and analysis tools. Quantitative research includes data analysis integrating ESG data with AI analytics to assess impacts on economic growth and volatility, and comparative analysis using AI to identify cultural and policy differences in consumption patterns across countries.

To begin the research, the author undertook extensive preparation and planning. This involved defining research objectives, formulating research questions, and establishing the research framework that combines

ESG standards with AI-driven data analysis. A detailed research plan was developed, including timelines, resource allocation, and key milestones, with collaboration from experts in ESG and AI fields. Necessary tools and software for qualitative and quantitative data analysis were acquired, and preliminary meetings with stakeholders were conducted to refine the research focus and methodology.

The next phase involved literature review and case study selection. The author performed an extensive literature review on consumer capitalism, ESG frameworks, and AI applications to identify key theories and previous research findings. By synthesizing these findings, research gaps and areas for further exploration were identified. Case studies from diverse geographical regions and economic contexts were selected to ensure a comprehensive analysis of consumer capitalism's impacts, and specific data requirements for each case were outlined.

Data collection followed, wherein the author designed qualitative data collection instruments such as interview guides and content analysis frameworks. Qualitative data was collected through in-depth interviews with stakeholders and content analysis of advertisements and corporate marketing strategies. Quantitative data was gathered from international organizations (IMF, World Bank, OECD) and national statistical departments, and this data was integrated into AI-driven analytics platforms for preliminary processing and analysis.

Data analysis and interpretation were conducted using various tools. Qualitative data analysis was performed using NVivo to code and identify key themes and patterns from interviews and content analysis [3]. Quantitative data analysis was conducted using SPSS and AI analytics to assess the impacts of consumer capitalism on economic growth, social inequality, and cultural values. Cross-validation of qualitative and quantitative findings was done to ensure consistency and reliability, and the combined findings were interpreted to draw comprehensive conclusions about the characteristics and impacts of consumer capitalism.

Drafting and revising the research paper was the next critical step. The author drafted the initial version of the research paper, including introduction, methodology, findings, discussion, and conclusion sections. The draft was reviewed and revised based on feedback from co-authors and experts, followed by a thorough review for consistency, clarity, and alignment with research objectives. The research paper was then finalized and prepared for submission.

The importance of the EAIA model was realized through this rigorous and systematic approach [4]. By integrating ESG principles with advanced AI analytics, the model provided a comprehensive and multidimensional analysis of consumer capitalism. Its enhanced predictive capability allowed for proactive measures to address the negative impacts of consumer capitalism, while real-time monitoring ensured data accuracy and timely insights. AI's efficiency in resource management aligned with the ESG framework's environmental goals, promoting sustainable practices and reducing the ecological footprint. This model offered actionable insights for policymakers and businesses, enabling effective policy formulation and strategies to balance economic growth with social equity and environmental sustainability. The innovative theoretical contributions of the EAIA model, combining ESG standards with AI technology, provided a new perspective on addressing the challenges of consumer capitalism and fostered interdisciplinary research.

The EAIA model employs a robust and systematic approach to ensure the credibility, reliability, and validity of the research findings. Sampling methods include purposeful sampling for qualitative data, selecting interview participants who are experts in the fields of economics, sociology, and AI, as well as diverse consumer groups, ensuring a wide range of perspectives and in-depth understanding of consumer capitalism. Quantitative sampling involves collecting data from reputable international organizations such as the IMF, World Bank, and OECD, as well as national statistical departments, to ensure high-quality and representative economic and social data. The use of a large and diverse dataset enhances the generalizability of the findings.

To maintain validation, the study employs multiple data collection methods, including interviews, content analysis, and quantitative data, to cross-validate findings, ensuring consistency and credibility. Preliminary findings and methodologies are reviewed by experts in ESG, AI, and consumer capitalism, with their feedback incorporated to refine the research design and analysis. Data collection instruments, such as interview guides, are pilot-tested with a small sample to ensure clarity, relevance, and reliability, with necessary adjustments made based on pilot test feedback.

Reliability checks are implemented through inter-coder reliability for qualitative content analysis, involving multiple coders to ensure consistency in coding [5]. Inter-coder reliability is calculated to ensure the coding process is reliable and free from bias. Quantitative data analysis includes checks for reliability, such as Cronbach's alpha for internal consistency, and test-retest reliability where applicable, with statistical methods applied to ensure the robustness of the data analysis.

The mixed-methods approach used in this study combines qualitative and quantitative methods to provide a comprehensive view of the research problem. Qualitative insights offer depth and context, while quantitative analysis provides empirical evidence. Findings from qualitative interviews and content analysis are cross-validated with quantitative data analysis to ensure consistency and reliability. Data collection follows a systematic approach, ensuring all relevant aspects of consumer capitalism are covered. Data from reliable sources and rigorous methodologies ensure high-quality data, with advanced AI tools used for real-time monitoring and data analysis, enhancing the accuracy and efficiency of data collection and analysis.

Ethical considerations are addressed by obtaining informed consent from all interview participants, ensuring they are aware of the research purpose and their rights. Measures are taken to protect the confidentiality and anonymity of participants, adhering to ethical standards in social science research. AI tools are used responsibly, ensuring that data privacy and ethical considerations are maintained throughout the research process. Robust data analysis is ensured through the use of NVivo for qualitative coding and thematic analysis, providing detailed insights into interview data and content analysis. Multiple coders ensure the reliability of qualitative findings, while SPSS and advanced AI analytics are employed for statistical analysis, including descriptive statistics, regression analysis, and predictive modeling, ensuring robust and reliable quantitative findings.

By incorporating these rigorous methodological practices, the EAIA model ensures the reliability, validity, and credibility of the research findings, making it a valuable contribution to the academic understanding of consumer capitalism and ESG integration.

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Intertextual Chinese-to-English Translation Quality Assessment of CSR Reports: A Corpus-Based Study

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Abstract

This study employs intertextual signals as parameters to conduct a corpus-assisted empirical assessment of Chinese-to-English translation quality of corporate social responsibility (CSR) reports. It's found that intertextuality, viewed as an "intertextual dumbbell" in a translation context, encompasses self-intertextuality, discoursal intertextuality and cultural intertextuality across the "intertextual networks" of source texts (ST) and target texts (TT). Parameters including cohesive conjunctions & adverbs, STTR, parallelisms, references, conventional expressions, allusions, parodies, parts & sub-parts, moves & steps, keyword list, picture captions and news & case headings, comment adjectives & adverbs and culture-loaded resources are set along each intertextual dimension, and analyzed in ST, TT and original English texts. Comparisons in parameter distribution reveals the impact of intertextual operations during translation on TT quality, suggesting a generally acceptable yet inadequate translation of Chinese companies' CSR reports. This study constructs an intertextual translation quality assessment (TQA) framework, demonstrating the feasibility of intertextual parameters and corpus methods. It addresses a gap in TQA of ESP genres and enriches intertextuality and translation theories. Practically, the empirical TQA serves as guidance for companies to enhance future translation practices and achieve effective communication with global stakeholders in line with international management norms.

Keywords: TQA, Intertextuality, CSR Reports, Corpus, Intertextual Dumbbell

1. Instruction

Translation quality assessment (TQA), central to translation criticism and applied translation studies, primarily focuses on literary translation, leaving a gap in assessing translation quality of genres in English for specific purposes (ESP). Corporate social responsibility (CSR) reports, a crucial instrument of non-financial information disclosure, aid companies in demonstrating their fulfillment of social responsibilities in various aspects, which would win them better investment opportunities in the future based on stakeholders' evaluation of their responsibility performance[1]. Particularly in the context of Chinese government's "Go Global" strategy and the "Belt and Road" initiative, English-translated CSR reports act as a pivotal conduit for China's international communication. High-quality CSR report translation will not only deliver information in a more accurate manner, but, more importantly, enhance companies' global image and stakeholder engagement, attract foreign investment and strengthen the government's effect of external publicity.

Translation is universally reckoned as "a communicative process which takes place within a social context"[2, p.3], while context is a collection of various parameters. Intertextuality, concerning the intricate connections between a text and others that came before it, offers a rich array of potential parameters for TQA with its systematic classifications and comprehensive manifestations. CSR reports, as a typical mixture of sub-genres, abound with generic features easy to identify and compare as intertextual parameters, which is of great operability in TQA. However, TQA has yet to be tackled from an intertextual perspective.

Corpus approaches based on massive authentic data enable the identification and comparison of linguistic features between source texts (ST) and target texts (TT) along each parameter, thereby facilitating the evaluation of translation quality. Despite predictions regarding the emergence of corpus-based TQA models[3], with qualitative methods prevailing, the potential of corpus methods has been underutilized. Therefore, following a corpus approach, this study seeks to assess the quality of English-translated CSR reports through the lens of intertextual transfer, so as to enlighten companies' CSR report translation practice, international communication efforts and stakeholder engagement strategies.

2. Literature Review

2.1 Parameter-Oriented TQA Models

Various parameter-oriented models or frameworks have been proposed by translation scholars and practitioners aimed at evaluating translation quality by comparing ST and TT along predefined parameters. Notable contributions include works by House[4] [5] [6], Wilss[7], Wu & Li[8], van den Broeck[9] [10], Fan [11], Bensoussan & Rosenhouse[12], Mu[13], Feng & Feng[14], Al-Qinai[15], Li & Yang[16], Williams[17], Hou[18], Si[19] [20], Munday[21] and He[22], among others. While these quantitative approaches mitigate subjectivity in TQA to some extent, they are not operational-friendly due to the substantial workload involved.

2.2 Applied TQA

Studies focusing on applied TQA are relatively scarce compared to those on literary translation, encompassing genres such as tourist texts[23], political speech[24], company profiles[20] and medical texts[25] [26]. However, these studies predominantly rely on existing TQA models, demonstrating similar routes and minimal innovation. Case study and manual identification of translation deviations are commonly employed methods, particularly suitable for individual texts, often of short length. Nevertheless, a clause-by-clause examination of ST and TT is time-intensive, and selecting typical cases for analysis or comparison in the case of long or multiple translation texts tends to obscure the overall quality of TT. Thus far, corpus tools haven't been fully leveraged to evaluate the quality of large-scale translation texts.

2.3 Studies of Intertextuality in Business Translation

While intertextual translation research has traditionally focused on literary texts, recent years have witnessed a growing interest among scholars in exploring intertextuality in the translation of various business genres. These genres cover advertisements[27], public signs[28] [29], legal texts[30] and medical English[31] [32]. However, there remains a notable absence of theoretical frameworks tailored to intertextual translation of business genres, and intertextuality in the translation of CSR reports or other corporate non-financial information disclosure texts remains largely unexplored.

3. Theoretical Framework

3.1 "Intertextual Dumbbell" in a Translation Context

Intertextuality is universally acknowledged to encompass diverse forms of expression, including citations, allusions, genres and forms, etc. Previous classifications of intertextuality, despite varying terminology, largely adhere to dichotomy, as observed in the works of Jenny[33], Riffaterre[34], Lemke[35], Kristeva[36], Hatim & Mason[2], Fairclough[37], Xin[38], Samoyault[39], Qin[40], Li[41], Luo[42], Shao[43] and Wang[44], a considerable number of which exhibit overlapping features.

All these distinctions recognize the existence of intertextuality in a spectrum comprised of the host text (HT), other texts in the host language (HL) and the host cultural circle (HC) in which HT is embedded, with tangibility and intangibility as two poles. This indicates three types of intertextuality in a monolingual context. The first type exists within HT itself, embodied as various means (explicit) to achieve cohesion and coherence inside texts, named "self-intertextuality". The second type occurs between HT and HL, manifested through either fixed references, clichés, idioms, proverbs and conventionalisms, etc. (explicit), or "deverbalized" devices like allusions and parodies (semi-explicit) on the one hand, and more general conventions in the layout, schematic structure, writing method and topical inclination shared in HL on the other hand, such as structure, genre, function and theme (implicit), necessitating readers' background knowledge of pre-texts in HL for identification, named "discoursal intertextuality". The third type operates between HT and HC, the identification of which requires a profound grasp of numerous aspects constituting HC, including the prevailing value system, aesthetic habits and socio-historical factors (implicit), etc., named "cultural intertextuality". These three types of intertextuality collectively form an "intertextual network", with the demand for readers' intertextual competence escalating outwardly as the tangibility of intertextuality diminishes.

In a translation context, the picture becomes more intricate as TT, a HT in the target language (TL), stands in its own intertextual network. Thus, it's warranted to generate an intertextual model in the context of CSR report translation, as illustrated in Figure 1.

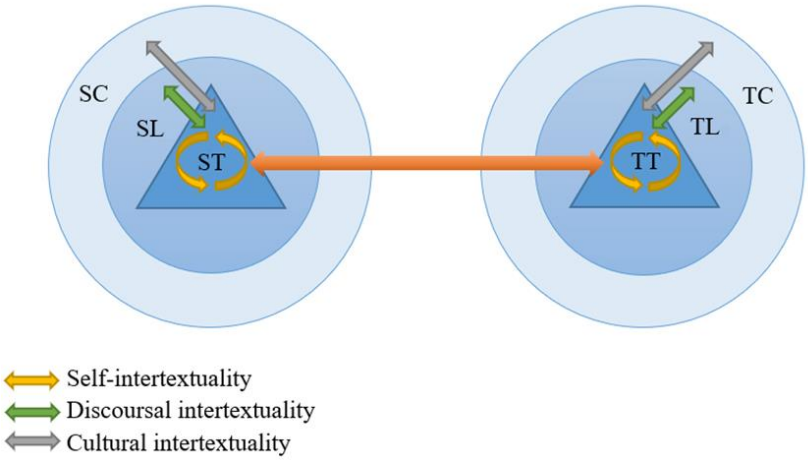

Figure 1 "Intertextual Dumbbell" in CSR Report Translation

In this model, both ST and TT form their respective intertextual network with the source language (SL) and source culture (SC) on the one hand, and TL and target culture (TC) on the other. The double arrows signify the bidirectional nature of these intertextual relations. Notably, ST and TT, despite belonging to different language systems, constitute a robust intertextual relationship wherein ST serves as a pre-text inducing the content, form and even the very generation of TT. Consequently, a dumbbell-shaped intertextual model emerges within a translation context.

3.2 Parameter System of Intertextual TQA for CSR Reports

It's pertinent to note that most existing manifestations of intertextuality originated from literary texts, making a direct application less relevant in CSR reports, simply because of the infrequent appearance of literary intertextual elements, such as allusions or parodies, in business genres. Hence, a focus on the generic characteristics of CSR reports, aided by corpus methods, is crucial for developing a parameter system tailored to the demands of intertextual TQA for CSR reports.

3.2.1 Self-intertextuality Dimension

Self-intertextuality pertains to cohesion and coherence inside texts, falling into grammatical cohesion, lexical cohesion and structural cohesion.

Grammatical Cohesion: Cohesive Conjunctions & Adverbs

Conjunction as the most common realization of grammatical cohesion, include such function words or phrases as cohesive conjunctions and adverbs. Its implication for TQA lies in the fact that translations adhering to the conventional norms in textual construction by the TL community are deemed of higher quality.

Lexical Cohesion: STTR

Repetition of a lexical item is the most direct form of lexical cohesion[45, p.571], while type-token ratio (TTR) reveals the extent same words are repeatedly used in a text. Since TTR decreases as texts lengthen due to the dilution by increasing tokens, standardized type-token ratio (STTR) is set as a parameter for comparisons among the three corpora in content continuity.

Structural Cohesion: Parallelisms

CSR reports feature a large number of typical parallelisms in tables of contents and titles and sub-titles in the main body, which hark back with one another in form, even if separated by lengthy contents, maintaining logical consistency. Due to different preferences in parallelism pattern of Chinese and English, the adaptation of TT to the reading habits of its target audience is influenced by its inclination to comparable texts in TL (hereinafter referred to as "CT") in the realizational pattern of parallelisms.

3.2.2 Discoursal Intertextuality Dimension

References

As the most frequently used and easily recognizable intertextual signals, references in ST of CSR reports are categorized into 4 types: direct speech, indirect speech, literary references borrowed from ancient poetry or proses and embedded references in which an expression in pre-texts are "built in" the writer's sentence, typically taking the form of "cardinal number + abbreviation" enclosed in quotation marks, such as "三重一大", "两学一做", "五险一金" and "三会一课", among others.

Conventional Expressions, Allusions and Parodies

Although relatively sparse in CSR reports due to their colloquial nature, conventional expressions encompass proverbs, two-part allegorical sayings, idioms, clichés and four-character phrases (excluding those with specific allusions) in Chinese. Allusions occasionally surface in "soft texts" in CSR reports, such as "Chairman's Message", "Outlook", cases and feature stories, evoking cultural resonance among ST readers. Parodies, defined as humorous or exaggerated imitations of styles of well-known persons or situations, predominantly involve manifest parodies adapting components of idiomatic expressions or literary works in this study, considering the absence of constitutive parodies in CSR reports.

Structure: Parts & Sub-parts

Structural intertextuality pertains to affinity in form, across lexical, sentential and discoursal levels[43, p.481-503). Since word imitating is more common in English literary works for vivid descriptions, and sentence imitating as manifest parody stands as a self-contained parameter, structural intertextuality mainly involves the imitation of writing structure in Chinese CSR reports. The entire CSR report considered a special business genre, its macro parts and sub-parts, serving as discernible elements of its schematic structure, contribute to realizing its communicative purpose.

Genre: Moves & Steps

Constraints on the way messages are organized in a particular genre are often manipulated by expert members of a discourse community to achieve private intentions within the framework of socially recognized purpose(s)[46, p.29]. Thus, comparisons of the structural organizations of typical sub-genres in ST and CT of CSR reports could discern their preferred ways of communicating intentions. Moves and steps, as discriminative elements of generic structure, are set as the parameter for genre analysis.

Theme: Keyword List

Thematic intertextuality involves the recurrence of the same topic across different texts, and keywords, indicative of a specific genre's "aboutness", elucidate the salient features which are functionally related to that genre[47]. By comparing keyword lists across ST, TT and CT of CSR reports, changes in theme during translation can be identified.

Function: Picture Captions and News & Case Headings/Comment Adjectives & Adverbs

Functional intertextuality entails similarities in use. As a form of non-financial information disclosure, CSR reports detail the socially responsible practices of companies, showing their content-centered nature. For instance, to enhance readability and persuasiveness, CSR reports frequently incorporate pictures accompanied by captions that succinctly explain the depicted figures, places or events. Additionally, news and cases regarding social responsibility performance are provided, such as recognitions and awards, product and service innovation and social responsibility actions, etc., prefaced by headings summarizing the main content. These captions and headings can quickly capture readers' attention, allowing them to grasp essential information within limited time.

Furthermore, it's essential to note that CSR reports also serve a promotional purpose of maintaining public relations[48, p.463], which mainly concerns all those aspects related to the attitude towards or evaluation of the discourse by writers and readers, achieved by appraisal and modality. Comment adjectives and adverbs, as two major ways of expressing appraisal and modality, are extensively used in ST of CSR reports, conveying companies' proud, convinced and optimistic attitude towards their social responsibility performance during the fiscal year.

3.2.3 Cultural Intertextuality Dimension

Difficulties arising out of differences of culture constitute the most serious problems for translators and have produced the most far-reaching misunderstandings among readers[49, p.2], and intertextual translation is inherently a translation of culture. Naturally, culture-loaded resources constitute the third dimension of intertextual network, which refer to any linguistic units, aside from the previously mentioned intertextual signals along self- and discoursal dimensions, from which readers could derive a cultural meaning.

4. Research Design

4.1 Research Questions

This study aims to empirically assess the rending of intertextual signals in Chinese companies' CSR reports by comparing ST, TT and CT, which helps identify negative intertextual deviations and equivalences that impact the overall quality of CSR report translation. Based on this research objective, two research questions are proposed:

(1) What are the characteristics of the distributions of self-, discoursal and cultural intertextuality in ST, TT and CT of Chinese companies' CSR reports, respectively?

(2) How do the intertextual operations generated during CSR report translation influence the overall quality of TT?

4.2 Data Collection

10 Chinese companies and 10 American companies were randomly selected from the Fortune Global 500 list. The former includes China National Petroleum, Huawei, China National Offshore Oil, China Minmetals, Bank of Communications, China Shipbuilding Industry Corporation, China Huaneng Group, Vanke, State Power Investment and Ansteel Group, and the latter Walgreens Boots Alliance, Phillips 66, Citigroup, Lowe's, Intel, Cisco, Oracle, Nike, ConocoPhillips and DXC Technology. The most recent CSR reports available at the time of data collection were downloaded from their official websites, particularly with both the Chinese and English-translated versions for Chinese companies, resulting in a total of 30 texts: 10 Chinese ones, 10 corresponding English-translated ones and 10 originally-created English ones. The first two collections constitute Chinese-English parallel corpora, while the other two combinations form two sets of comparable corpora, bilingual and monolingual respectively, due to their similar register, length and time span.

4.3 Corpus Building

After text cleaning, sentences in English-translated CSR reports were split or merged as needed to ensure strict alignment with their Chinese counterparts. Chinese characters were segmented using CorpusWordParser, and both documents were saved in TXT format before loaded into ParaConc for a final alignment check. This resulted in the creation of the "corpora of source, target and original CSR reports" (hereinafter referred to as "COSCR", "COTCR" and "COOCR") respectively, for which Table 1 provides the basic statistics.

Table 1 Basic Statistics of COSCR, COTCR & COOCR

COSCR			**COTCR**	**COOCR**
Character	**Word**	**Line**	**Word**	**Word**
420647	257985	15462	254125	307614

This study involves both automatic and manual annotation. The former primarily concerns Part-of-Speech (POS) tagging using TreeTagger 3.0, while the latter parameters that cannot be directly recognized by computers, including parallelisms, most discoursal intertextual parameters and culture-loaded resources, following the Text Encoding Initiative. Manual proofreading and correction were conducted in case of any errors in automatic annotation. The concordance function of AntConc 3.4.1 facilitated tag searches within the parameter framework of intertextual TQA. Intertextual statistics of the three corpora were then compared, before deviations and equivalences in TT were identified and assigned a positive or negative value. For ease of reference, intertextual operations that influence translation quality positively are denoted as "PIO" (positive intertextual operation), while those negatively "NIO" (negative intertextual operation). The former includes "PIE" (positive intertextual equivalence) and "PID" (positive intertextual deviation), while the latter "NIE"

(negative intertextual equivalence) and “NID” (negative intertextual deviation).

5. Intertextuality Distributions in COSCR, COTCR and COOCR

5.1 Distribution of Self-intertextuality

5.1.1 Grammatical Cohesion

Grammatical cohesion is achieved through conjunction system that marks relations where one span of text elaborates, extends or enhances another, earlier span of text[45, p.540]. Based on these three sub-systems, cohesive conjunctions & adverbs in the three corpora were classified, with absolute frequencies and frequencies per 10,000 words calculated, as shown in Table 2.

Table 2 Cohesive Conjunctions & Adverbs in COSCR, COTCR & COOCR

Frequency / Sub-system	Absolute freq.			Freq. per 10000 words		
	COSCR	COTCR	COOCR	COSCR	COTCR	COOCR
Elaboration	86	3889	4015	3.3	153.0	130.5
Extension	992	813	1985	38.5	32.0	64.5
Enhancement	335	366	485	13.0	14.4	15.8
Total	1413	5068	6485	54.8	199.4	210.8

In COSCR, the majority of cohesive conjunctions & adverbs indicate extending relations, followed by those indicating enhancing and elaborating relations. In both COTCR and COOCR, however, elaboration resources rank 1st, with extension and enhancement resources ranking 2nd and 3rd, respectively.

5.1.2 Lexical Cohesion

Given that English function words have a greater capacity to dilute STTR compared to Chinese, the evaluation of lexical cohesion focused solely on the repetition of content words. Consequently, all function words were removed from the three corpora, with only the STTRs (per 10,000 words) of the remaining content words calculated and compared, as shown in Table 3.

Table 3 STTR of COSCR, COTCR & COOCR

Data / Corpora	General				Content words only			
	Type	Token	TTR	STTR	Type	Token	TTR	STTR
COSCR	13877	257985	5.38	21.46	13825	238555	5.80	23.25
COTCR	21947	254125	8.64	25.36	22268	190348	11.7	34.2
COOCR	25641	307614	8.34	25.42	25000	248456	10.06	30.53

The outcomes presented are actual ratios multiplied by 100. Both TTRs and STTRs of content words show a slight increase in all three corpora, indicating a smaller reduction in the number of types compared to tokens.

5.1.3 Structural Cohesion

Parallel structures in CSR reports mainly derive from the tables of contents and titles within the main body, identified manually based on the principles of “same level, more than three in number, identical syntactic structure and same number of characters/words”. The statistics of each syntactic type and its sub-types of parallelisms in the three corpora are illustrated in Table 4.

Table 4 Parallelisms in COSCR, COTCR & COOCR

Data / Syntactic structure		COSCR		COTCR		COOCR	
		Freq.	%	Freq.	%	Freq.	%
Nominal	N-N phrase	81	25.5%	34	10.7%	14	10.6%

structure	A-N phrase	60	18.9%	62	19.5%	13	9.8%
	Noun	5	1.6%	8	2.5%	38	28.8%
	Coordinate nouns	2	0.6%	/	/	10	7.6%
	N-modifier phrase	/	/	16	5.0%	5	3.8%
	Gerundial phrase	/	/	89	28.0%	28	21.2%
	Subtotal	148	46.5%	209	65.7%	108	81.8%
Sentence /S-P structure	Sentence	5	1.6%	7	2.2%	4	3.0%
	N-V phrase	3	0.9%	/	/	/	/
	N-A phrase	2	0.6%	/	/	/	/
	Subtotal	10	3.1%	7	2.2%	4	3.0%
Verbal structure	V-O phrase	156	49.1%	22	6.9%	8	6.1%
	Verb	1	0.3%	/	/	6	4.5%
	Subtotal	157	49.4%	22	6.9%	14	10.6%
P-O phrase		3	0.9%	2	0.6%	3	2.3%
Adjective		/	/	2	0.6%	3	2.3%
Mixture		/	/	68	21.4%	/	/
Untranslated		/	/	8	2.5%	/	/
Total		318	100%	318	100%	132	100%

In COSCR, 4 types of syntactic structure of parallelisms were observed, namely nominal structure, sentence/subject-predicate (S-P) structure, verbal structure and preposition-object (P-O) structure. Nominal structure can be realized by noun-noun (N-N) phrases, adjective-noun (A-N) phrases, coordinate nouns or nouns. S-P structure comprises noun-verb (N-V) phrases and noun-adjective (N-A) phrases. Verbal structure consists of verb-object (V-O) phrases and verbs. Conversely, COTCR and COOCR include two additional sub-types, N-modifier phrases and gerundial phrases, within nominal structure. Additionally, in COTCR and COOCR, sentences are the only form of S-P structure, and single adjectives are also found in small numbers.

5.2 Distribution of Discoursal Intertextuality

Given that references, conventional expressions, allusions, parodies and culture-loaded resources in in COTCR are mainly ST-induced, comparing their standardized frequencies among the three corpora seems futile. Therefore, for parameters related to explicit and semi-explicit discoursal intertextuality, as well as culture-loaded resources in the subsequent section, only descriptions of COSCR are presented.

5.2.1 References

Both direct speech and embedded references were identified through concordances of quotation marks, excluding lines not serving a “referential role” based on a specific context analysis. Indirect speech with clear sources was obtained partially through concordances of “evidentials” (e.g., “指出”, “提出”, “曾说”), assisted by manual inspection. References from poetry or prose, however, often lack source indications and quotation marks, necessitating full manual identification. Repeated references were counted based on their actual occurrences, and the statistics are presented in Table 5.

Table 5 References in COSCR

Reference type	Direct speech	Indirect speech	Literary reference	Embedded reference	Total
Frequency	65	10	12	403	490

The majority of references in COSCR are embedded references, often with abbreviations referring to national strategies, company regulations, political culture and social phenomena. Direct speech with indicated sources ranks 2nd, which plays a significant role in enhancing the report’s traceability and authenticity.

5.2.2 Conventional Expressions, Allusions and Parodies

Because of the formal style of CSR reports as written discourse, the number of conventional expressions in COSCR is relatively small. Manual identification revealed the use of 31 conventional expressions in COSCR. Examples include “你中有我、我中有你”, “一方有难八方支援” and “一肩挑”, to name just a few. The range of allusions in CSR reports extends beyond simple literary ones to include historical figures, expressions from political speeches repeatedly quoted by later generations, and various social responsibility awards named after individuals who have made outstanding contributions in certain fields. In COSCR, a total of 96 allusions were identified, such as “**鲁班**奖”, “**黑猫**一号” and “**授渔**计划”, etc. Parodies, as literary rhetorical devices, are rarely found in business genres like CSR reports. In COSCR, there were only 36 parodies, including examples such as “潮起海天阔，扬帆正当时” and “谋事在先，成事在干”.

5.2.3 Structure

All CSR reports in COSCR, COTCR and COOCR consist of three parts: “Leading in”, “Main Body” and “Appendices”, containing both obligatory and optional sub-parts. The percentages of each sub-part in all three corpora were calculated, with sub-parts appearing in 80% or more labeled as obligatory, while those less than 80% optional. The results are presented in Table 6.

Table 6 Parts & Sub-parts of ST, TT and CT of CSR Reports

Part	Sub-part	ST		TT		CT	
		%	Type	%	Type	%	Type
P1: Leading in	Report Introduction	100%	OB	100%	OB	/	
	Table of Contents	100%	OB	100%	OB	100%	OB
	Chairman’s Message	100%	OB	100%	OB	100%	OB
	Company Profile	100%	OB	100%	OB	70%	OP
	Awards & Recognition	90%	OB	90%	OB	40%	OP
	Organizational Structure	60%	OP	60%	OP	/	
	Industrial Layout	50%	OP	50%	OP	/	
	Corporate Culture	70%	OP	70%	OP	60%	OP
	Materiality	50%	OP	50%	OP	90%	OB
	Corporate Governance	60%	OP	60%	OP	70%	OP
	Sustainability Management	90%	OB	80%	OB	80%	OB
	Stakeholder Engagement	100%	OB	100%	OB	60%	OP
	SDG Implementation	20%	OP	20%	OP	50%	OP
	Party Building	50%	OP	40%	OP	/	
P2: Main body	Focus Story	80%	OB	80%	OB	60%	OP
	Economic Responsibility	100%	OB	100%	OB	100%	OB
	Environmental Responsibility	100%	OB	100%	OB	100%	OB
	Employee Responsibility	100%	OB	100%	OB	100%	OB
	Community Responsibility	100%	OB	100%	OB	100%	OB
P3: Appendices	Report Introduction	/		/		100%	OB
	KPI	80%	OB	80%	OB	80%	OB
	Outlook	70%	OP	70%	OP	/	
	Glossary	30%	OP	30%	OP	/	
	Index	100%	OB	100%	OB	60%	OP
	UN Global Compact	30%	OP	30%	OP	/	
	Assurance Statement	60%	OP	60%	OP	30%	OP
	Feedback Form	80%	OB	80%	OB	/	
	Copyright Notice	/		/		20%	OP

Note: OB = obligatory; OP = optional

5.2.4 Genre

Since for ease of TQA, it is necessary to extract representative parts from ST and TT for a comparison[50], obligatory sub-parts that are highly conventionalized in CSR reports were extracted for genre analysis, including "Report Introduction" and "Chairman's Message". The percentages of each move in all three corpora were calculated, with moves appearing in 80% or more labeled as obligatory, while those less than 80% optional. Table 7 and Table 8 display the move structures of "Report Introduction" and "Chairman's Message" in the three corpora.

Table 7 Move Structure of "Report Introduction" in COSCR, COTCR & COOCR

Move	COSCR		COTCR		COOCR	
	%	Type	%	Type	%	Type
Starting Year	60%	OP	60%	OP	/	
Report Ordinal	70%	OP	70%	OP	30%	OP
Reporting Objective	30%	OP	30%	OP	20%	OP
Reporting Entity	60%	OP	60%	OP	/	
Designations	100%	OB	100%	OB	10%	OP
Reporting Period	100%	OB	100%	OB	90%	OB
Release Cycle	90%	OB	90%	OB	20%	OP
Reporting Principles	30%	OP	30%	OP	30%	OP
Main Content	60%	OP	60%	OP	90%	OB
Data Sources	90%	OB	90%	OB	90%	OB
Issues Involved	20%	OP	20%	OP	40%	OP
Reporting Process	40%	OP	40%	OP	70%	OP
References	100%	OB	100%	OB	100%	OB
Language	80%	OB	80%	OB	/	
Data Specification	50%	OP	50%	OP	30%	OP
Reliability Assurance	20%	OP	20%	OP	50%	OP
Links to More Information	10%	OP	10%	OP	90%	OB
Availability & Contact Information	100%	OB	100%	OB	80%	OB
Usage	/		/		20%	OP
Editorial Board	10%	OP	10%	OP	10%	OP

Note: OB = obligatory; OP = optional

Table 8 Move Structure of "Chairman's Message" in COSCR, COTCR & COOCR

Move	COSCR		COTCR		COOCR	
	%	Type	%	Type	%	Type
Lead	/		/		60%	OP
Courtesy Title	10%	OP	10%	OP	10%	OP
Extending Greetings	30%	OP	30%	OP	/	
Establishing Credentials	50%	OP	50%	OP	60%	OP
Report Overview	10%	OP	10%	OP	80%	OB
Philosophy of Social Responsibility	90%	OB	90%	OB	100%	OB
Advantages in Responsibility Fulfillment	20%	OP	20%	OP	10%	OP
Background Review	60%	OP	60%	OP	90%	OB
Political Responsibilities	80%	OB	80%	OB	/	
CSR Performance	90%	OB	90%	OB	90%	OB
Affirming Achievements	/		/		40%	OP
Outlook	100%	OB	100%	OB	50%	OP
Expressing Appreciation	40%	OP	40%	OP	10%	OP
Soliciting Feedbacks	40%	OP	40%	OP	30%	OP

Signature	100%	OB	100%	OB	100%	OB
Time	30%	OP	30%	OP	20%	OP

Note: OB = obligatory; OP = optional

5.2.5 Theme

Using AntConc with LCMC (Lancaster Corpus of Mandarin Chinese) and AmE06 as a reference corpus for COSCR and COOCR respectively, keyword lists were generated, and the top 30 ones are displayed in order of keyness in Table 9.

Table 9 Top 30 Keywords of COSCR and COOCR

Rank	COSCR			COOCR		
	Freq.	Keyness	Keyword	Freq.	Keyness	Keyword
1	1066	3152.054	员工	5990	11188.488	OUR
2	950	2943.582	2017	3606	3418.747	WE
3	1636	2890.89	管理	990	2846.639	2017
4	1045	2633.823	安全	833	2418.556	CSR
5	1117	2516.234	项目	950	2275.861	EMPLOYEES
6	1329	2357.348	公司	950	2198.184	ENVIRONMENTAL
7	742	2110.147	创新	1080	2038.199	BUSINESS
8	843	1982.778	责任	13944	2007.452	AND
9	780	1833.752	报告	969	1967.298	ENERGY
10	704	1686.655	集团	975	1959.641	REPORT
11	621	1673.043	能源	669	1942.394	GRI
12	776	1597.558	开展	663	1898.82	SUSTAINABILITY
13	1150	1541.12	企业	750	1840.283	SUPPLY
14	516	1504.542	提升	664	1771.113	EMISSIONS
15	1210	1473.467	中国	606	1759.478	CITI
16	617	1408.464	华	795	1712.082	MANAGEMENT
17	530	1357.341	绿色	554	1608.499	CISCO
18	709	1355.04	服务	613	1505.307	CHAIN
19	488	1307.812	推进	731	1371.816	GLOBAL
20	419	1298.275	2016	594	1368.552	CORPORATE
21	857	1259.493	建设	460	1335.577	ORACLE
22	403	1248.699	可持续发展	460	1335.577	WALGREENS
23	451	1241.474	鞍钢	633	1296.869	RIGHTS
24	473	1208.436	培训	648	1282.937	APPROACH
25	432	1116.109	电	463	1275.232	SUPPLIERS
26	489	1051.404	合作	516	1271.355	SUSTAINABLE
27	353	1043.52	扶贫	450	1118.682	WASTE
28	339	1037.217	环保	854	1103.645	HUMAN
29	350	1018.913	社区	485	1094.301	ENVIRONMENT
30	1271	1005.868	发展	439	1087.995	EMPLOYEE

To gain a deeper understanding of the thematic intertextuality revealed by these keywords, they were categorized based on the components of CSR defined in Jamali's "3+2" CSR model[51]. This model distinguishes between economic, legal and ethical responsibilities under mandatory CSR, as well as strategic and altruistic discretionary responsibilities under voluntary CSR. To be specific, economic responsibility entails companies prioritizing the economic interests of shareholders and investors by producing goods and services to maximize profits, creating job opportunities, pursuing technological advancement, tapping new markets and resources, and promoting innovation. Legal responsibility requires companies to abide by laws and regulations enacted by governments and other relevant organizations. Ethical responsibility involves adhering to standards,

norms or expectations that reflect fairness, justice or respect for stakeholders' moral rights[52, p.41]. Strategic discretionary CSR concerns philanthropic activities aimed at long-term economic returns for shareholders, while altruistic discretionary CSR pertains to philanthropic activities unrelated to companies' strategic goals.

In both corpora, the top 30 keywords predominantly relate to ethical responsibility, such as "员工", "安全", "绿色" and "可持续发展" in COSCR, and "EMPLOYEES", "ENVIRONMENTAL", "SUSTAINABILITY" and "EMISSIONS" in COOCR. Following are keywords associated with economic responsibility, such as "项目", "创新" and "合作" in the former, and "BUSINESS" and "SUPPLY" in the latter. In COSCR, a few keywords indicate strategic or altruistic responsibilities under voluntary CSR, such as "扶贫", whereas no such resources were found in COOCR. Additionally, there appear many frequently mentioned reporting entities or industrial fields, such as "公司", "集团", "能源" and "企业" in COSCR, and "OUR", "WE", "ENERGY", "CITI" and "CISCO" in COOCR. Moreover, some "omnipotent" verbs conveying the abstract notion of "conducting a certain performance" were found in COSCR, such as "开展" and "推进", which are absent in COOCR. In COOCR, the top 30 keywords are primarily nouns and adjectives.

5.2.6 Function

5.2.6.1 Informative Function

Three major realizational patterns of picture captions and news & case headings in COSCR were identified, namely sentences, verbal phrases, and nouns or nominal phrases, whose frequencies and proportions are detailed in Table 10.

Table 10 Picture Captions and News & Case Headings in COSCR

Realizational pattern	COSCR		COTCR		COOCR	
	Freq.	%	Freq.	%	Freq.	%
Sentence	369	45.1%	369	45.1%	114	37.4%
Verbal phrase	148	18.1%	7	0.9%	2	0.7%
Noun or nominal phrase	301	36.8%	368	45.0%	156	51.1%
Gerundial phrase	/		66	8.1%	33	10.8%
Untranslated	/		8	1.0%	/	
Total	818	100%	818	100%	305	100%

5.2.6.2 Promotional Function

Two aspects deserve further elaboration regarding the extraction of comment adjectives & adverbs. First, the inherent context-sensitivity of Chinese POS and potential inaccuracies in word segmentation tools may lead to discrepancies in POS tagging. This entails a manual check in COSCR, examining POS tags beyond those automatically labeled as "a" and "d" to rectify any misclassifications. Second, even for accurately tagged adjectives and adverbs, those lacking evaluative significance in conveying writers' comments on companies' social responsibility performances were excluded. Table 11 displays the absolute frequencies and frequencies per 10,000 words of comment adjectives & adverbs in the three corpora.

Table 11 Comment Adjectives & Adverbs in COSCR, COTCR & COOCR

POS tag	COSCR		POS tag	COTCR		COOCR	
	Absolute freq.	Freq. per 10000 words		Absolute freq.	Freq. per 10000 words	Absolute freq.	Freq. per 10000 words
a	7441	288.4	JJ	6203	244.1	6407	208.3
			JJR	167	6.6	349	11.3
			JJS	70	2.8	137	4.5
			Sub-total	6440	253.4	6893	224.1
d	2006	77.8	RB	1177	46.3	1390	45.2
			RBR	196	7.7	169	5.5

			RBS	152	6.0	105	3.4
			Sub-total	1525	60.0	1664	54.1
Total	9447	366.2	/	7965	313.4	8557	278.2

Notes:

a = adjective; d = adverb

JJ = adjective; JJR = comparative adjective; JJS = superlative adjective

RB = adverb; RBR = comparative adverb; RBS = superlative adverb

Most attitude resources express a meaning of appreciation or judgment, accompanied by numerous graduation resources predominantly reflecting positive evaluations of companies' social responsibility actions, progress and achievements.

5.3 Distribution of Cultural Intertextuality

Culture-loaded resources in COSCR can be broadly categorized into three groups, namely political cultural resources, language cultural resources, and socio- and historical cultural resources, the distributions of which are displayed in Table 12.

Table 12 Culture-Loaded Resources in COSCR

Type	Political cultural resource	Language cultural resource	Socio- and historical cultural resource	Total
Frequency	15	46	374	435

Socio- and historical cultural resources constitute the largest segment, with a frequency of 374, encompassing various aspects of societal and historical contexts. Notable examples include terms of administrative divisions in different countries, such as "扶贫县", "茨城县", "大区", "自治州", "小队", and so on. 46 language cultural resources stemming from inherent characteristics of the Chinese language were identified, featuring puns utilizing the pronunciation of Chinese characters for rhetorical effects. Examples include "**衣旧**心暖·**书送**希望", "中油**伴YOU**·石油探源丝路行", "'**家**'年华活动" and "'**交享阅**'品牌项目", etc. Furthermore, a small number of linguistic resources reflect political culture, such as "团委", "共青团" and "两会", etc.

6. Intertextual TQA of CSR Reports

In this section, it's illustrated how the intertextual translation operations in COTCR are assigned a positive or negative value with examples for each parameter where necessary.

6.1 TQA of Self-intertextuality in CSR Reports

6.1.1 Grammatical Cohesion

The significance of differences among the three corpora in the standardized frequency of cohesive conjunctions & adverbs was assessed using the "Log-likelihood and Effect Size Calculator" developed by Paul Rayson at Lancaster University. Table 13 presents the LL values resulting from comparisons between any two corpora in each sub-system.

Table 13 LL Values of Cohesive Conjunctions & Adverbs across COSCR, COTCR & COOCR

LL / Sub-system	COOCR vs. COSCR	COTCR vs. COSCR	COTCR vs. COOCR
Elaboration	+ 4190.7	+ 4738.6	+ 49.93
Extension	+ 185.95	- 15.18	- 308
Enhancement	+ 7.54	+ 1.88	- 1.71

Total	+ 2697.74	+ 2242.86	- 8.79

Notes:

1. A LL of 3.8 or higher is significant at the level of $p < 0.05$.
2. The plus or minus symbol before the LL value indicates overuse or underuse respectively in corpus 1 relative to corpus 2.
3. 95th percentile; 5% level; $p < 0.05$; critical value = 3.84

The results indicate that, at the $p < 0.05$ level, except for the overuse of enhancing devices in COTCR relative to COSCR and its underuse relative to COOCR, the differences in all other items are statistically significant. Overall, cohesive conjunctions & adverbs in COOCR and COTCR are overwhelmingly more than those in COSCR, while those in COTCR are noticeably fewer than those in COOCR. Accordingly, translators should deliberately employ more explicit cohesive means to clarify the logical relations between propositions, so that TT could better suit the reading preferences of the target audience.

It's observed that there are no NIEs in the translation of cohesive conjunctions & adverbs in COSCR. This is due to the significantly higher use of cohesive resources in each sub-system in COOCR compared to COSCR, resulting in all equivalences being positive. Deviant operations are manifested in two ways: the deletion of cohesive resources in TT and the shift between the three sub-systems. The former undoubtedly constitutes an NID, while the latter may lead to a PID.

Extract 1

ST: 未来全球 GDP 的增长仍有变数，**然而**随着世界经济的发展，势必需要更多的能源来保障世界经济的繁荣与发展。	TT: **Although** there are still uncertainties in global GDP growth, the world certainly requires more energy to ensure global economic prosperity and development in the future. (China National Petroleum Corporation) **(PID)**

In ST of Extract 1, "然而" is a conjunction in the extension system, indicating adversative relations. In TT, it's rendered as "although" in the cause-condition sub-system of the enhancement system, completely preserving the logical relationship in ST, which asserts that "uncertainties in global GDP growth won't affect the world's energy demand". Consequently, this transformation is categorized as a PID.

6.1.2 Lexical Cohesion

To visualize operations in lexical cohesion, STTRs of content words in the three corpora are transformed into a bar chart as represented in Figure 2.

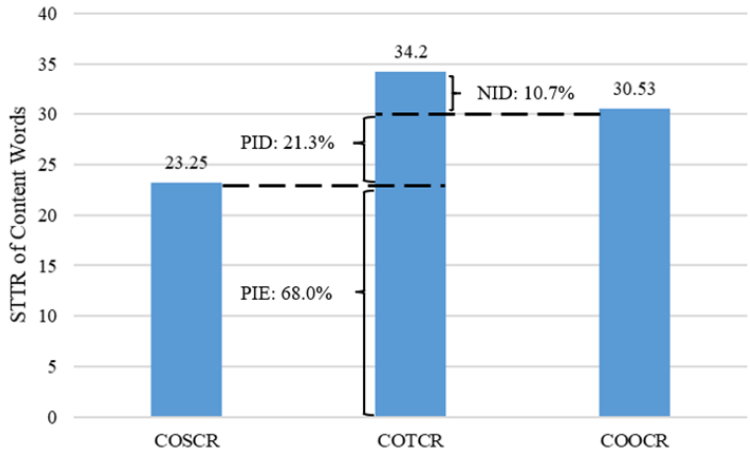

Figure 2 Positive and Negative Operations in Lexical Cohesion

Compared with COOCR, COTCR exhibits a greater variety of content words, which is even greater than in COSCR. With COOCR as the benchmark, COTCR demonstrates a PIE rate of 68%. Of the remaining 32% of deviant operations, 21.3% are categorized as PIDs, while 10.7% NIDs caused by "normalization", wherein TT tends to follow or exaggerate typical patterns and practices in TL. As there are no NIEs involved, it is reasonable to conclude that in the intertextual translation of CSR reports along lexical cohesion, there is a PIO rate of 89.3% and an NIO rate of 10.7%.

6.1.3 Structural Cohesion

To facilitate comparisons, data regarding the syntactic structures of parallelisms in the three corpora are transformed into a bar chart as presented in Figure 3.

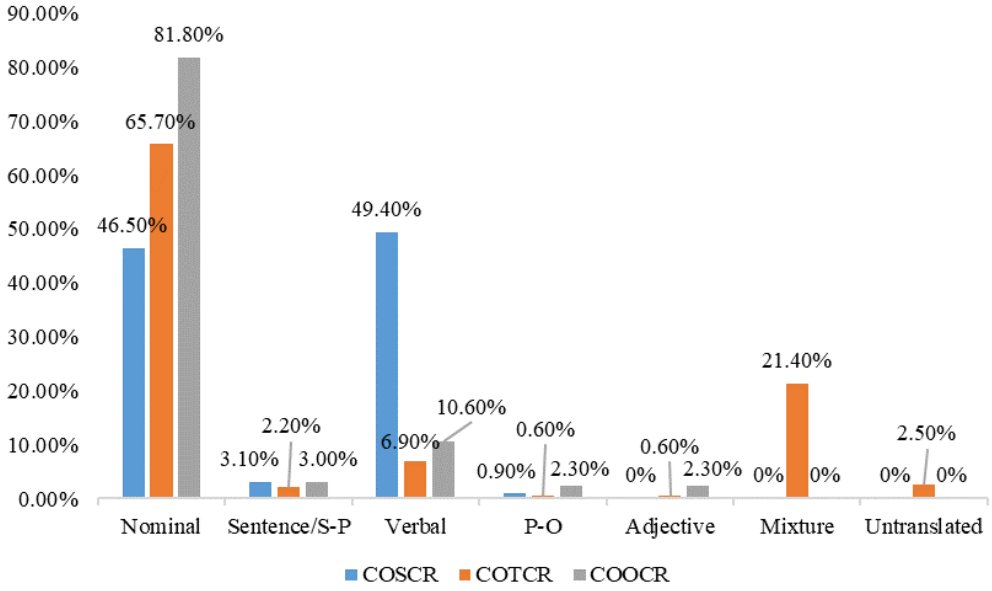

Figure 3 Comparisons of Syntactic Structures of Parallelisms among the Three Corpora

Compared with COSCR where verbal and nominal structures are nearly balanced with a slight predominance of the former, COOCR exhibits a significantly higher proportion of nominal structures, accounting for 81.8%. Apart from the 21.4% of mixture and the 2.5% of untranslated items in COTCR, the distribution trends of other types are consistent across the three corpora. The Log-likelihood and Effect Size Calculator generated a LL value of "-115.44" for COOCR against COSCR, indicating that, at the $p < 0.05$ level, the frequency of parallelisms in COOCR is markedly lower than that in COSCR. Consequently, reducing parallelisms through mixed structures is deemed acceptable.

Further observation reveals that in COOCR, nominal structures primarily manifest as pure nouns and gerundial phrases, with relatively low but similar proportions of N-N phrases, A-N phrases and coordinate nouns. This lends valuable insight for value assignment of the intertextual operations in translating parallelisms.

Extract 2

ST:	TT:
保障能源安全	Guarantee energy security
稳定市场供应	Stabilize market supply
履行社会责任	Fulfill social responsibility
	(China National Petroleum Corporation)
	(NIE)

In Extract 2, ST comprises three V-O phrases, and the translator reproduces these structures in TT without

alteration. However, according to the statistics above, V-O phrases accounts for 49.1% in COSCR but only 6.1% in COOCR. Moreover, English V-O phrases essentially form imperative sentences, failing to convey the indicative mood in ST. Therefore, this example is judged an NIE.

6.2 TQA of Discoursal Intertextuality in CSR Reports

6.2.1 References

Extract 3

ST: 国家电投秉持安全第一原则，进一步强化“红线”意识、“底线”思维，健全安全发展理念、落实安全责任、普及安全知识、提升安全素质，2017 年实现**“六不发生、两下降”**的年度安全目标。	TT: SPIC has always upheld the safety first principle, further strengthened the “red line” awareness and the “bottom line” thinking pat tern, completed the concept of safety development, implemented safety responsibilities, popularized safety knowledge, and improved safety quality. In 2017, it achieved the annual safety goals of **“six non-occurrences and two declines”**. (State Power Investment Corporation) (**NIE of embedded reference**)

Extract 3 represents merely a fraction of similar occurrences in TT. To facilitate mention and recollection, and conserve space, structures like “cardinal number + abbreviation” are often employed in ST to refer to corporate rules and regulations, strategic goals and other matters. Such references are either familiar to Chinese readers who share the same socio-, political and economic contexts, or mentioned repeatedly in other information disclosures, obviating the need for full explication. However, translation poses a challenge as target readers lack similar intertextual knowledge. In Extract 3, expressions like “六不发生” and “两下降” just hold no meaning for target readers. Hence, an intact transfer would cause comprehension difficulties, rendering this operation an NIE.

6.2.2 Conventional Expressions, Allusions and Parodies

Extract 4

ST: 行者方致远，奋斗路正长。	TT: **Keep on going, and one can walk far. Keep on struggling, and one has a long way to go**. (State Power Investment Corporation) (**NID**)

The translation adequately renders the first half of the conventional expression in Extract 4. The latter half, however, is meant to remind the company of its heavy social responsibilities and encourage ongoing efforts. To maintain symmetry with the first half, the translator adopts a structure functionally equivalent to a conditional sentence. But a logical distortion is caused wherein “the harder we struggle, the more unsatisfactory our fulfillment of CSR is”, which makes this operation an NID.

Extract 5

ST: “**黑猫**一号”，是首个由万科物业自主研发的智能机器门。	TT: “**Black Cat** One” is the first smart door independently developed by Vanke Property. (China Vanke Co., Ltd.)

(**NIE**)

The allusion to the “black and white cat theory” is involved in Extract 5. Originating from Deng Xiaoping’s proposal in the 1960s that “black or white, one catching mice is a good cat”, the theory suggests that whether adopting a planned or market economy, efficiency in achieving productivity matters most. Vanke’s R&D department named their intelligent robot “黑猫一号” (Black Cat No.1), linking this allusion to the product’s function of ensuring household safety through “owner identification”. However, in most Western cultures, black cats are associated with evil spirits, misfortune and even death. Hence, a literal translation of “黑猫” into “black cat” not only fails to promote the product’s intelligence but instead evokes negative associations with “uneasiness and untrustworthiness”, hence an NIE.

Extract 6

ST: 2017 年，中国石油启动了多个输气管道工程和阿瓦提支线工程，实现了大北气田、英买力气田及和田河气田等 5 大气田同已建管网相互连通，使“**西气西用**”与“西气东输”互为补充，加大南疆利民管线供气，缓解南疆地区冬季供气不足的压力。	TT: In 2017, CNPC launched several gas pipeline projects and the Awat branch pipeline project, interconnecting the five large gas fields including Dabei Gas Field, Yingmaili Gas Field and Hetianhe Gas Field with constructed pipeline network. This has effectively coordinated **gas supply to the western** and eastern regions in China, boosted gas supply to southern Xinjiang, and alleviated their gas supply shortage. (China National Petroleum Corporation)

(**PID**)

In Extract 6, the term “西气西用” was coined from a series of national strategies, such as “南水北调” (South-North Water Transmission Project), “西电东送” (West-East Power Transmission Project) and “西气东输” (West-East Natural Gas Transmission Project). To alleviate the cognitive burden of target readers, instead of simply translating “西气西用” and “西气东输” into parallel noun phrases, the translator streamlines the benefits of the interconnection of gas pipelines succinctly by splitting and merging the elements. Hence, this operation is classified as a PID.

6.2.3 Structure

Only two deviations are observed in TT: the frequencies of “Sustainability Management” and “Party Building” are each reduced by one. Generally, CT demonstrates a more flexible schematic structure compared to ST, with decreases in the frequencies of the sub-parts of both “Leading in” and “Appendices”. Certain obligatory sub-parts in ST, such as “Company Profile”, “Awards & Recognition”, “Stakeholder Engagement”, “Focus Story” and “Index”, become optional in CT, while “Materiality” become obligatory. Additionally, “Organizational Structure”, “Industrial Layout”, “Party Building”, “Outlook”, “Glossary”, “UN Global Compact Implementation” and “Feedback Form” in ST are omitted in CT, of which “Feedback Form” is obligatory in ST.

The distribution tendencies of the sub-parts in ST and CT facilitate value assignment to the translation operations in TT. Equivalent transfers in TT of sub-parts obligatory in both texts are considered positive, except

for the reduction in “Sustainability Management”, which is recorded as an NID. For sub-parts obligatory in ST but optional in CT, equivalent transfers within the proportion limit of CT are deemed PIEs, while those exceeding the maximum frequency in CT NIEs. For instance, “Awards & Recognition” appears 9 times in ST, but only 4 times in CT as an optional sub-part, resulting in 4 PIEs and 5 NIEs in TT. Equivalent operations in TT of sub-parts present in ST but absent in CT are classified as NIEs, except for the reduction of “Party Building” in TT, which is recorded as a PID.

6.2.4 Genre

The move structures of both “Report Introductions” and “Chairman’s Messages” in COTCR exactly match those in COSCR, indicating no deviation during translation in terms of generic intertextuality. Compared with ST, in “Report Introductions” in COOCR, “Usage” is added as an optional move, while “Starting Year”, “Reporting Entity” and “Language” no longer appear, of which “Language” is an obligatory move in ST. Similarly, obligatory “Designations” and “Release Cycle” become optional in CT, whereas “Main Content” and “Links to More Information” obligatory. Regarding “Chairman’s Messages”, “Lead” and “Affirming Achievements” are added as two optional moves. “Outlook” which is obligatory in ST become optional, while “Report Overview” and “Background Review” obligatory. Besides, “Extending Greetings” and “Political Responsibilities” are omitted in CT, the latter being obligatory in ST.

Based on the above characteristics of the three texts in move structure, several inferences can be drawn. First, for moves obligatory in both texts in COSCR and COOCR, equivalent transfers are considered positive. Second, for moves obligatory in ST but optional in CT, equivalent transfers within the proportion limit of CT are deemed PIEs, while those exceeding the maximum frequency in CT NIEs. Lastly, for moves in ST that are omitted in CT, equivalent operations are treated as NIEs.

6.2.5 Theme

Three situations are found in the translation evaluation of specific keywords. First, some of the top 30 keywords of COSCR and COOCR exhibit semantic correspondences, such as “员工”-EMPLOYEES, “管理”-MANAGEMENT, “报告”-REPORT, “能源”-ENERGY and “企业”-CORPORATE, etc., whose bilingual concordances can be generated in ParaConc. Although most equivalent translations can be recorded as PIEs, deviations require value assignment based on specific contexts.

Extract 7

ST: 我们坚持“员工生命高于一切”，持续深化社会安全管理体系运行，全面加强社会安全风险防控，持续提升突发事件应急处置能力。	TT: **Personnel** safety has always been an overriding priority in our operations. (China National Petroleum Corporation) (**PID**)

In Extract 7, the keyword “员工” in COSCR isn’t translated as “EMPLOYEE(S)” in the list of top 30 keywords of COOCR due to several reasons. One the one hand, “personnel safety” is a more conventional expression in TL compared to “employee safety”. On the other, both “personnel” and “safety” extend the intensions of “员工” and “生命”, encompassing not only “life security” of “persons paid to work”, but also “safety in all other aspects” of “all other related personnel in the company”. This practice doesn’t compromise the ideational and interpersonal meaning in ST, hence classified as a PID.

Second, concerning keywords appearing in the top 30 of COSCR but not in COOCR, equivalent transfers within the proportion limit of COOCR are deemed PIEs, while those exceeding the maximum frequency in CT NIEs for violating the genre convention of TL with an overuse. Deviations, however, require value assignment based on specific contexts.

Extract 8

ST: 国家电投全面优化完善供应商评价管理体系，供应商需要通过质量、环境、安全等体系认证。	TT: SPIC has fully optimized and improved the management system, standards and methods for supplier evaluation, and continuously improved the overall quality of the suppliers. (State Power Investment Corporation) **(NID)**

In Extract 8, the general expression of "improved the overall quality of the suppliers" alone fails to accurately convey the ideational meaning in ST that "suppliers need to pass quality, environmental, safety, and other system certifications", which is a pretermission and hence an NID.

Third, in the top 30 of COOCR, there are also keywords not appearing in COSCR, notably self-mentions such as "OUR" and "WE". Translating reporting entities into inclusive possessive and personal pronouns conforms to the genre conventions of CSR reports in TL in that a positive corporate image and a harmonious stakeholder relationship are achieved by narrowing the distance between target readers and the reporting entity. Therefore, translations of keywords indicating reporting entities in the top 30 of COSCR as "OUR" or "WE" are considered PIDs. Remaining operations, however, deviant or equivalent, require value assignment based on specific contexts.

Extract 9

ST: 作为"共和国钢铁工业长子"，鞍钢人秉持"创新、求实、拼争、奉献"的企业精神，以攻坚克难的磅礴力量……立足岗位，为鞍钢打胜扭亏增效攻坚战贡献力量。	TT: As the "Eldest Son of Steel Industry of the Republic", **Ansteel**'s staff members hold on to the spirit of "innovation, pragmatism, striving, devotion" and the perseverance to solve difficulties...**They** base **themselves** on **their** positions and make contributions to stopping losses and making profits for Ansteel Group. (Ansteel Group Corporation) **(NIE)**

In Extract 9, "鞍钢人" (literally "people in Ansteel") in ST is translated into "Ansteel's staff", excluding the reporter, which could be further evidenced by the use of "they", "themselves" and "their" in the second sentence. This translation thus narrows the intension of "鞍钢人" and enlarges the distance between target readers and the reporting entity, which hinders a harmonious stakeholder relationship and a favorable corporate image. Consequently, it's judged as an NIE.

6.2.6 Function

6.2.6.1 Informative Function

For ease of comparison, statistics concerning the realizational patterns of captions and headings in the three corpora are summarized in Figure 4.

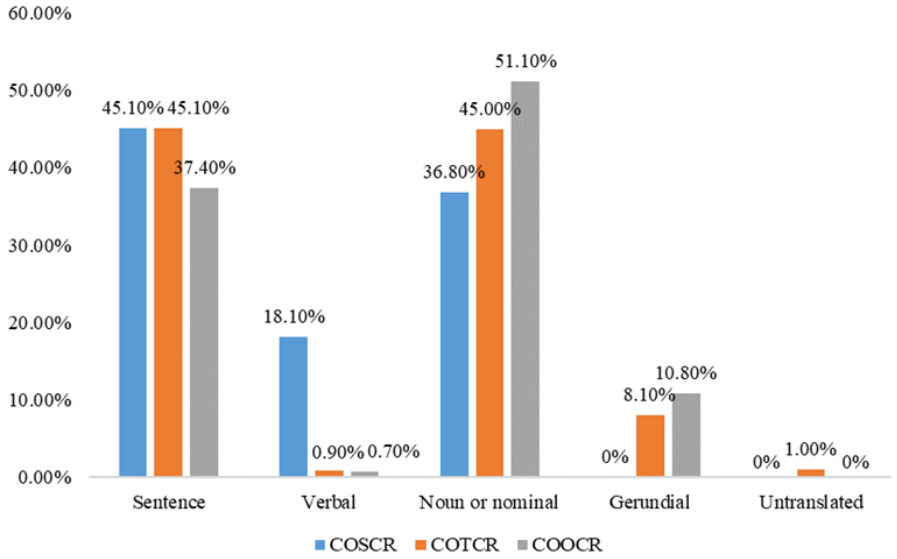

Figure 4 Comparisons of Realizational Patterns of Captions and Headings among the Three Corpora

As revealed, sentences and nouns or nominal phrases are the top two realizational patterns in all three corpora. Neither of the gaps between the two patterns in COSCR and COOCR is large, but there is an opposite relative dominance. Affected by COSCR, the percentage of the sentence pattern in COTCR hasn't declined, causing an underuse of nouns or nominal phrases compared to COOCR. Besides, most verbal phrases in COSCR have been divided mainly into nouns or nominal phrases and gerundial phrases in COTCR.

Extract 10

ST: 签约国家雪车雪橇中心项目	TT: Shanghai Baoye Group **signs** contract on National Sliding Center (Ansteel Group Corporation) **(PID)**

Headlines serve as concise summaries of news articles, enabling readers to quickly grasp essential information. Due to the existence of non-subject sentences in Chinese, many picture captions and news & case headings in COSCR lack a clear subject, as illustrated in Extract 10. However, this structure can hinder effective information transmission by depriving readers of the subject involved in the news. In this example, the translator supplements the subject, transforming the verbal phrase into a complete sentence. Additionally, simple present tense is selected, which aligns with the common usage in COOCR, making it a PID.

6.2.6.2 Promotional Function

The significance of differences in standardized frequency of comment adjectives & adverbs among COSCR, COTCR and COOCR was assessed using the Log-likelihood and Effect Size Calculator. The LL values between any two corpora are listed in Table 14.

Table 14 LL Values of Comment Adjectives & Adverbs across COSCR, COTCR & COOCR

LL / POS	COOCR vs. COSCR	COTCR vs. COSCR	COTCR vs. COOCR
Adjective	- 228.16	- 57.95	+ 50.3
Adverb	- 120.46	- 58.68	+ 8.56
Total	- 339.76	- 104.94	+ 58.62

At the $p < 0.05$ level, the differences in each item are statistically significant. Generally, COOCR and COTCR employ significantly fewer comment adjectives & adverbs compared to COSCR, with COOCR exhibiting a greater underuse than COTCR. This suggests that translators should consciously reduce the use of comment adjectives & adverbs during translation to align with the reading habits of TL. As a result, equivalent translations within the proportion limit of COOCR are considered PIEs, while those exceeding the maximum proportion NIEs for violating the genre convention of TL with an overuse. Deviant operations, however, require value assignment based on specific contexts.

Extract 11

ST: ERP 应用集成建设**全面**完成，云技术平台**深化**应用，数据共享及集成应用能力增强，数字化与智能化建设**稳步**实施，信息系统应用成效日益显著。	TT: Additionally, construction of the integrated application of ERP system was **completed**, application of the cloud technology platform **was deepened**, capability of data sharing and integrated application was enhanced, digital and intelligent construction was in **steady** progress, and outstanding achievements were made in the information system application. (China National Petroleum Corporation) (**PID**)

In Extract 11, "全面" (comprehensively) and "完成" (complete) are semantically overlapping, leading the translator to delete the redundant comment adverb. Similarly, "深化" (deeply) and "稳步" (steadily) are transformed into the verb "deepen" and the adjective "steady", respectively. These adjustments enrich expression without violating TL conventions, thereby classified as PIDs.

6.3 TQA of Cultural Intertextuality in CSR Reports

This section illustrates how translation operations of culture-loaded resources in COSCR are evaluated and assigned a positive or negative value, providing examples of each type.

Extract 12

ST: 信托由**国家电投团委**作为委托人，百瑞信托作为受托人，信托资金用于贫困救助等公益慈善事业。	TT: The Trust is entrusted by **SPIC** and Bairui Trust is the trustee. The Trust funds are used for charity projects, such as poverty relief. (State Power Investment Corporation) (**PID of political cultural resource**)

In Extract 12, "国家电投团委" (the Youth League Committee of SPIC) is translated as "SPIC". Since it is the direction of trust that target readers may be interested in rather than any specific organization of either the trustor or the trustee, the translator omits "团委". This operation, not significantly impacting the transfer of ideational meaning, is considered a PID.

The intertextuality of language cultural resources in ST is mainly reflected in puns, which are clever or amusing uses of words with the same sound but different meanings, or of words with two meanings.

Extract 13

ST: 福气暖南疆	TT: Bringing **Warmth** to Southern Xinjiang in Winter (China National Petroleum Corporation) **(NID of language cultural resource)**

Extract 13 is the heading of a case in a CSR report. The natural gas project in southern Xinjiang has provided people there with clean energy, which not only ensures heating during winter, but accelerates local economic development. Therefore, "福气" (literally "blessing gas") refers to both natural gas and its positive economic, social and psychological effects on the local community. However, the translator simply renders it as the abstract noun "warmth", failing to convey the core of the case effectively. In this sense, it's not a valid case heading, hence an NID.

Extract 14

ST: 新时代**东风**正劲，中国梦党建在先	TT: Strong **East Wind** of the New Era and the Priority of the Party Construction in Building the Chinese Dream (State Power Investment Corporation) **(NIE of socio- and historical cultural resource)**

Similarly, "东风" (east wind) in Chinese culture carries auspicious connotations, which is a symbol of favorable conditions. In "万事俱备，只欠东风" (everything is ready for a fire attack except for the east wind which will feed the fire), for instance, its meaning is extended to "the most important factor in completing a certain task". However, in Extract 14 where "东风" refers to "all favorable conditions for reforms and developments", the translator's literal translation ignores the lack of this associative meaning in western cultures, breaking the intertextual relation in ST and resulting in an NIE.

6.4 Overall Quality Assessment

After quantitative comparisons of COSCR, COTCR and COOCR in each parameter along the three intertextual dimensions, and qualitative evaluations of the translation operations, quantitative work was resumed to generate an overall quality statement regarding the intertextual translation of CSR reports by Chinese companies.

Utilizing ParaConc for bilingual concordancing, the translation of each cohesive device in COSCR was scrutinized. Of the 1413 cohesive conjunctions & adverbs, COTCR exhibits 857 PIEs, 121 PIDs, 435 NIDs, and no NIEs, the first two constituting 978 PIOs. Regarding lexical cohesion, a PIO rate of 89.3% and an NIO rate of 10.7% are observed. Out of the 318 parallelisms, there are 93 PIEs, 165 PIDs, 46 NIEs and 14 NIDs, yielding 258 PIOs. Similarly, the rest of the parameters demonstrate varying ratios of PIEs, PIDs, NIEs and NIDs, contributing to their respective PIOs. The proportion of PIOs converted into a centesimal system, intertextual scores of CSR report translation are generated for each parameter, as listed in Table 15.

Table 15 Intertextual Scores of CSR Report Translation

Translation operation / Parameter	PIE	PID	NIE	NID
Grammatical cohesion	857	121	0	435
	Score: 69.2			
Lexical cohesion	Score: 89.3			
Structural cohesion	93	165	46	14
	Score: 81.1			

References	35	306	244	45
	Score: 54.1			
Conventional expressions	7	14	7	3
	Score: 67.7			
Allusions	3	33	52	8
	Score: 37.5			
Parodies	9	14	11	2
	Score: 63.9			
Structure	141	1	54	1
	Score: 72.1			
Genre	76/59	0	36/16	0
	Score: 73.3			
Theme	17897	3409	898	462
	Score: 94.0			
Informative function	305	259	229	25
	Score: 68.9			
Promotional function	2077	2344	3714	1312
	Score: 46.8			
Culture-loaded resources	0	246	155	34
	Score: 56.6			

As shown in Table 15, of the 13 parameters, most score below 70, with only 3 exceeding 80. If 60 is set as the "cut-off score" as a common practice in a centesimal system, this obviously suggests much room for improvement in many areas to enhance the overall quality of intertextual translation of CSR reports.

7. Conclusion

To conclude, the translation of intertextual signals in Chinese companies' CSR reports is qualified but inadequate. This study introduces an intertextual TQA framework, the parameters proving operable and corpus methods feasible, which sheds light upon future TQA endeavors. It addresses a gap in TQA of ESP genres, and the three dimensions and manifestations of intertextuality, along with the concept of the "intertextual dumbbell", contribute to enriching intertextuality and translation theories. The empirical TQA serves as a valuable guidance for companies' standardization of non-financial information disclosure, so that they can enhance communication with global stakeholders and unlock greater business values. Moreover, improved quality of CSR report translation definitely contributes to a favorable international image and fruitful external publicity of the government, aligning with the goal of effectively conveying Chinese narratives.

This study presents an initial intertextual TQA framework, with opportunities for further exploration and refinement, particularly regarding the weighting of parameters. In addition, while it establishes the feasibility of assessing business text translation quality from an intertextual perspective with corpus methods, future investigations could delve into the causes of NIOs and propose corresponding translation strategies and modifications to address them effectively.

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Research on Misreporting Behavior in a Supply Chain Considering Consumers' Low-Carbon Preferences and Manufacturers' Emission Reduction Efforts

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Abstract

In the context of studying misreporting behavior, this paper investigates the impact of consumers' low-carbon preferences and manufacturers' emission reduction efforts on the decision-making of supply chain members. A two-level supply chain profit model consisting of a single manufacturer and a single retailer is established. The paper examines the specific impact of consumers' low-carbon preferences and manufacturers' emission reduction efforts under the scenarios of no cost-sharing for emission reduction and cost-sharing for emission reduction. Finally, through comparative analysis, the study explores the impact of cost-sharing for emission reduction on the decisions and profits of supply chain members.

Research analysis found that in conditions where the potential market size is large enough, consumers' low-carbon preferences, manufacturers' emission reduction efforts, and cost-sharing for emission reduction have a positive impact on the decisions of supply chain participants, and members' deceptive behavior will not affect them.

When the potential market is limited, the specific impact results vary. In cases where emission reduction costs are not shared, the impact of consumers' low-carbon preferences on order quantity, wholesale price, and manufacturers' investment in emission reduction technology R&D is segmented: when low-carbon preferences are at the lower and higher extremes, they have a promoting relationship with optimal order quantity and wholesale price, but do not promote manufacturers' emissions reduction. With an increase in manufacturers' investment in emission reduction technology R&D, retailer profits initially decrease and then increase. Regardless of deception, manufacturer emission reduction investment is always positively correlated with order quantity and wholesale price, and the specific impact of manufacturers' emission reduction efforts on their own profits is related to the extent of consumers' low-carbon preferences. In cases where emission reduction costs are shared, the impact of manufacturers' emission reduction efforts on profits of both parties is related to the coefficient of cost-sharing for emission reduction. If the coefficient of cost-sharing for emission reduction is large, it will lead to a decrease in manufacturer profits followed by an increase. The coefficient of cost-sharing for emission reduction is small, an increase in manufacturers' investment in emission reduction technology R&D will lead to a decrease in retailer profits followed by an increase. The impact of cost-sharing for emission reduction behavior is related to consumers' low-carbon preferences.

In cases where both parties do not misreport and only the retailer misreports, cost-sharing for emission reduction

behavior will increase manufacturer profits, independent of the size of the potential market.

Keywords: misreporting behavior, consumers' low-carbon preferences, manufacturers' emission reduction efforts, cost-sharing for emission reduction

1. Introduction

1.1 Research background and question formulation

With the emergence of a series of ecological and environmental issues such as global climate change, countries have begun to pay attention to environmental protection. They have introduced various green emission reduction policies to actively address environmental climate change. The "China's Policies and Actions for Addressing Climate Change" white paper [1] issued by Xinhua News Agency mentions that in 2020, China proposed to "increase the nationally determined contributions, adopt more robust policies and measures, strive to peak carbon dioxide emissions before 2030, and achieve carbon neutrality by 2060". This indicates that China will transition to a "high-quality" development model, focusing on high-efficiency, green, and sustainable development. Reducing carbon emissions is an inevitable trend for future development. The "Comprehensive Work Plan for Energy Conservation and Emission Reduction in the 14th Five-Year Plan" [2] issued by the State Council clearly states that by 2025, the energy consumption of the national GDP will decrease by 13.5% compared to 2020. Enterprises can establish their targets for reducing carbon emissions per unit of output by this requirement. The policy requires that enterprises cannot exceed the total amount of market quotas allocated for free by the government. It also introduces a carbon trading market, enabling enterprises to buy or sell carbon emissions rights in the market according to their circumstances. Carbon trading mechanisms can help regulate production costs for low-emission enterprises, potentially leading to economic benefits. In contrast, high-emission enterprises may experience increased production costs and social pressure.

Today, the flow and sharing of information are essential for cooperation and coordination among enterprises. In supply chains operating under carbon trading mechanisms, various enterprises frequently encounter information asymmetry during their cooperative processes or transactions. Due to the dissemination of information, some enterprises opt to withhold certain information or refrain from sharing it with others for their own benefit, deeming it their proprietary information. For example, cost information and demand information. This creates motivation for participants in the supply chain to falsify information to gain more profits from carbon trading. Therefore, it is more practical and meaningful to conduct relevant research on supply chains considering the backdrop of information asymmetry. Emissions reduction is an important goal for major enterprises and an inevitable development trend. Enterprises will consider investing in emissions reduction efforts based on their individual development and profit situation. Consumer willingness and preference for low-carbon products directly impact the demand for products. This implies that consumer low-carbon products compel enterprises to reduce emissions and manufacture low-carbon products. The "2022 China Sustainable Consumption Report," released by the Associated Press [3] indicates that most consumers are willing to influence more people to participate in low-carbon consumption by sharing their experiences with low-carbon products. Additionally, 90% of consumers are willing to try purchasing low-carbon products when they see others share information about low-carbon consumption. If manufacturers and retailers can accurately understand consumer preferences for low-carbon products, they can conduct production and operations more purposefully and effectively. This, in turn, can enhance market competitiveness and establish a positive corporate image.

With government calls for emissions reduction and environmental driving forces, enterprises' measures to reduce emissions enhance their corporate image, expand product markets, and increase corporate competitiveness. However, investing in emissions reduction is a part of production costs, and taking proactive steps to reduce emissions inevitably results in increased costs. In the operation of a complete supply chain, suppliers provide products and services to enterprises while also generating a series of carbon emissions. As carbon emissions from component procurement also contribute significantly to the total carbon emissions of the product, reducing carbon emissions through supplier management is a method for enterprises to decrease emissions. This paper aims to develop a basic game model centered on dishonest reporting behavior in the second-tier supply chain. It will analyze the effects of investment in emissions reduction technology research and development by manufacturers, consumers' low-carbon preferences, and cost-sharing of emissions reduction in the context of carbon information asymmetry on decision outcomes.

1.2 Purpose of the study

Carbon emissions occur not only in the manufacturing process but also in assembly, sales, distribution, and transportation between various links. The key factor driving the sales of low-carbon products is the consumers' low-carbon preferences. These efforts are often influenced and constrained by various factors throughout the investment-to-return process. Furthermore, in a low-carbon supply chain, carbon information is the most critical data throughout the chain. The government actively promotes and encourages enterprises to reduce emissions. However, to increase profits, enterprises may be motivated to falsify carbon information. In the carbon trading market, enterprises may understate their actual carbon emissions to sell more carbon emission quotas and boost their carbon trading revenue. The multi-level structure of the supply chain increases the uncertainty in transmitting information, amplifying the impact of false information within the supply chain. It is difficult to avoid information asymmetry, which also affects the operation of the supply chain.

Based on the Stackelberg game theory, this paper establishes a two-level supply chain model consisting of manufacturers and retailers. It investigates the impact of consumers' low-carbon preferences and manufacturer emission reduction efforts on the decision-making of supply chain members in the presence of false reporting behavior. The study determines the relationship outcomes under various constraints, compares and analyzes two scenarios, explores the efficacy of cost sharing for emission reduction, and concludes with recommendations of significant reference value based on the analysis results.

1.3 Framework of research

This paper investigates the profit function of the second-tier supply chain under a carbon trading mechanism, considering the impact of consumers' low-carbon preferences and manufacturers' efforts to reduce emissions. By reviewing previous literature and utilizing mathematical models, the optimal decisions of supply chain members are established and solved based on game theory under various false reporting scenarios. The study also compares the effectiveness of cost-sharing behaviors in emission reduction. The research results of this paper provide a significant supplement to the study of supply chains with misreporting backgrounds and can offer references for management decision-making under information asymmetry.

Consumers' preferences and demand for low-carbon products have become more significant. However, there is a delay between the increase in consumers' low-carbon preferences and their actual purchasing behavior.

Similarly, there is a relationship between manufacturers' investments in emission reduction and the corresponding benefits. Additionally, the surplus and shortage of carbon emission quotas can lead enterprises to seek additional profits in the carbon trading market. This situation may prompt them to misreport their actual carbon emissions to maximize their interests. This, in turn, affects the decisions of other participants in the supply chain. The results of this study can help enterprises better understand the impact of consumers' low-carbon preferences and manufacturers' emission reduction efforts on decision-making. It can also provide a decision-making basis and opinion reference for addressing misreporting behavior by upstream or downstream enterprises in the supply chain. This can help mitigate the negative impact of carbon information asymmetry on the supply chain

1.4 Framework of research

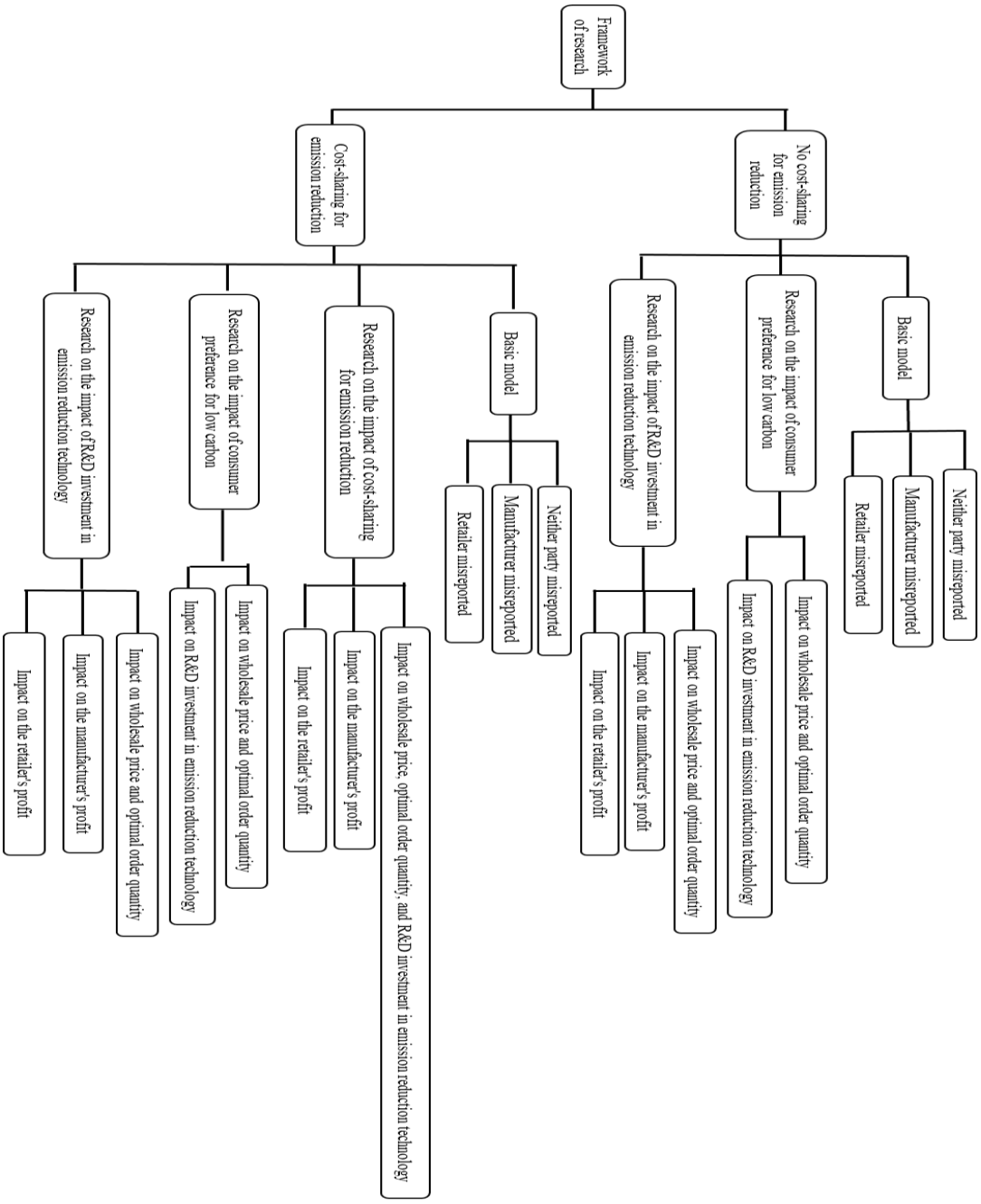

Figure 1. Framework of research

2. Literature Review

The literature relevant to this research can be divided into the following four main themes: supply chain research on information asymmetry and misreporting of carbon information, consumer preferences for low-carbon in supply chain, manufacturers' emission reduction efforts in low-carbon supply chain, and coordination research on cost-sharing contracts in the supply chain. Finally, this study will compare and elucidate the differences and innovations of this research with previous studies.

Supply chain research on information asymmetry and misreporting of carbon information

Cheng, Zhang, & Chen [5] found that under conditions of complete information, both manufacturers and retailers with decentralized decision-making can achieve the benefits and emission reduction effects typically associated with centralized decision-making. In the context of information asymmetry, manufacturers need to target different retailers based on varying wholesale prices. In special cases, they may terminate cooperation with low-quality retailers to ensure the profitability of pipeline members and enhance environmental performance. Liu, Zhou, Yang, Hoepner, & Kakabadse [6] found that enterprises with higher carbon emissions tend to choose to disclose more information for communication to manage risks and threats, despite their unsatisfactory organizational performance. Xu and Zhang [7] found that compared with when the information was symmetric (neither party misreported), the manufacturer underreported the unit. The initial carbon emissions and carbon emission reduction costs of the original product will promote its emission reduction and increase product sales. Yang, Zheng, & Ji [8] found that if the manufacturer chooses to lie about carbon information and the misreporting decision satisfies the optimal misreporting equation, the manufacturer's profits do not increase substantially, and its false reporting behavior does not have an impact on supply chain performance. However, when retailers have carbon information advantages, they will choose to falsely report to increase their own profits.

Zong, Shen, & Su [9] found that manufacturers' misreporting behavior will increase their own profits but cause the entire supply chain and retailers to suffer as a result. Moreover, the study reveals that deceptive practices by manufacturers only impact the low-carbon greenness of the product, not the pricing strategy. Chen & Fan [10] ' conclusion demonstrates that misreporting cost information will have a negative impact on supply chain participants and affect the quality of products. Performance level. Ma, Yang, Zhang, & Hua [11] analyzed and found that subsidies can encourage manufacturers to share information with the government, effectively reducing the motivation for misreporting, and inhibiting false reporting. Behavior. Yan, Wang, Liu, & Liu [12] compared a manufacturer that misreported cost information and complete information with another manufacturer that misreported only cost information. The impact of the strategy on supply chain performance: the results show that although the manufacturer's misreporting behavior benefits some participants in the supply chain, it ultimately puts the entire supply chain at a disadvantage.

Consumers' low-carbon preferences in supply chain

Sun, Cao, Alharthi, Zhang, Taghizadeh-Hesary, & Mohsin [13] found that the more apparent the consumers' low-carbon preferences, the higher the level of carbon emission transfer by the manufacturer. Only when the lag time of emission reduction technology remains within a limited range, will the increase in consumers' low-carbon preference enhance the overall profits of the supply chain. Huang [14] found that if consumers do not have low-carbon preferences, if retailers' low-carbon marketing and pricing strategies fail to stimulate consumers' purchasing behavior, even centralized decision-making within the supply chain cannot prevent low-carbon products from losing market share. Xu et al. [7] discovered that consumers' low-carbon preferences will promote emission reductions and boost manufacturers' profits. Yu & Hou [15] investigated the influence of consumers'

low-carbon preferences on market demand and the effects of uncertainty in carbon emission reduction behavior. The conclusion indicates that the coefficient of consumer low-carbon preference has a positive impact on carbon system emissions and supply chain profits. Positive influence. Liu & Li [16] analyzed the equilibrium strategy of the supply chain under centralized and decentralized decision-making. The study revealed that the emission reduction effect of the supply chain remains unchanged when the low-carbon preference parameter approaches infinity or zero.

Manufacturers' emission reduction efforts in low-carbon supply chain

Han & Wang [17] conducted a comparative analysis of the decision-making outcomes between centralized and decentralized approaches. The research results show that manufacturers' carbon emission reduction behavior can enable companies to obtain more potential benefits. Yu et al. [15] concluded that the manufacturer's emission reduction effort coefficient positively affects supply chain profits. Yang & Zheng [18] developed a low-carbon supply chain model consisting of a single supplier and a single manufacturer. They utilized the emission reduction efforts of both parties as decision variables and the product emission reduction as the state variable to formulate an uncertain differential equation. Their study demonstrates that enhancing the emission reduction efficiency of supply chain enterprises can boost supply chain profits and decrease carbon emissions.

Coordination research on cost-sharing contracts in the supply chain

Zhi, Chen, & Liu [19] found that centralized decision-making can help promote the reduction of carbon emissions in the supply chain and improve overall supply chain performance. At the same time, cost-sharing contracts can effectively coordinate supply chain models. Furthermore, the feasibility of cost-sharing agreements is constrained by the supplier's emission reduction technology level and the pertinent carbon attributes of the product. Zhou, Huang, Chen, & Xu [20] found that decision-making changes and profit impacts under two conditions: with and without emission reduction cost-sharing contracts. The study specifically found that after the implementation of the emission reduction cost-sharing contract, the order quantity of low-carbon products increased, the retail price decreased, and under certain conditions, the profits of manufacturers and retailers were Pareto improved. Li, Xie, & Ying [21] discovered that the emission reduction cost-sharing contract can enhance the emission reduction effect, achieve a higher level of emission reduction, and lead to increased profits for both suppliers and retailers after its implementation. Li, Wang, Shang, Ou, & Qin [22] found that when consumers have strong low-carbon preferences, sharing the manufacturer's emission reduction costs is beneficial to retailers. He, He, Shi, Xu, & Zhou [23]' results indicate that two-way cost-sharing contracts can bring benefits to the entire supply chain and its members. Zhou, Bao, Chen, & Xu [24] focused on optimizing low-carbon supply chain management decisions and enhancing supply chain performance through contract design. The results indicate that emission reduction sharing contracts can achieve channel coordination when retailers do not have fairness concerns.

Difference and innovation

Previous studies by scholars have primarily conducted separate analyses and discussions on supply chain misreporting behavior and consumer low-carbon preferences. And most scholars included participants' emission reduction efforts as a fundamental element in the model without examining it as a variable. This article considers the misreporting behavior of supply chain participants as the foundational background. It incorporates consumers' low-carbon preferences and manufacturers' emission reduction efforts as variables into the model framework to provide a tangible analysis of the research elements in the low-carbon supply chain and examine the two variables. The impact on supply chain decision-making without cost sharing and with cost sharing, and whether participants' false reporting behavior will change the impact of variables on decision-making, makes the analysis results have

a clearer premise scope and more detailed. Finally, the two situations are compared and analyzed to study whether the retailer's emission reduction cost-sharing behavior is helpful for supply chain decision-making.

3. Parameters Setting and Model Construction

3.1 Parameters setting

All parameters appearing in this article and their meanings are shown in the table:

Table1. Model parameter symbols and meanings

Symbol	Meaning
R	Investment in research and development of emission reduction technology
w_0	The optimal wholesale price at which the retailer does not participate in abatement cost sharing and neither party misreports
w_m、w_r	Wholesale prices when manufacturers misreport and retailers misreport
Q_0	The optimal order quantity when the retailer does not participate in emission reduction cost sharing and neither party misreports
Q_m、Q_r	The order quantity when the manufacturers misreport and the retailers misreport
c_m	Manufacturer’s production cost
c_r	Retailer’s transportation cost
p_m、p_r	carbon trading price of manufacturers and retailer
p	Retail price of unit product (no subscript)
Q	Market demand for single-cycle
k	Potential market size
d	Sensitivity coefficient of price
m	Coefficient of emission reduction cost
μ	The impact coefficient of R&D investment in emission reduction technology on emission reductions
e	Emission reduction
α_r	Total carbon allowance initially allocated to the retailer
α_m	Total carbon allowance initially allocated to the manufacturer
M_r	Retailer’s actual carbon emissions
M_m	Manufacturer’s actual carbon emissions
a_r、b_r	Coefficient of retailer’s carbon emission
a_m、b_m	Coefficient of manufacturer’s carbon emission
f_{**k}	Participant’s public profits when misreporting

f_{**z}	Participants' true profits when misreporting
f_{mmk}	Manufacturer's public profits when manufacturer misreports
f_{mrk}	Retailer's public profits when manufacturer misreports
f_{rrk}	Retailer's public profits when retailer misreports
f_{rmk}	Manufacturer's public profits when retailer misreports
β	Consumers' low-carbon preference
ϕ	Coefficient of cost-sharing for emission reduction
γ_m	Manufacturer's misreporting coefficient of carbon price
η_m	Manufacturer's misreporting coefficient of carbon emissions
η_r	Retailer's misreporting coefficient of carbon emissions
γ_r	Retailer's misreporting coefficient of carbon price
f^*_m	Manufacturer's profit when retailer participates in cost-sharing for emission reduction (the superscript indicates the model decision when retailers participate in cost-sharing for emission reduction)

3.2 Model assumptions

Assumption 1: This article considers a two-level supply chain composed of a single manufacturer and a single retailer. Referring to the research model proposed by Yang et al. [18]., the carbon quotas of the manufacturer and the retailer are both in surplus. There is no carbon emission transfer between the two parties. The carbon trading income from the surplus carbon quotas is part of the overall revenue.

Assumption 2: Referring to the research model proposed by Zhou & Wu [25]., the market demand faced by manufacturers and retailers is a linear function of the product's emission reduction and sales price. The functional relationship is assumed to be $Q = k - dp + \beta e$.

Assumption 3: Referring to the research model proposed by Sun et al. [13]., the amount of emission reduction is related to the investment in research and development of emission reduction technology. The functional relationship is assumed to be $e = \mu R$.

Assumption 4: Referring to the research model proposed by Yang et al. [18]., the actual carbon emissions of manufacturers and retailers are related to the order quantity. The functional relationship is assumed to be $M_r = a_r Q + b_r$, $M_m = a_m Q + b_m$.

Assumption 5: Referring to the research model proposed by Sun et al. [13], the manufacturer's carbon emission reduction cost is related to the investment in research and development of emission reduction technology. The carbon emission reduction cost is $\frac{1}{2}mR^2$.

Assumption 6: This article is based on the misreporting of carbon information. Except for the misreporting of carbon information, all other supply chain information is symmetrical.

3.3 Basic model

Referring to the research model proposed by Yang et al. [18] with carbon information asymmetry. The profit

earned from selling low-carbon products is one of the components, while the carbon emission quota in the carbon trading market is the other. The profits obtained from, the specific profit functions of manufacturers and retailers are as follows:

$$f_m = (w - c_m)Q + p_m(\alpha_m - (M_m - e)) - \frac{1}{2}mR^2 \tag{3.1}$$

$$f_r = (p - w - c_r)Q + p_r(\alpha_r - M_r) \tag{3.2}$$

In the Stackelberg game, manufacturers aim to achieve their own profits while also meeting the expected profits of retailers. Based on the decision-making reaction of the retailer in the game, the manufacturer determines the unit wholesale price and emission reduction technology R&D investment that can maximize its own profits; the retailer, as a follower, decides on the order based on the wholesale price determined by the manufacturer and the emission reduction technology R&D investment quantity.

4. Research on No Cost-sharing for Emission Reduction Behavior Based on Different Misreporting Subjects

4.1 Model construction and solution results of different misreporting subjects

4.1.1 The situation of neither party misrepresentation

4.1.1.1 Model construction

The profit functions of the manufacturer and retailer are:

$$f_m = (w - c_m)Q + p_m\left(\alpha_m - \left((a_mQ + b_m) - \mu R\right)\right) - \frac{1}{2}mR^2 \tag{4.1}$$

$$f_r = \left(\frac{k + \beta\mu R - Q}{d} - w - c_r\right)Q + p_r(\alpha_r - (a_rQ + b_r)) \tag{4.2}$$

4.1.1.2 Equilibrium outcomes

After solving, the optimal order quantity and wholesale price are:

$$Q_0 = \frac{d(km + \beta\mu^2 p_m - dm(c_m + c_r + a_m p_m + a_r p_r))}{4dm - \beta^2\mu^2} \tag{4.3}$$

$$w_0 = \frac{2km + (2dm - \beta^2\mu^2)c_m - 2dmc_r}{4dm - \beta^2\mu^2} + \frac{(2\beta\mu^2 + (2dm - \beta^2\mu^2)a_m)p_m - 2dma_r p_r}{4dm - \beta^2\mu^2} \tag{4.4}$$

$$R_0 = \frac{\mu(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r))}{-4dm + \beta^2\mu^2} \tag{4.5}$$

Since it is necessary to explore the impact of R&D investment in emission reduction technologies on individual decisions, subsequent models need to solve the results with R (which will not be explained below).

The solutions with R are:

$$Q_0 = \frac{1}{4}(k + R\beta\mu - d(c_m + c_r + a_m p_m + a_r p_r)) \tag{4.6}$$

$$w_0 = \frac{k + R\beta\mu + d(c_m - c_r + a_m p_m - a_r p_r)}{2d} \tag{4.7}$$

4.1.2 The situation of manufacturer misrepresentation

4.1.2.1 Model construction

Manufacturers may falsify carbon information to increase profits and make decisions that prioritize their financial gain. Referring to the research model proposed by Yang et al. [18], it assumed that the carbon emissions disclosed by the manufacturer is $\eta_m M_m$, the public carbon price is $\gamma_m p_m$, where η_m>0, γ_m>0. 0<η_m<1 indicates underreporting of carbon emissions; η_m>1 indicates overreporting of carbon emissions. Similarly, γ_m. Currently, the retailer's real profit, the manufacturer's public profit, and the manufacturer's real profit are respectively:

$$f_{\mathrm{mrz}} = \left(\frac{k+\beta\mu R-Q}{d} - w_m - c_r\right)Q + p_r\left(\alpha_r - (a_r Q + b_r)\right) \tag{4.8}$$

$$f_{\mathrm{mmk}} = (w_m - c_m)Q + \gamma_m p_m\left(\alpha_m - (\eta_m(a_m Q + b_m) - \mu R)\right) - \frac{1}{2}mR^2 \tag{4.9}$$

$$f_{\mathrm{mmz}} = (w_m - c_m)Q + p_m\left(\alpha_m - \left((a_m Q + b_m) - \mu R\right)\right) - \frac{1}{2}mR^2 \tag{4.10}$$

4.1.2.2 Equilibrium outcomes

The optimal order quantity and wholesale price after solving are:

$$Q_m = \frac{d\left(km + \beta\mu^2 p_m\gamma_m - dm(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{4dm - \beta^2\mu^2} \tag{4.11}$$

$$w_m = \frac{(2dm - \beta^2\mu^2)c_m + 2m\left(k - d(c_r + a_r p_r)\right)}{4dm - \beta^2\mu^2} + \frac{2\beta\mu^2 p_m\gamma_m + (2dm - \beta^2\mu^2)a_m p_m\gamma_m\eta_m}{4dm - \beta^2\mu^2} \tag{4.12}$$

$$R_m = \frac{\mu\left(-k\beta - 4dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{-4dm + \beta^2\mu^2} \tag{4.13}$$

The solutions with R are:

$$Q_m = \frac{1}{4}\left(k + R\beta\mu - d(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right) \tag{4.14}$$

$$w_m = \frac{k + R\beta\mu + d(c_m - c_r - a_r p_r + a_m p_m\gamma_m\eta_m)}{2d} \tag{4.15}$$

4.1.3 The situation of retailer misrepresentation

4.1.3.1 Model construction

Referring to the research model proposed by Yang et al. [19], it assumed that, if a manufacturer does not misreport, the carbon emissions disclosed by retailers are $\eta_r M_r$, the public carbon price is $p_r\gamma_r$. When a retailer misreports, the retailer's public profits and true profits, as well as the manufacturer's true profits are:

$$f_{\mathrm{rrk}} = \left(\frac{k+\beta\mu R-Q}{d} - w - c_r\right)Q + p_r\gamma_r\left(\alpha_r - \eta_r(a_r Q + b_r)\right) \tag{4.16}$$

$$f_{\mathrm{rrz}} = \left(\frac{k+\beta\mu R-Q}{d} - w - c_r\right)Q + p_r\left(\alpha_r - (a_r Q + b_r)\right) \tag{4.17}$$

$$f_{\mathrm{rmz}} = (w - c_m)Q + p_m\left(\alpha_m - \left((a_m Q + b_m) - \mu R\right)\right) - \frac{1}{2}mR^2 \tag{4.18}$$

4.1.3.2 Equilibrium outcomes

The optimal order quantity and wholesale price after solving are:

$$Q_r = \frac{d\left(km + \beta\mu^2 p_m - dm(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r)\right)}{4dm - \beta^2\mu^2} \tag{4.19}$$

$$w_r = \frac{2km + (2dm - \beta^2\mu^2)c_m - 2dmc_r}{4dm - \beta^2\mu^2} + \frac{(2\beta\mu^2 + (2dm - \beta^2\mu^2)a_m)p_m - 2dma_r p_r \gamma_r \eta_r}{4dm - \beta^2\mu^2} \tag{4.20}$$

$$R_r = \frac{\mu\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r)\right)}{-4dm + \beta^2\mu^2} \tag{4.21}$$

The solutions with R are:

$$Q_r = \frac{1}{4}\left(k + R\beta\mu - d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r)\right) \tag{4.22}$$

$$w_r = \frac{k + R\beta\mu + d(c_m - c_r + a_m p_m - a_r p_r \gamma_r \eta_r)}{2d} \tag{4.23}$$

4.2 Research on the impact of consumers' low-carbon preferences

4.2.1 Impact on wholesale prices and optimal order quantities

Theorem 1. When the potential market size is large enough, the increase in consumers' low-carbon preferences will boost sales, leading to an increase in wholesale prices. Conversely, when the potential market size is limited, consumers' low-carbon preference will exhibit two extremes: either lower or higher. In a range, consumers' low-carbon environmental awareness will stimulate consumption, causing an increase in the order quantity and wholesale price .In the case of a limited market size, both parties have the incentive to misreport.

Proof. The analysis results show that consumers' low-carbon preferences does not affect the optimal order quantity and wholesale price.

When neither party misreports,

$$\frac{\partial Q_o}{\partial \beta} = 0 \tag{4.24}$$

$$\beta_1 = \frac{-km + dm(c_m + c_r + a_r p_r + a_m p_m)}{\mu^2 p_m} - \frac{\sqrt{m\left(-4d\mu^2 p_m^2 + m\left(k - d(c_m + c_r + a_m p_m + a_r p_r)\right)^2\right)}}{\mu^2 p_m} \tag{4.25}$$

$$\beta_2 = \frac{-km + dm(c_m + c_r + a_r p_r + a_m p_m)}{\mu^2 p_m} + \frac{\sqrt{m\left(-4d\mu^2 p_m^2 + m\left(k - d(c_m + c_r + a_m p_m + a_r p_r)\right)^2\right)}}{\mu^2 p_m} \tag{4.26}$$

$$\begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r), \ \beta_1 < \beta_2 < 0 \\ 0 < k < d(c_m + c_r + a_m p_m + a_r p_r), \ 0 < \beta_1 < \beta_2 \end{cases} \tag{4.27}$$

The first derivative function is a linear function of two variables with respect to β, and the highest power coefficient is $\mu^2 p_m$>0.

Therefore, when $k > d(c_m + c_r + a_m p_m + a_r p_r)$, there is a positive correlation between consumers' low-carbon preferences and the optimal order quantity. When $0 < k < d(c_m + c_r + a_m p_m + a_r p_r)$, the optimal order quantity first increases, then decreases, and then increases as consumers' low-carbon preference increases.

When manufacturer misreports,

$$\begin{cases} k > d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m) \text{，} \beta_1 < \beta_2 < 0 \\ 0 < k < d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m) \text{，} 0 < \beta_1 < \beta_2 \end{cases} \tag{4.28}$$

$$\begin{cases} k > d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), \ \dfrac{\partial \beta_1}{\partial \eta_m} > 0, \dfrac{\partial \beta_2}{\partial \eta_m} < 0 \\ 0 < k < d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), \ \dfrac{\partial \beta_1}{\partial \eta_m} < 0, \dfrac{\partial \beta_2}{\partial \eta_m} > 0 \end{cases} \tag{4.29}$$

When $0 < k < d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m)$, the larger ηm, the wider the range of negative correlation between consumer low-carbon preference and optimal order quantity; $k > d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m)$, misreporting has no effect.

The consequences of misreporting by a retailer are like those of misreporting by a manufacturer. Both parties have a motive for underreporting when the market size is limited.

Theorem 1 demonstrates that in a limited potential market, when consumers have a low preference for low-carbon products, their desire to purchase such products resembles starting from scratch, leading to a moderate increase in product sales. Conversely, when consumers have a high preference for low-carbon products, their loyalty to these products is strengthened. As consumers' preference for low-carbon products intensifies, their purchasing desire escalates accordingly. Based on a sufficiently large market size, the potential low-carbon consumer groups can be larger or even unrestricted. Judging from the overall situation, the stronger the low-carbon preferences, the higher the likelihood of purchasing them.

4.2.2 Impact on manufacturers' R&D investment in emission reduction technology

Theorem 2. When the potential market size is large enough, the increase in consumers' low-carbon preferences will encourage manufacturers to reduce emissions. However, based on a limited potential market size, when consumers' low-carbon preference is in the two extreme ranges of low and high, their environmental awareness will not directly lead to manufacturers reducing emissions. Conversely, when consumers' low-carbon preference falls within the middle range, their environmental awareness will drive manufacturers to make efforts to reduce emissions.

Proof. When neither party misreports,

$$\frac{\partial R_0}{\partial \beta} = 0 \tag{4.30}$$

$$\beta_1 = \frac{2\left(2d\mu^2 p_m - \sqrt{d\mu^2\left(4d\mu^2 p_m^2 - m\left(k - d(c_m + c_r + a_m p_m + a_r p_r)\right)^2\right)}\right)}{\mu^2(d(c_m + c_r + a_m p_m + a_r p_r) - k)} \tag{4.31}$$

$$\beta_2 = \frac{2\left(2d\mu^2 p_m + \sqrt{d\mu^2\left(4d\mu^2 p_m^2 - m\left(k - d(c_m + c_r + a_m p_m + a_r p_r)\right)^2\right)}\right)}{\mu^2(d(c_m + c_r + a_m p_m + a_r p_r) - k)} \tag{4.32}$$

The first derivative function is a linear function of two variables with respect to β, and the highest power coefficient is $k - d(c_m + c_r + a_m p_m + a_r p_r)$.

$$\begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r) \text{，concave function，} \beta_1 < \beta_2 < 0 \\ 0 < k < d(c_m + c_r + a_m p_m + a_r p_r) \text{，convex function，} 0 < \beta_1 < \beta_2 \end{cases} \tag{4.33}$$

When $k > d(c_m + c_r + a_m p_m + a_r p_r)$, there is a positive correlation between consumers' low-carbon preferences and manufacturers' R&D investment in emission reduction technology; when $0 < k <$

$d(c_m + c_r + a_m p_m + a_r p_r)$, as consumers' low-carbon preferences increase, manufacturers' investment in research and development of emission reduction technologies will first decrease, then increase and then decrease.

When manufacturer misreports,

$$\begin{cases} k > (c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), & \text{concave function}, \quad \beta_1 < \beta_2 < 0 \\ 0 < k < (c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), & \text{convex function}, \quad 0 < \beta_1 < \beta_2 \end{cases} \tag{4.34}$$

$$\begin{cases} k > (c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), & \frac{\partial \beta_1}{\partial \gamma_m} > 0, \frac{\partial \beta_2}{\partial \gamma_m} < 0, \frac{\partial \beta_1}{\partial \eta_m} > 0, \frac{\partial \beta_2}{\partial \eta_m} < 0 \\ 0 < k < d(c_m + c_r + a_r p_r), & \frac{\partial \beta_1}{\partial \gamma_m} < 0, \frac{\partial \beta_2}{\partial \gamma_m} > 0, \frac{\partial \beta_1}{\partial \eta_m} > 0, \frac{\partial \beta_2}{\partial \eta_m} < 0 \end{cases} \tag{4.35}$$

When the potential market size is large enough, false reporting will not have an impact on it; when the potential market size is limited, the increase in γ_m and the decrease in η_m will increase the scope of the positive correlation between consumers' low-carbon preferences and manufacturers' emission reduction efforts.

Theorem 2 demonstrates that when the potential market size is limited due to low consumer preference for low-carbon products, manufacturers' investments in emission reduction may not be sufficient to encourage more consumers to purchase and may not offset the rising costs of emission reduction. Consequently, manufacturers tend to limit their investment in researching and developing emission reduction technologies. Conversely, when consumers exhibit a strong preference for low-carbon products, the number of consumers incentivized by emission reduction investments stabilizes.

4.3 Research on the impact of manufacturers' emission reduction efforts

4.3.1 Impact on wholesale prices and optimal order quantities

Theorem 3. Regardless of whether manufacturers misreport or not, their investment in research and development of emission reduction technologies will increase retailers' optimal order quantities and simultaneously raise the wholesale price of products.

Proof. In three situations: neither party misreports, the manufacturer misreports, and the retailer misreports,

$$\frac{\partial Q}{\partial R} = \frac{\beta \mu}{4} > 0 \tag{4.36}$$

$$\frac{\partial w}{\partial R} = \frac{\beta \mu}{2d} > 0 \tag{4.37}$$

Therefore, the manufacturer's emission reduction efforts are all positively correlated with the optimal order quantity and the wholesale price.

Theorem 3 demonstrates that an increase in R&D investment in emission reduction technology by manufacturers will incentivize environmentally conscious consumers to make purchases, but it will also raise manufacturers' costs.

4.3.2 Impact on manufacturer's profit

Theorem 4. When consumers have a high degree of low-carbon preferences and the potential market size is significant, manufacturers will benefit from increased investment in research and development of emission reduction technologies. On the contrary, an increase in manufacturers' R&D investment in emission reduction technologies will lead to a decrease in manufacturers' profits. When consumers' low-carbon preferences is not strong enough, and the potential market size is large, manufacturers' increased investment in research and

development of emission reduction technologies will initially increase and then decrease their own profits. Moreover, manufacturers can maximize their profits regardless of whether they misreport or not.

Proof. When neither party misreports,

$$\frac{\partial f_m}{\partial R} = 0 \tag{4.38}$$

$$R = \frac{\mu\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)}{-4dm + \beta^2\mu^2} \tag{4.39}$$

$$\frac{\partial^2 f_m}{\partial R^2} = -m + \frac{\beta^2\mu^2}{4d} \tag{4.40}$$

$$\begin{cases} \beta > \dfrac{\sqrt{4\mathrm{dm}}}{\mu}, \ \dfrac{\partial^2 f_m}{\partial R^2} > 0, \begin{cases} 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), \ R > 0 \\ k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), \ R < 0 \end{cases} \\ 0 < \beta < \dfrac{\sqrt{4\mathrm{dm}}}{\mu}, \ \dfrac{\partial^2 f_m}{\partial R^2} < 0, \begin{cases} 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), \ R < 0 \\ k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), \ R > 0 \end{cases} \end{cases} \tag{4.41}$$

The results when the manufacturer misreports are the same as when the manufacturer does not misreport.

When $\frac{\partial f_{\mathrm{mmz}}}{\partial \gamma_m} = 0, \frac{\partial f_{\mathrm{mmz}}}{\partial \eta_m} = 0, \gamma_m \eta_m = 1$. Because $\frac{\partial^2 f_{\mathrm{mmz}}}{\partial {\gamma_m}^2} < 0, \frac{\partial^2 f_{\mathrm{mmz}}}{\partial {\eta_m}^2} < 0$

Therefore, when $\gamma_m \eta_m = 1, f_m = f_{\mathrm{mmz}}$; when $\gamma_m \eta_m \neq 1$, $f_{\mathrm{mmz}} < f_m$, so, $f_{\mathrm{mmz}} \leqslant f_m$.

When retailer misreports,

$$\frac{\partial^2 f_{\mathrm{rmz}}}{\partial R^2} = -m + \frac{\beta^2\mu^2}{4d} \tag{4.42}$$

$$\begin{cases} \beta > \dfrac{\sqrt{4\mathrm{dm}}}{\mu}, \ \dfrac{\partial^2 f_{\mathrm{rmz}}}{\partial R^2} > 0, \begin{cases} 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), \ R > 0 \\ k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), \ R < 0 \end{cases} \\ 0 < \beta < \dfrac{\sqrt{4\mathrm{dm}}}{\mu}, \ \dfrac{\partial^2 f_{\mathrm{rmz}}}{\partial R^2} < 0, \begin{cases} 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), \ R < 0 \\ k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), \ R > 0 \end{cases} \end{cases} \tag{4.43}$$

The impact of the misreporting coefficient is the same as if the manufacturer misreported it.

Theorem 4 demonstrates that when consumers exhibit clear low-carbon preferences and the market size is substantial, manufacturers' efforts to reduce emissions can stimulate consumers to buy low-carbon products, leading to a significant increase in sales and ultimately boosting profits. However, in cases where consumers' low-carbon preferences are not sufficiently evident and the potential market size is large, manufacturers' initial efforts to reduce emissions can still yield certain benefits. Manufacturers' emission reduction initiatives are influenced by consumers' low-carbon preferences, which in turn influence their purchasing behavior. Nevertheless, as manufacturers escalate their investments in emission reduction technologies, the prices of low-carbon products also rise. If consumers' own low-carbon preferences are not strong enough to justify the increased prices and drive purchasing behavior, the manufacturer's revenue will decrease.

4.3.3 Impact on retailer's profit

Theorem 5. When the potential market size is large, an increase in the manufacturer's R&D investment in emission reduction technology will boost the retailer's profits. However, when the potential market size is limited,

the retailer's profit will initially increase as the manufacturer's R&D investment in emission reduction technology increases but will eventually decrease. At the same time, deceptive behavior only changes the inflection point of its trend in the case of limited potential market size, without changing its overall trend.

Proof. When neither party misreports,

$$\frac{\partial f_r}{\partial R} = 0 \tag{4.44}$$

$$R = \frac{-k + d(c_m + c_r + a_m p_m + a_r p_r)}{\beta\mu} \tag{4.45}$$

$$\frac{\partial^2 f_r}{\partial R^2} = \frac{\beta^2\mu^2}{8d} > 0 \tag{4.46}$$

Therefore, $R = \frac{-k+d(c_m+c_r+a_m p_m+a_r p_r)}{\beta\mu}$ is the minimum point.

When $k > d(c_m + c_r + a_m p_m + a_r p_r)$, Retailer profits increase as manufacturers invest more in research and development of emission reduction technology. When $0 < k < d(c_m + c_r + a_m p_m + a_r p_r)$, Retailers' profits first decrease and then increase as manufacturers increase their investment in research and development of emission reduction technology.

When manufacturer misreports,

$$\frac{\partial {f_{\mathrm{mrz}}}^2}{\partial R^2} = \frac{\beta^2\mu^2}{8d} > 0 \tag{4.47}$$

$$\begin{cases} k > d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), & R < 0 \\ 0 < k < d(c_m + c_r + a_r p_r + a_m p_m \gamma_m \eta_m), & R > 0 \end{cases} \tag{4.48}$$

$$\frac{\partial R}{\partial \gamma_m \eta_m} = \frac{d a_m p_m}{\beta\mu} > 0 \tag{4.49}$$

As $\gamma_m \eta_m$ increases, R will become larger, and the scope of the positive relationship between the retailer's profit and the manufacturer's R&D investment in emission reduction technology will become smaller.

When retailer misreports,

$$\frac{\partial {f_{\mathrm{rrz}}}^2}{\partial R^2} = \frac{\beta^2\mu^2}{8d} > 0 \tag{4.50}$$

$$\begin{cases} k > d\left(c_m + c_r + a_m p_m + a_r p_r (2 - \gamma_r \eta_r)\right), & R < 0 \\ 0 < k < d\left(c_m + c_r + a_m p_m + a_r p_r (2 - \gamma_r \eta_r)\right), & R > 0 \end{cases} \tag{4.51}$$

$$\frac{\partial R}{\partial \gamma_r \eta_r} = -\frac{d a_r p_r}{\beta\mu} < 0 \tag{4.52}$$

When $\gamma_r \eta_r$ becomes larger, R will become smaller, and the scope of the positive relationship between the retailer's profit and the manufacturer's R&D investment in emission reduction technology will become larger.

Theorem 5 demonstrates that a larger potential market size leads to a larger potential low-carbon consumer group. Consequently, an increase in R&D investment in emission reduction technology by manufacturers will not only attract the attention of low-carbon consumers but also appeal to consumer groups with low-carbon preferences. Increase, thereby benefiting retailers. At the same time, due to the substantial market size, the adverse effects of subtle information asymmetry will be somewhat mitigated. When the potential market size is limited, manufacturers start to reduce emissions, which results in higher wholesale prices. However, at this time, the increase in sales of low-carbon products cannot offset the retailer's costs due to the rise in wholesale prices. Therefore, the retailer's profits will decrease first. As manufacturers continue to reduce emissions, retailers' profits increase due to the rising sales of low-carbon products. The misreporting behavior of both parties will not alter

the trend of the impact of emission reduction technology R&D investment on retailers' profits, but it will affect the value of emission reduction technology R&D investment at the critical point.

5. Research on Cost-sharing for Emission Reduction Behavior Based on Different Misreporting Subjects

5.1 Model construction and solution results of different misreporting subjects

In a low-carbon environment, retailers take the initiative to share part of the manufacturers' emission reduction costs to encourage them to make efforts in reducing emissions. This practice prompts manufacturers to increase the production of low-carbon products. The emission reduction cost-sharing coefficient is the ϕ.

5.1.1 The situation of neither party misrepresentation

5.1.1.1 Model construction

The profit functions of the manufacturer and retailer are:

$$f^*_m = (w - c_m)Q + p_m\left(\alpha_m - \left((a_m Q + b_m) - \mu R\right)\right) - \frac{1}{2}(1-\phi)mR^2 \tag{5.1}$$

$$f^*_r = \left(\frac{k + \beta\mu R - Q}{d} - w - c_r\right)Q + p_r\left(\alpha_r - (a_r Q + b_r)\right) - \frac{1}{2}\phi mR^2 \tag{5.2}$$

5.1.1.2 Equilibrium outcomes

According to the game sequence in the previous chapter, the optimal order quantity and wholesale price obtained are:

$$Q_o{}^* = \frac{d\left(km(-1+\phi) - \beta\mu^2 p_m - dm(-1+\phi)(c_m + c_r + a_m p_m + a_r p_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.3}$$

$$w_0{}^* = \frac{\beta\mu^2(\beta c_m + (-2+\beta a_m)p_m)}{\beta^2\mu^2 + 4dm(-1+\phi)} + \frac{2m(-1+\phi)\left(k + d(c_m - c_r + a_m p_m - a_r p_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.4}$$

$$R^*{}_0 = \frac{\mu\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.5}$$

The solutions with R are:

$$Q_o{}^* = \frac{1}{4}\left(k + R\beta\mu - d(c_m + c_r + a_m p_m + a_r p_r)\right) \tag{5.6}$$

$$w_0{}^* = \frac{k + R\beta\mu + d(c_m - c_r + a_m p_m - a_r p_r)}{2d} \tag{5.7}$$

5.1.2 The situation of manufacturer misrepresentation

5.1.2.1 Model construction

The retailer's true profit, the manufacturer's disclosed profit, and the true profit are respectively:

$$f^*{}_{\mathrm{mrz}} = \left(\frac{k + \beta\mu R - Q}{d} - w - c_r\right)Q + p_r\left(\alpha_r - (a_r Q + b_r)\right) - \frac{1}{2}\phi mR^2 \tag{5.8}$$

$$f^*{}_{\mathrm{mmk}} = (w - c_m)Q + p_m\gamma_m\left(\alpha_m - (\eta_m(a_m Q + b_m) - \mu R)\right) - \frac{1}{2}(1-\phi)mR^2 \tag{5.9}$$

$$f^*_{\text{mmz}} = (w - c_m)Q + p_m\left(\alpha_m - \left((a_m Q + b_m) - \mu R\right)\right) - \frac{1}{2}(1-\phi)mR^2 \tag{5.10}$$

5.1.2.2 Equilibrium outcomes

The obtained optimal order quantity and wholesale price are:

$$Q^*_m = \frac{d(km(-1+\phi) - \beta\mu^2 p_m\gamma_m)}{\beta^2\mu^2 + 4dm(-1+\phi)} - \frac{d\left(dm(-1+\phi)(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.11}$$

$$w^*_m = \frac{\beta\mu^2\left(\beta c_m + p_m\gamma_m(-2+\beta a_m\eta_m)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} + \frac{2m(-1+\phi)\left(k + d(c_m - c_r - a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.12}$$

$$R^*_m = \frac{\mu\left(-k\beta - 4dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.13}$$

The solutions with R are:

$$Q^*_m = \frac{1}{4}\left(k + R\beta\mu - d(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right) \tag{5.14}$$

$$w^*_m = \frac{k + R\beta\mu + d(c_m - c_r - a_r p_r + a_m p_m\gamma_m\eta_m)}{2d} \tag{5.15}$$

5.1.3 The situation of retailer misrepresentation

5.1.3.1 Model construction

The retailer's public profit, real profit and manufacturer's real profit are:

$$f^*_{\text{rrk}} = \left(\frac{k + \beta\mu R - Q}{d} - w - c_r\right)Q + p_r\gamma_r\left(\alpha_r - \eta_r(a_r Q + b_r)\right) - \frac{1}{2}\phi mR^2 \tag{5.16}$$

$$f^*_{\text{rrz}} = \left(\frac{k + \beta\mu R - Q}{d} - w - c_r\right)Q + p_r\left(\alpha_r - (a_r Q + b_r)\right) - \frac{1}{2}\phi mR^2 \tag{5.17}$$

$$f^*_{\text{rmz}} = (w - c_m)Q + p_m\left(\alpha_m - \left((a_m Q + b_m) - \mu R\right)\right) - \frac{1}{2}(1-\phi)mR^2 \tag{5.18}$$

5.1.3.2 Equilibrium outcomes

The obtained optimal order quantity and wholesale price are:

$$Q^*_r = \frac{d\left(km(-1+\phi) - \beta\mu^2 p_m - dm(-1+\phi)(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.19}$$

$$w^*_r = \frac{\beta\mu^2(\beta c_m + (-2+\beta a_m)p_m) + 2m(-1+\phi)\left(k + d(c_m - c_r + a_m p_m - a_r p_r\gamma_r\eta_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.20}$$

$$R^*_r = \frac{\mu\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r)\right)}{\beta^2\mu^2 + 4dm(-1+\phi)} \tag{5.21}$$

The solutions with R are:

$$Q^*_r = \frac{1}{4}\left(k + R\beta\mu - d(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r)\right) \tag{5.22}$$

$$w^*_r = \frac{k + R\beta\mu + d(c_m - c_r + a_m p_m - a_r p_r\gamma_r\eta_r)}{2d} \tag{5.23}$$

5.2 Research on the impact of cost-sharing behavior on emission reduction

5.2.1 Impact on wholesale prices, optimal order quantities and Manufacturers' emission reduction efforts

Theorem 6. When the potential market size is large, cost-sharing behavior for emission reduction will increase

the retailer's optimal order quantity, raise wholesale prices, and incentivize manufacturers to invest in emission reduction efforts. When the potential market size is limited, the impact of emission reduction cost-sharing behavior is related to consumers' preference for low-carbon products. When the low-carbon preferences of consumers is lower than a certain critical value, the optimal ordering quantity, wholesale prices, and manufacturers' emission reduction investments increase. At the same time, when the potential market size is large, false reporting has no impact on the results; however, when the potential market size is limited, there will be a tendency to underreport information.

Proof. When neither party misreports,

$$\frac{\partial\left(Q_0 - {Q^*}_0\right)}{\partial\phi} = \frac{dm\beta\mu^2\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)}{\left(\beta^2\mu^2 + 4dm(-1+\phi)\right)^2} \tag{5.24}$$

When $\frac{\partial(Q_0 - {Q^*}_0)}{\partial\phi} = 0, \beta_1 = 0$, $\beta_2 = \frac{4dp_m}{-k+d(c_m+c_r+a_m p_m+a_r p_r)}$,

$$\begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r), & \beta_2 < 0, \quad {Q^*}_0 > Q_0 \\ 0 < k < d(c_m + c_r + a_m p_m + a_r p_r), & \beta_2 > 0, \begin{cases} 0 < \beta < \beta_2, & {Q^*}_0 > Q_0 \\ \beta > \beta_2, & {Q^*}_0 < Q_0 \end{cases} \end{cases} \tag{5.25}$$

When manufacturer misreports,

$$\frac{\partial\left(Q_m - {Q^*}_m\right)}{\partial\phi} = \frac{dm\beta\mu^2\left(-k\beta - 4dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)}{\left(\beta^2\mu^2 + 4dm(-1+\phi)\right)^2} \tag{5.26}$$

When $\frac{\partial(Q_{\mathrm{m}} - {Q^*}_{\mathrm{m}})}{\partial\phi} = 0, \beta_1 = 0$, $\beta_2 = \frac{4dp_m\gamma_m}{-k+d(c_m+c_r+a_r p_r+a_m p_m\gamma_m\eta_m)}$,

$$\begin{cases} k > d(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m), & \beta_2 < 0, \quad {Q^*}_m > Q_m \\ 0 < k < d(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m), & \beta_2 > 0, \begin{cases} 0 < \beta < \beta_2, & {Q^*}_m > Q_m \\ \beta > \beta_2, & {Q^*}_m < Q_m \end{cases} \end{cases} \tag{5.27}$$

$$\frac{\partial\beta_2}{\partial\eta_m} = -\frac{4d^2 a_m p_m^2\gamma_m^2}{\left(k - d(c_m + c_r + a_r p_r + \eta a_m p_m\gamma_m)\right)^2} < 0 \tag{5.28}$$

Overreporting will reduce the scope of consumers' low-carbon preferences, where emission reduction sharing is positively related to the optimal order quantity.

When retailer misreports,

$$\frac{\partial\left(Q_r - {Q^*}_r\right)}{\partial\phi} = \frac{dm\beta\mu^2\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r)\right)}{\left(\beta^2\mu^2 + 4dm(-1+\phi)\right)^2} \tag{5.29}$$

When $\frac{\partial(Q_r - {Q^*}_r)}{\partial\phi} = 0, \beta_1 = 0$, $\beta_2 = \frac{4dp_m}{-k+d(c_m+c_r+a_m p_m+a_r p_r\gamma_r\eta_r)}$,

$$\begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r), & \beta_2 < 0, \quad {Q^*}_r > Q_r \\ k < d(c_m + c_r + a_m p_m + a_r p_r\gamma_r\eta_r), & \beta_2 > 0, \begin{cases} 0 < \beta < \beta_2, & {Q^*}_r > Q_r \\ \beta > \beta_2, & {Q^*}_r < Q_r \end{cases} \end{cases} \tag{5.30}$$

$$\frac{\partial\beta_2}{\partial\eta_m} = -\frac{4d^2 a_r p_m p_r\gamma_r}{\left(k - d(c_m + c_r + a_m p_m + \eta a_r p_r\gamma_r)\right)^2} < 0 \tag{5.31}$$

Overreporting will reduce the scope of consumers' low-carbon preferences, where emission reduction sharing

is positively related to the optimal order quantity.

The certification process for wholesale prices and manufacturer emissions reduction inputs is similar.

Theorem 6 demonstrates that when retailers share a portion of the emission reductions, the cost pressure on manufacturers decreases, allowing manufacturers to allocate funds towards further emission reductions. At the same time, retailers will increase low-carbon and green marketing efforts to encourage consumers to make more purchases, using the increased sales to offset the rising costs of emission reduction. When consumers' low-carbon preferences exceeds a certain critical threshold, these products become more prevalent, leading to a stabilization of the consumer group. The sales of low-carbon products are no longer increasing significantly, but manufacturers' investment in emission reduction will continue to rise. The portion of emission reduction costs that retailers share represents a small fraction of the total costs incurred by manufacturers. Consequently, it is insufficient to play a significant mitigating role. Moreover, there is a declining interest among new consumers in low-carbon products. As a result, manufacturers are likely to prioritize investments in managing emission reduction costs, leading to stagnant order quantities for retailers compared to previous periods. Therefore, manufacturers will also adjust wholesale prices for retailers.

5.2.2 Impact on manufacturer profits

Theorem 7. In the scenario where neither party misreports and only the retailer misreports, cost-sharing emission reduction will increase the manufacturer's profits.

Proof. When neither party misreports,

$$\frac{\partial\left(f_m - f^*{}_m\right)}{\partial\phi} = -\frac{m\mu^2\left(k\beta + 4dp_m - d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)^2}{2\left(\beta^2\mu^2 + 4dm(-1+\phi)\right)^2} < 0 \tag{5.32}$$

So, $f_m - f^*{}_m < 0$, $f^*{}_m > f_m$.

When retailer misreports,

$$\frac{\partial\left(f_{\mathrm{rmz}} - f^*{}_{\mathrm{rmz}}\right)}{\partial\phi} = -\frac{m\mu^2\left(k\beta + 4dp_m - d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)^2}{2\left(\beta^2\mu^2 + 4dm(-1+\phi)\right)^2} < 0 \tag{5.33}$$

So, $f_{\mathrm{rmz}} - f^*{}_{\mathrm{rmz}} < 0$, $f^*{}_{\mathrm{rmz}} > f_{\mathrm{rmz}}$.

Theorem 7 demonstrates that if the manufacturer does not misreport, the cost-sharing behavior for emission reduction will enhance the manufacturer's profits. This can somewhat deter the manufacturer's inclination to deceive.

5.2.3 Impact on retailer profits

Theorem 8. The impact of cost-sharing behavior for emission reduction on retailers' profits is closely related to the potential market size. When the potential market size is large and the cost-sharing coefficient is lower than a certain value, the cost-sharing of emission reduction will increase the profit of retailers. When the addressable market size is within a certain range, it increases the retailer's profits, regardless of the sharing factor. Moreover, misreporting only affects the boundaries of the potential market size and does not impact the inclination to enhance profits.

Proof. When neither party misreports,

$$\frac{\partial\left(f_r - f^*{}_r\right)}{\partial\phi} = 0, \qquad \phi = \frac{\beta^2\mu^2}{8md} + \frac{2(8dm - 3\beta^2\mu^2)p_m}{8m\left(-k\beta - 2dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)} \tag{5.34}$$

$\frac{\partial(f_r - f^*_r)}{\partial \phi}$ is a linear function about ϕ, therefore,

$$\frac{\partial^2(f_r - f^*_r)}{\partial \phi^2} = 8dm\left(-k\beta - 4dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right)\left(-k\beta - 2dp_m + d\beta(c_m + c_r + a_m p_m + a_r p_r)\right) \tag{5.35}$$

When $0 < k < d(c_m + c_r + a_m p_m + a_r p_r) - \frac{4dp_m}{\beta}$ or $k > d(c_m + c_r + a_m p_m + a_r p_r) - \frac{2dp_m}{\beta}$,

$$\frac{\partial^2(f_r - f^*_r)}{\partial \phi^2} > 0 \tag{5.36}$$

$$\begin{cases} k > d\left(c_m + c_r + \left(-\frac{8}{\beta} + \frac{16dm}{\beta^3\mu^2} + a_m\right)p_m + a_r p_r\right), \ \phi_0 > 0, \begin{cases} 0 < \phi < \phi_0, \ f_r - f^*_r < 0 \\ \phi > \phi_0, \ f_r - f^*_r > 0 \end{cases} \\ k < d\left(c_m + c_r + \left(-\frac{8}{\beta} + \frac{16dm}{\beta^3\mu^2} + a_m\right)p_m + a_r p_r\right), \ \phi_0 < 0, f_r - f^*_r > 0 \end{cases} \tag{5.37}$$

When $d(c_m + c_r + a_m p_m + a_r p_r) - \frac{4dp_m}{\beta} < k < d(c_m + c_r + a_m p_m + a_r p_r) - \frac{2dp_m}{\beta}$,

$$\frac{\partial^2(f_r - f^*_r)}{\partial \phi^2} < 0 \tag{5.38}$$

$$\begin{cases} k > d\left(c_m + c_r + \left(-\frac{8}{\beta} + \frac{16dm}{\beta^3\mu^2} + a_m\right)p_m + a_r p_r\right), \ \phi_0 < 0, f_r - f^*_r < 0 \\ k < d\left(c_m + c_r + \left(-\frac{8}{\beta} + \frac{16dm}{\beta^3\mu^2} + a_m\right)p_m + a_r p_r\right), \ \phi_0 > 0, \begin{cases} 0 < \phi < \phi_0, \ f_r - f^*_r > 0 \\ \phi > \phi_0, \ f_r - f^*_r < 0 \end{cases} \end{cases} \tag{5.39}$$

When manufacturer misreports,

$$\frac{\partial(f_{\mathrm{mrz}} - f^*_{\mathrm{mrz}})}{\partial \phi} = 0, \qquad \phi = \frac{\beta^2\mu^2}{8md} + \frac{2(8dm - 3\beta^2\mu^2)p_m\gamma_m}{8m\left(-k\beta - 2dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)} \tag{5.40}$$

$$\frac{\partial^2(f_{\mathrm{mrz}} - f^*_{\mathrm{mrz}})}{\partial \phi^2} = 8dm\left(-k\beta - 4dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right)\left(-k\beta - 2dp_m\gamma_m + d\beta(c_m + c_r + a_r p_r + a_m p_m\gamma_m\eta_m)\right) \tag{5.40}$$

When a retailer misreports, it is like the above; the misreporting only affects the critical value of its potential market size and does not change the overall trend.

Theorem 8 demonstrates that When the potential market size is large, the consumer base is large enough to increase the sales of low-carbon products, so that the retailer's income increases; At the same time, retailers share less emission reduction costs for manufacturers, so that manufacturers can actively reduce emissions while increasing their own costs, and the benefits brought to retailers by increasing the sales of low-carbon products are greater than the shared emission reduction costs, so the cost-sharing of emission reductions increases the profits of retailers.

5.3 Research on the impact of consumers' low-carbon preferences

Theorem 9-10 are same with Theorem 1-2.

Please refer to 4.2 for more details.

5.4 Research on the impact of manufacturers' efforts to reduce emissions

Theorem 11 is same with Theorem 3.

Please refer to 4.3 for more details.

5.4.2 Impact on manufacturer profits

Theorem 12. When the emission reduction cost-sharing coefficient is large and the potential market size is significant, the manufacturer's increase in R&D investment in emission reduction technology will boost the manufacturer's profits. If the potential market is limited, the manufacturer's profits will decrease and then increase. When the cost-sharing factor for abatement is small and the market size is constrained, abatement efforts can reduce manufacturers' profits. Whether the manufacturer misreports or not, it has no effect on its relationship; When retailers overreport carbon information, they increase the range of positive correlations.

Proof. When neither party misreports,

$$\frac{\partial^2 f^*{}_m}{\partial R^2} = \frac{\beta^2\mu^2}{4d} + m(-1+\phi) \tag{5.41}$$

$$\begin{cases} 0 < \phi < 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}}, & \dfrac{\partial^2 f^*{}_m}{\partial R^2} < 0, & \begin{cases} k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), & R > 0 \\ 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), & R < 0 \end{cases} \\ 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}} < \phi < 1, & \dfrac{\partial^2 f^*{}_m}{\partial R^2} > 0, & \begin{cases} k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), & R < 0 \\ 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r), & R > 0 \end{cases} \end{cases} \tag{5.42}$$

When the manufacturer misreports, the results are consistent with the situation where neither misreporting occurs.

When retailer misreports,

$$\frac{\partial^2 f^*{}_{\mathrm{rmz}}}{\partial R^2} = \frac{\beta^2\mu^2}{4d} + m(-1+\phi) \tag{5.43}$$

$$\begin{cases} 0 < \phi < 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}}, & \dfrac{\partial^2 f^*{}_{\mathrm{rmz}}}{\partial R^2} < 0, & \begin{cases} k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), & R > 0 \\ 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), & R < 0 \end{cases} \\ 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}} < \phi < 1, & \dfrac{\partial^2 f^*{}_{\mathrm{rmz}}}{\partial R^2} > 0, & \begin{cases} k > \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), & R < 0 \\ 0 < k < \dfrac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r), & R > 0 \end{cases} \end{cases} \tag{5.44}$$

$$\begin{cases} 0 < \phi < 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}}, & \dfrac{\partial R}{\partial \gamma_r} > 0, \dfrac{\partial R}{\partial \eta_r} > 0 \\ 1 - \dfrac{\beta^2\mu^2}{4\mathrm{dm}} < \phi < 1, & \dfrac{\partial R}{\partial \gamma_r} < 0, \dfrac{\partial R}{\partial \eta_r} < 0 \end{cases} \tag{5.45}$$

When $0 < \phi < 1 - \frac{\beta^2\mu^2}{4\mathrm{dm}}$ and $k > \frac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r)$, the increase of γ_r and η_r will make the scope of the positive correlation between manufacturer's R&D investment in emission reduction technology and manufacturer's profit wider; when $1 - \frac{\beta^2\mu^2}{4\mathrm{dm}} < \phi < 1$ and $0 < k < \frac{-4dp_m}{\beta} + d(c_m + c_r + a_m p_m + a_r p_r \gamma_r \eta_r)$, The increase of γ_r and η_r will make the scope of the positive correlation between manufacturer's R&D investment in emission reduction technology and manufacturer's profit wider.

Theorem 12 demonstrates that the cost-sharing coefficient and potential market size influence the connection between manufacturers' R&D investment in emission reduction technologies and their profits. When the potential market size is large enough and the retailer's cost-sharing coefficient exceeds a certain critical value, the manufacturer will achieve a favorable situation of increased sales and reduced costs. Consequently, the manufacturer's profits will also increase significantly. Conversely, if the potential market is restricted, the initial reduction will occur when emission reduction investment costs are low, leading to a reduction in manufacturers' profits due to the lack of consumer groups. However, as emission reduction investment increases in the later period, retailers' cost-sharing for emission reduction has a more pronounced effect.

5.4.3 Impact on retailer profits

Theorem 13. When the emission reduction cost-sharing coefficient is small and the potential market size is large enough, the manufacturer's increase in R&D investment in emission reduction technology will increase the retailer's profits. However, when the market size is limited, the manufacturer's R&D investment in emission reduction technology will cause retailers' profits to decrease first and then increase. When the cost-sharing factor for abatement is large and the market size is constrained, the increase in emission reduction efforts can reduce retailers' profits. At the same time, both sides have incentives to underreport carbon information.

Proof. When neither party misreports,

$$\frac{\partial f^*_r}{\partial R} = 0, \qquad R = \frac{\beta\mu\left(-k + d(c_m + c_r + a_m p_m + a_r p_r)\right)}{\beta^2\mu^2 - 8dm\phi} \tag{5.46}$$

$$\frac{\partial^2 f^*_r}{\partial R^2} = \frac{\beta^2\mu^2}{8d} - m\phi \tag{5.47}$$

$$\begin{cases} 0 < \phi < \dfrac{\beta^2\mu^2}{8\mathrm{dm}}, & \dfrac{\partial^2 f^*_r}{\partial R^2} > 0, & \begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r), & R < 0 \\ 0 < k < d(c_m + c_r + a_m p_m + a_r p_r), & R > 0 \end{cases} \\ \dfrac{\beta^2\mu^2}{8\mathrm{dm}} < \phi < 1, & \dfrac{\partial^2 f^*_r}{\partial R^2} < 0, & \begin{cases} k > d(c_m + c_r + a_m p_m + a_r p_r), & R > 0 \\ 0 < k < d(c_m + c_r + a_m p_m + a_r p_r), & R < 0 \end{cases} \end{cases} \tag{5.48}$$

When manufacturer misreports,

$$\frac{\partial^2 f^*_{mrz}}{\partial R^2} = \frac{\beta^2\mu^2}{8d} - m\phi \tag{5.49}$$

$$\begin{cases} 0 < \phi < \dfrac{\beta^2\mu^2}{8\mathrm{dm}}, & \dfrac{\partial R}{\partial \eta_m} > 0, \dfrac{\partial R}{\partial \gamma_m} > 0 \\ \dfrac{\beta^2\mu^2}{8\mathrm{dm}} < \phi < 1, & \dfrac{\partial R}{\partial \eta_m} < 0, \dfrac{\partial R}{\partial \gamma_m} < 0 \end{cases} \tag{5.50}$$

When retailer misreports,

$$\frac{\partial^2 f^*_{rrz}}{\partial R^2} = \frac{\beta^2\mu^2}{8d} - m\phi \tag{5.51}$$

$$\begin{cases} 0 < \phi < \dfrac{\beta^2\mu^2}{8\mathrm{dm}}, & \dfrac{\partial^2 f^*_{rrz}}{\partial R^2} > 0, & \begin{cases} k > d\left(c_m + c_r + a_m p_m + a_r p_r(2 - \gamma_r\eta_r)\right), & R < 0 \\ 0 < k < d\left(c_m + c_r + a_m p_m + a_r p_r(2 - \gamma_r\eta_r)\right), & R > 0 \end{cases} \\ \dfrac{\beta^2\mu^2}{8\mathrm{dm}} < \phi < 1, & \dfrac{\partial^2 f^*_{rrz}}{\partial R^2} < 0, & \begin{cases} k > d\left(c_m + c_r + a_m p_m + a_r p_r(2 - \gamma_r\eta_r)\right), & R > 0 \\ 0 < k < d\left(c_m + c_r + a_m p_m + a_r p_r(2 - \gamma_r\eta_r)\right), & R < 0 \end{cases} \end{cases} \tag{5.52}$$

When $\gamma_r\eta_r = 1$, it is consistent with the situation where no misreport is made; when $0 < \gamma_r\eta_r < 1$, The critical value of potential market size becomes larger; when $\gamma_r\eta_r > 1$, The critical size of the potential market becomes smaller.

$$\begin{cases} 0 < \phi < \dfrac{\beta^2\mu^2}{8\mathrm{dm}}, & \dfrac{\partial R}{\partial \eta_r} > 0, \dfrac{\partial R}{\partial \gamma_r} > 0 \\ \dfrac{\beta^2\mu^2}{8\mathrm{dm}} < \phi < 1, & \dfrac{\partial R}{\partial \eta_r} < 0, \dfrac{\partial R}{\partial \gamma_r} < 0 \end{cases} \tag{5.53}$$

When $\frac{\beta^2\mu^2}{8\mathrm{dm}} < \phi < 1$, underreporting carbon information will increase the scope of the positive correlation between manufacturers' R&D investment in emission reduction technologies and retailers' profits. When $0 < \phi < \frac{\beta^2\mu^2}{8\mathrm{dm}}$, underreporting of carbon information will increase the scope of the positive correlation between manufacturers' R&D investment in emission reduction technologies and retailers' profits.

Theorem 13 demonstrates that when the emission reduction cost-sharing coefficient is small and the potential market size is large enough, the manufacturer's investment in research and development of emission reduction technology stimulates consumers' purchasing behavior. Consequently, the retailer's benefit exceeds the portion that aids the manufacturer in cost-sharing. When the potential market size is limited, the manufacturer's early investment in emission reduction does not attract consumers to buy, and the retailer's cost increases, and the retailer's cost increase is greater than the sales revenue, so the profit decreases. In the later stage, after the manufacturer's investment in emission reduction technology research and development increased, the sales volume of low-carbon products increased, and the sales revenue was greater than the shared emission reduction cost, and the retailer's profit increased accordingly. When the cost sharing coefficient of emission reduction is large, underreporting carbon information will attract more low-carbon preference consumers to make purchases and balance the shared emission reduction costs by increasing sales revenue.

6. Conclusion and Research limitations

6.1 Research conclusion

This paper examines the influence of consumers' low-carbon preferences, manufacturers' emission reduction initiatives, and cost-sharing for emission reduction on the decisions made by manufacturers and retailers in the context of carbon information asymmetry. Research analysis found that in conditions where the potential market size is large enough, consumers' low-carbon preferences, manufacturers' emission reduction efforts, and cost-sharing for emission reduction have a positive impact on the decisions of supply chain participants, and members' deceptive behavior will not affect them.

When the potential market is limited, the specific impact results vary. In cases where emission reduction costs are not shared, the impact of consumers' low-carbon preferences on order quantity, wholesale price, and manufacturers' investment in emission reduction technology R&D is segmented: when low-carbon preferences are at the lower and higher extremes, they have a promoting relationship with optimal order quantity and wholesale price, but do not promote manufacturers' emissions reduction. With an increase in manufacturers' investment in emission reduction technology R&D, retailer profits initially decrease and then increase. Regardless of deception, manufacturer emission reduction investment is always positively correlated with order quantity and wholesale price, and the specific impact of manufacturers' emission reduction efforts on their own profits is related to the extent of consumers' low-carbon preferences. In cases where emission reduction costs are shared, the impact of manufacturers' emission reduction efforts on profits of both parties is related to the coefficient of cost-sharing for emission reduction. If the coefficient of cost-sharing for emission reduction is large, it will lead to a decrease in manufacturer profits followed by an increase. The coefficient of cost-sharing for emission reduction is small, an increase in manufacturers' investment in emission reduction technology R&D will lead to a decrease in retailer

profits followed by an increase. The impact of cost-sharing for emission reduction behavior is related to consumers' low-carbon preferences.

The effectiveness of cost-sharing for reducing emissions by retailers also depends on the size of the potential market. When the potential market size is large, cost -sharing for emission reduction will lead to an increase in the retailer's optimal order quantity, higher wholesale prices, and incentivize manufacturers to invest in emission reduction. This, in turn, will boost the retailer's profits. In a scenario where both parties refuse to lie and only the retailer deceives, the distribution of emission reduction costs will boost the manufacturer's profits.

Based on the above conclusion, this article can offer the following insights. First, information sharing and good cooperation among members can solve the problem of information asymmetry at the root, and at the same time, they can timely transmit consumer preferences and adjust production. Secondly, the cost sharing of emission reduction helps manufacturers to reduce emissions, and strengthens the cooperation between the two, which is conducive to the operation and development of the supply chain. Third, a large enough market size can weaken the negative impact of information asymmetry. Therefore, enterprises should pay more attention to the downstream of the supply chain and expand the market. Fourth, the government should assume the responsibility of market supervision, establish a punishment mechanism, and provide an open and transparent market environment for enterprises. Fifth, as a speculative behavior, misreporting has certain risks, and enterprises should timely consider the opportunity cost and corresponding risks of choosing misreporting.

6.2 Research limitations

This paper is based on carbon information asymmetry. It considers consumers' low-carbon preferences and manufacturers' emission reduction efforts as variables and establishes a simple two-level supply chain model consisting of a single manufacturer and a single retailer. Decision-making analysis is conducted under two scenarios: emission cost sharing and emission reduction cost sharing. Although this paper integrates and innovates existing research results to better reflect real-world activities, the actual situation and influencing factors are more complex and diverse. Therefore, this article also has certain flaws.

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Can Stakeholder Engagement and Green Innovation Enhance ESG and Financial Performance? Evidence from the International Financial Center

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Abstract

Based on the stakeholder theory and resource-based view, the aim of this study is to examine the potential relationships between environmental, social, and governance (ESG) performance and financial performance, with a focus on the mediating function of enterprises' stakeholder engagement, the mediating function of green innovation ability, and the serial multiple mediation effects of stakeholder engagement and green innovation. This research use the method of Bootstrap to test the serial multiple mediation effects. The the empirical results in this study show that ESG performance has positively significant effects on financial performance; Second, ESG performance has positively significant effects on stakeholder engagement; Stakeholder engagement has positively significant effects on green innovation; The serial multiple mediation effects of stakeholder engagement and green innovation are negatively mediating the relationship between ESG and financial performance, that may due to enterprise owns limited resources. The first contribution of this study is that find out that a positive correlation between stakeholder engagement and green innovation; Second, the research proved the exist of the serial multiple mediation effects between ESG, stakeholder engagement, green innovation and financial performance.

Keywords:

Environmental, Social, and Governance (ESG), Financial Performance (FP), Stakeholder Engagement (SE), Green Innovation (GI).

1 Introduction

The Environmental, Social, and Governance (ESG) framework provides holistic disclosure information of enterprises' externally and internally sustainable practices, through quantifying the environmental and social impacts [1]; ESG reflects the actions that businesses take to improve social welfare or corporate governance [2]. In the past decade, managers, investors or other stakeholders seek for the ESG information. As a non-financial framework, ESG is combining with the traditional financial system, committed to guide and supervise enterprises from a single profit-oriented development transfer to a comprehensive and sustainable development mode. Coordinating with this trend, many international organizations, including the MSCI, the Sustainability Accounting Standards Board (SASB), the Global Reporting Initiative (GRI), and the Social Stock Exchange (SSE) are devoting to provide the practical ESG information for public.

ESG performance is currently as one of the important factors to effect a firm's financial performance (FP). The relationship between ESG and financial performance are endless. A causal effect of ESG attributes on firm value could plausibly be either positive or negative [2]. For example, some scholars [3][4][5][6] supported that greater ESG/CSR performance can enable enterprises to obtain better financial performance. Friede et al. [7] claimed that roughly 90% of studies find a non-negative ESG-FP relation. However, Based on different measurements of financial performance, such as ROA [8], short-run returns [9], Tobin's q [10], long-run returns [11], the empirical results by these researchers proved an opposite results, which is the ESG performance had significantly negative effect, or no any effects on financial performance.

The discussions about ESG and financial performance did not have a final consensus yet, and the previous studies mentioned above did not consider the exist of mediating effects. However, a simplistic and binary analysis frameworks or research models have been insufficient to explain the complex relationship between ESG performance and financial performance [12][13]. because ESG regulations, policies and ESG rating requires implement into many practical productive outcomes or management mediums, so as to transfer as financial performance. ESG practices are high potential to make effects on financial performance through indirect routes, instead of appearing as direct and immediately ways. Hence, some possible variables acting as mediators of transformation between ESG performance and financial performance are ought to be further discovered and confirmed.

In order to investigate the possible transferring intermediaries between ESG and financial performance, this study is from firm's external and internal sides [14] to list the factors that influence financial performance, and based on these factors, trying to explain how ESG practices can make these factors improvement. In this process, possible mediating mechanism can be extracted.

Internally, efficient and flexible internal management strategies, democratic and fair human resource management programs, and advanced and unique innovation capabilities are the key factors that ensure the operation of the enterprise, supporting the front-end departments of the enterprise in market expansion and development [13]. Externally, from marketing aspect, a good reputation, an eco-friendly and humanize brand image are vital for long-term development of financial performance, customers tend to choose a firm with good public relations image [15]. From investing aspect, long-term style

investors prefer to finance those enterprises who have sustainable strategies, to protect their investment decision benefits [14]. Trust building between firms and investors can help firm obtain more funding, with less financing cost.

Based on the requirement of ESG, the enterprises with high ESG performance may offset the uncertainty and volatility in the market, because these firms taken more social responsibilities, complied with laws and regulations, paid more non-financial costs, and protect the rights and interests of a wider range of stakeholders [13]. Companies could enhance corporate image and reputation, avoiding to public in media as a negative role [14]. Hence, enterprises should recognize new requirements, implement strategies to optimize each aspect among environmental, social and governance [16].

From the environmental perspective, one of the most proactive approaches to generated the rewards of environmental growth is through green innovation [17]. Green innovation and ESG rating are positively correlated, with ESG rating primarily encouraging business innovation through lowering agency costs and loosening funding restrictions [18]. When green innovation levels improve, a company's reputation is positively impacted by its ESG total performance and environmental performance [19]. High reputation tends to attract more investors and consumers, that may contribute to higher financial performance. Green innovation participated in the transfer process from ESG performance or independent environmental performance to financial earning.

However, reviewing the existing research, as pioneer of ESG in the Asia-Pacific region, there was no research by using green innovation as a mediating variable to explore the impact of ESG on financial performance in the Hong Kong Stock Exchange. Hence, the first question is promoted as follow: would it possible for green innovation as the variable to mediate the relationship between ESG and financial performance, based on HKEX?

For the perspective of "social", the MSCI claimed that Social involves many stakeholders, including but not limited to employees, suppliers, dealers and contractors, customers and consumers, local communities, governments, the media, the public, and industry associations. Hence, aiming for help different stakeholders, Social contains many subtopics, for example, labor management, product safety and quality, community relations, health care, employee benefits and mental health, health and population risk insurance et al. Specifically, investors and businesses must take into account how their actions will affect these stakeholders and solve of these relevant sub-social topics. The development of Social part is coordinated with stakeholder theory, firms chase profit and earning, with consideration of stakeholders' rights and benefits.

A wide range of stakeholders as an important factor in "social" part, they are the beneficiaries and supervisors for these "Social" topics at the same time. Questions are proposed: what are the functions of stakeholders in the ESG process? According to stakeholder theory and stakeholder instrumental theory, stakeholders can make effects on financial performance, and stakeholder engagement is an essential procedure during firm's daily operation. Hence, a question is proposed: Can stakeholders through engaging behaviors to mediate the relationship between ESG performance and financial performance?

Considering from the internal and external sides that can affects on financial performance, and combined with the two aspects of Environmental and Social in ESG framework, this study attempted to use green innovation and stakeholder engagement, respectively, as mediating variables, to further investigate the conduction mechanism between ESG to financial performance. Further, this study proposed that there is a mediating role, which aims to test: whether the stakeholder engagement and GI can mediating together between ESG and financial performance, instead of function independently?

Thus, the following three research questions are proposed:
(1) To examine the mediating role of stakeholder engagement (SE) between ESG performance and financial performance (FP).
(2) To examine the mediating role of green innovation (GI) between ESG performance and financial performance (FP).
(3) To examine the serial multiple mediating role of stakeholder engagement (SE) and green innovation (GI) between ESG performance and financial performance (FP).

The contribution of this paper is firstly to propose a new relational framework between ESG and financial performance, introducing stakeholder engagement (refer to the social aspect) and green innovation (refer to the environmental aspect) as two mediating variables, respectively. Further, the two factors are examined together as serial mediating factors in ESG and financial performance, which may more comprehensively reflect the operation mechanism of ESG transfer to financial performance.

The structure of this paper is organized as follows: Section 2 presents the hypotheses and relevant theories and literature. Section 3 shows research design, including the research framework, data and variables. Section 4 is methodology; Section 5 is empirical results; Section 6 is the conclusion for this paper.

2 Literature Review and Hypotheses Development

2.1 ESG and financial performance

The discussions about the relationship between ESG performance and financial performance mainly can be divided into two mainstreams. Some studies show that the ESG performance positively effects on financial performance [3][4][5][6] while other studies indicate that ESG may cause negative impacts on financial performance [8][9][10][11].

From environmental aspect, firms implemented social responsibility by conducting eco-friendly activities, improving green technologies to reduce pollution and energy waste. These strategies can help to build up good reputation [20] and brand image [15] in public, which can release the funding constrains, attract customers with environmental awareness. These outcomes can further contribute to

higher financial performance, especially in long-term period. From social aspect, the key elements contained health and safety, health and education, labour standards, community relations, human rights, and diversity policies [21]. Good S performance is relied on tight connection between enterprises and its stakeholders. Firms protected and improved stakeholders' rights, for example, increasing employee benefits, compiling with government regulations, conducting community charitable activities, and actively communicating with the media. These practices can create better situation for firms' development, including team member with high cohesion, society with good impression, government trust [14]. These outcomes can indirectly contribute to high efficient operation, and improve the financial performance. From governance aspect, optimize operation governance schedule can effectively increase working efficiency, eliminate waste some unnecessary materials cost. This can directly lower the cost and improve firm's profit. Further, it can transfer good signal to external investors, increasing stakeholders' confidences, lowering the financing cost and finally increasing financial performance.

From three elements of ESG, the possible routes that the ESG can transfer to financial outcomes is practical and clear for firm to integrate in operating process. Based on that, the first hypothesis is proposed as follow:

H1: ESG performance have a positive effect on firm financial performance.

2.2 ESG and financial performance: meditating by stakeholder engagement

Stakeholder theory aims to shift management discourse from focusing on shareholder needs to focusing on strategically and ethically important relationships with various stakeholders [22]. Stakeholder theory links management research with normative analysis, researchers can better address management problems by using the relationships between a business and its stakeholders as the unit of research. Based on stakeholder theory, instrumental stakeholder theory (IST) emerged as a sub-category to convert profit-driven managers to stakeholder thinking [23]. Instrumental stakeholder theory supports high-trust, cooperative, and information-sharing relationships with stakeholders, which positively impact a firm's performance [24]. Ethical treatment of stakeholders can improve a company's bottom line and reduce costs related to unfavorable actions. Instrumental stakeholder theory suggests that stakeholder engagement can be a strategy for achieving objectives and can lower costs related to unfavorable actions [25]. Therefore, Instrumental stakeholder theory is significant for research on stakeholder quality and its effects on firm performance.

Firms adopted more ESG practices to follow value-adding initiatives, especially in periods of high uncertainty and to minimize corporate risk-taking, Vural [26] though these business behaviors implied higher extent of stakeholder engagement. Afsharipour [27] believed that the growth of ESG would affect the engagement of boards of directors and shareholders in mergers and acquisitions, which in turn affected the transaction process and had impacts on the total economic value generated by business mergers. Barko et al. [28] state that "Activist type" stakeholders' engagement can induce ESG rating adjustments. These studies can prove that ESG performance is related to stakeholder engagement.

High financial performance is reliably associated with stakeholder engagement, five configurations of national institutions, corporate qualities [29]. Scholtens & Zhou [30] discovered that there is a complex

relationship between shareholder performance and many components of stakeholder interactions, during the engaging process in the community, so examining the factors and mechanism about how stakeholder interactions benefit financial performance is valuable. Ayuso et al. [31] shows that there is evidence proving a company's financial performance is positively related to stakeholder engagement and board diversity.

Combined the two direct relationships between ESG - financial performance and stakeholder engagement - financial performance, Ansong [32] proposed that stakeholder engagement can be a mediation to affect the relationship between CSR performance and financial performance. Considering that CSR can be the precursor to ESG appearing and development, this study proposes hypothesis 2 and 3 as follow:

H2: ESG performance has a positive effect on stakeholder engagement
H3: Stakeholder engagement mediates the relationship between ESG and financial performance.

2.3 ESG and financial performance: meditating by green innovation

The fundamental issue facing economics is how to distribute resources wisely and address the fact of resource scarcity. Based on available resources, businesses must decide what things to produce, how much to make, and for whom to manufacture them. Based on the basic economy problem and the resource-based theory, if firms' resources are valuable, rare, inimitable, non-sustainable, and organized (VRIN-O), it is possible for firms build up sustained competitive advantage [33][34][35]. Green innovation is generally considered to be an innovation model consisting of improved products, processes or management with the goal of achieving environmental sustainability. Based on resource-based view, strong innovation capabilities are valuable intangible assets that can bring added value to enterprises, which can become practical tools to create competitive advantages for enterprises [36][37][38].

As concern the interaction relationship between the ESG performance and corporate green innovation, ESG ratings mainly promoted corporate innovation by reducing costs and easing financing constraints. Mukhtar et al. [39] explored the relationship between ESG practices and green innovation orientation, the results showed that ESG practices can significantly improve green innovation. Similar, the results of a research by Chen & Shen [18] shown that there was a significant positive correlation between ESG ratings agency and corporate innovation.

Aguilera & Ortiz [40] found that green innovative enterprises did not obtain better financially when compared to non-green innovative firms. However, when only focusing on green innovative businesses, results shown there was a positive correlation between the level of green innovation and business profitability. Based on the US and European oil and gas companies, Aastvedt et al. [41] found that firms' innovation score has a positive effect on financial performance of the US and European companies, although the path of GI's impact differs between the two countries.

Another new research, conducted by Khan & Liu [19], investigated the effects of ESG on the financial and non-financial outcomes, based on the manufacturing enterprises registered in China between 2009 and 2019, examined moderator in the research was green innovation. The findings demonstrated that

corporate financial performance is negatively impacted by ESG performance and enterprises' environmental actions; However, this effect is positively moderated by green innovation. Chouaibi et al. [17] claimed that better ESG performance increased firm value, while weaknesses ESG rating decreased firm value. Furthermore, the authors find that green innovation fully mediates the relationship between ESG practices and financial performance in the UK and Germany. So, hypothesis 4 and 5 is proposed:

H4: ESG performance has a positive effect on green innovation.
H5: Green innovation mediates the relationship between ESG and financial performance.

2.4 ESG and financial performance: serially meditating by stakeholder engagement and green innovation

Researchers were encouraged by Freeman et al. [42] to integrate the resource-based view and stakeholder theory into their work [35]. The proponents of the business ecosystem argue that resource-based view must be strengthened in the process of inter-organizational cooperation [43], enterprises and stakeholders should understand how the ecological and business ecosystems can stay in a balance point.

Daft [44] characterized a firm's resources in terms of achieving greater efficacy and efficiency. Resources are any "assets, capabilities, organizational processes, firm attributes, information, knowledge" that support the aspirational objective of the firm's efficacy and efficiency. Based on the resource-based view, human capitals and knowledge capabilities belong to intangible assets, as precious resources to improve enterprises earning. The hypothesis 4 focus on both of two factors, stakeholder engagement (from human capitals aspect) and GI (from knowledge capabilities aspect), to research the ESG practice from a resource-based view.

Gutierrez et al. [45] thought that companies were benefited from numerous strategic stakeholder engagement, that is a basis for them to achieve innovate and accomplish the Sustainable Development Goals (SDGs). Jones et al. [24] attempted to investigate the reasons for stakeholders to engage in innovation, and the results of his study identified eight antecedents of stakeholder engagement in innovation in a B2B environment. The outcomes for the study can prove that the stakeholders have various motivations to involve in firm's innovation process. Goodman [46] conducted semi-structured interviews and category eight roles stakeholders play in the sustainability-oriented innovation process, he found that compared with traditional stakeholder categories, new emerging stakeholders play a more significant role in promoting the innovation capabilities and behaviors of enterprises. Indeed, different types of stakeholder engagement have different levels of impacts on corporate innovation abilities [47][48][49]. These studies imply there is a correlation existing between SE and GI, and the level of correlation may be affected by the stakeholder category.

For the relationship between ESG performance, stakeholder engagement and green innovation performance, Ghassim & Bogers [38] implied that external engagement initiatives have no immediate bearing on financial performance, but if a company turned the knowledge gained from external stakeholders into creative outputs, it would start to reap the financial rewards. Besides, Weng et al. [36] discovered that green innovation were significantly impacted by pressure from stakeholders, including

competitors, employees, and the government. The association between green product innovation and employees was moderated by innovation orientation.

Consider current discussion and results from previous studies [26][27][32][36][38][40][41][47][48][49], this study proposes hypotheses about a serial multiple relationship between ESG performance, stakeholder engagement, green innovation and financial performance:

H6: Stakeholder engagement has a positive effect on green innovation

H7: There is a serial multiple mediation effect of ESG performance on financial performance through stakeholder engagement and green innovation.

2.5 Research Framework

Figure 1 is the framework to show the research proposed model for this study. Four hypotheses are included in this framework. The main target of this research is to test the fourth path is significant or not. Based on the results, we can know whether stakeholder engagement and green innovation can make multiple mediating effects on the relationship between ESG performance and financial performance.

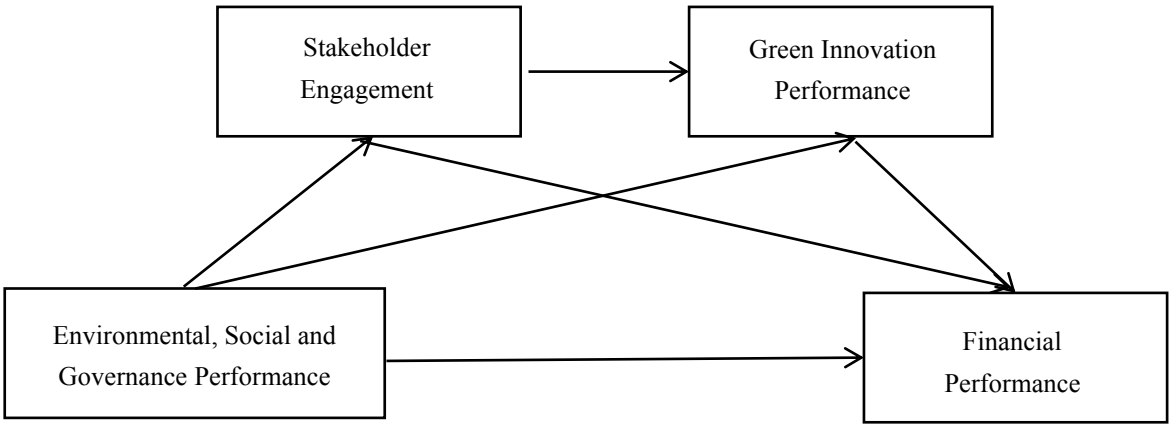

Fig. 1. The research proposed model.

3 Research Design

3.1 Data

Data from 2018-2022 are selected for this study, because the Task Force on Climate-related Financial Disclosures (TCFD) released the TCFD Recommendations Report in 2017, which clearly established industry standards for climate-related risk disclosure.

First, we search for the ESG rating. For the Hong Kong stock market, Bloomberg[1] is based on original

[1] Bloomberg is a global provider of business, financial information and news.

industrial proportion in market, to choose a part of represented companies from each industry, evaluating and giving ESG score for each company. In 2018, total 427 Hong Kong listed firms had ESG Disclosure Score in Bloomberg after deleting companies with missing value, 350 firms are finally selected.

Second, the financial performance data is obtained from WIND[2]. The 350 selected firms are used to match the financial index in WIND database.

The stakeholder engagement score data is based on firm' s yearly ESG reports and manually calculated by the coding scheme, which is designed and combined the standards established by Venturelli et al. [50] and Bellucci et al. [51] .

The GI data is provided by INCOPAT database, and this study follow Li et al. [52] and Standards [53][54][55][56] published by National Bureau of Statistics of China to screen the green innovation patent.

Considering the influence of such a time bias, caused by the delay between stakeholder engagement activities actual happen time and issuance in reports, this study chooses 2018-2021 year stakeholder engagement data, and made one year-lag on data of ESG performance, financial performance and green innovation patent, which covering 2019-2022 year.

After matching all datasets, the number of final observations is 1400 in total.

3.2 Variables

Financial performance

This study uses Tobin Q to measure the financial performance. Tobin's Q incorporates market opinion about the firm's future cash flow and risk, i.e., forward-looking market valuation. High Tobin's Q is related to good management because it implies that a firm's managers can create greater market value from the same underlying assets [58]. Hence, this study measured firm performance by Tobin Q, in line with other research [57][58].

ESG performance

Follow Shaikh [59] and Bermejo et al. [60], this study uses ESG scores published by Bloomberg to measure firm's ESG performance. The ESG scores are including a total score, E score, S score and G score.

Bloomberg measured the ESG Scores mainly from 4 aspects: "ESG Integration, Engagement & Voting, Regulatory Obligations & Reporting, Fund Selection" [1, p.4]. For ESG Integration part, screening for performance on material ESG issues; in-depth research and in-house scores creation; portfolio and index construction are considered. Company engagement on ESG performance and disclosure, shareholder proposals, resolutions and voting decisions problems are concerned in Engagement & Voting part. Sustainable investment and sustainability preferences are assessing in third part. The last part measures the comparison of fund ESG performance.

Stakeholder engagement

This study uses content analysis to establish a coding scheme for stakeholder engagement. The study uses HKEX listed companies' ESG reports and annual reports as research sample between 2018 and

[2] WIND is one of the major data providers in China, which serves 90% of China's financial institutions.

2022. The coding schedule is divided into three sub steps: evaluating dimension setting, level and specific score setting, and framework outcome.

Coding scheme 1 is to measure and evaluate the quality of stakeholder engagement, across the various qualitative and quantitative dimensions, 15 variables are designed as follow.

Coding Scheme 1: shown in Appendix 1

Coding scheme 2 is made for explaining the stakeholder types. On the basis of coding scheme 1, the analysis further subdivided stakeholders into the following 15 categories. These 15 types of designs take into account stakeholder engagement standards and existing research frameworks [51][61][62].

Coding Scheme 2: shown in Appendix 2

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Coding scheme 3 is made for explaining the channel types. Similarity, on the basis of coding scheme 1, the variable "Channel No." can be subdivided as 8 main types, which include Standard Procedures, Focus Groups, Interviews, Surveys, Meetings, Internet Communication, Other Web App and Others. The coding establishment mainly refers to a study about stakeholder engagement by Bellucci et al. [51], the final version is showed in as Appendix 3

Coding Scheme 3: shown in Appendix 3

After finishing the primary data code, this study is refered to Venturelli et al. [50] and use following module to calculate a total stakeholder engagement score, showing as variable "SE-Score". To calculate the total "SE score" for each company, each score for a measuring item was related to the highest value attributed [max var (i)] and multiplied by 100. The average of these qualitative scores determined the stakeholder engagement total score for each company:

$$SE\ score = \frac{\sum_{i=1}^{10}\left(\frac{var(i)}{max\ var(i)} * 100\right)}{10}, \textit{ where i ranged from 1 to 10.}$$

For "SE score", the study tests the score which contain 10 variables.

Green innovation

This study adopted the number of green innovation patents as the proxy to measure extent of green innovation [63][64][65][66][67]. According to the methods from Cormier & Magnan [68] and Li et al. [52], a patent is primarily treated as 'green patent' if it contains any one of the selected keywords (keywords explained in coding scheme 4). Further, this study added "the classification standard of strategic emerging industries[53]", "Statistical Classification of Intellectual Property (Patent) Intensive Industries [54]", "Statistical Classification of Energy Saving, Environmental Protection and Cleaning Industry [55]" as screening standards to precisely select the patents for green innovation.

Coding Scheme 4: shown in Appendix

4 Methodology

For test the serial multiple mediators' effects of stakeholder engagement and green innovation on the relationship between ESG performance and financial performance, this study uses the method of Bootstrap. Compared with other two test methods, Taylor [69] and Hayes [70] recommended that Bootstrap is the better way to implement in the serial multiple mediators test.

Table 1 shows the descriptive statistics for data, where a total of 1373 valid observations were obtaind after eliminating missing values and outliers. The mean of the explanatory variable ESG is 52.310, the standard deviation is 6.473, the minimum score is 30.510, and the maximum is 74.137. The mean of the explained variable "Tobin q" is 1.278, the standard deviation is 3.032, the minimum is 0.009, and the maximum is 30.744. The mean of the first mediating variable "stakeholder engagement score" is 44.186, the standard deviation is 16.792, the minimum is 0, and the maximum is 86.111. The mean of the patents number for green innovation is 9.57, the standard deviation is 88.071, the minimum is 0, and the maximum is 1791.

Table 1

Descriptive statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
ESG	1,400	52.310	6.473	30.510	74.137
FP ("Tobin q")	1,384	1.278	3.032	0.009	30.744
SE	1,384	44.186	16.792	0.000	86.111
GI	1,400	9.57	88.071	0.000	1791
Valid number (match each variable): 1373					

Table 2 is the correlation coefficient matrix between the 4 variables. ESG has a positive correlation with financial performance (0.079, $p<0.05$), it also has a positive correlation with stakeholder engagement (0.099, $p<0.05$). Stakeholder engagement has a positive correlation with GI (0.079, $p<0.05$).

Table 2

Correlation matrix

	ESG	FP	SE	GI
ESG	1			
FP	0.079**	1		
SE	0.099**	0.023	1	
GI	0.030	-0.030	0.079**	1
*Note: ***p<0.01, **p<0.05, *p<0.1*				

5 Empirical Results

In order to avoid the "pseudo-regression" caused by the multi-collinearity problem between the variables, this paper calculated the VIF statistical value of each variable before regression, as shown in Table 3. It can be seen that the mean of VIF value is 1.01, which is less than 10. It indicates that there is no serious collinearity problem in this model.

Table 3

VIF

	VIF	1/VIF
ESG	1.01	0.987
SE	1.02	0.980
GI	1.01	0.990
Mean	1.01	

Table 4 shown all the regression results for hypotheses in this research. Based on Table 4, Table 5 shown the details about the significant direct effect results. First, the result shown that the ESG has a positive effect on financial performance (0.0369, $p<0.01$), so the hypothesis 1 is supported; Second, the result shown that the ESG has a positive effect on stakeholder engagement (0.2640, $p<0.01$), so the hypothesis 2 is supported; Third, the relationship between stakeholder engagement and green innovation is proved, firm's stakeholder engagement is positive to green innovation (0.1442, $p<0.01$).

Table 4

Reg.		Fit Index			coeff.	
Y	X	R	R^2	F	β	T
SE	ESG	0.1027	0.0106	14.6260	0.2640	3.8244***
GI	ESG	0.0828	0.0069	4.7286	0.3036	0.8194
	SE				0.4129	2.8642***
FP	ESG	0.0878	0.0077	3.5491	0.0369	2.9531***
	SE				0.0032	0.6517
	GI				-0.0012	-1.2723

Table 5

Direct Effect of ESG on FP (H1)					
Effect	se	t	p	LLCI	ULCI
0.0369***	0.0127	2.9078	0.0037	0.0120	0.0618
Direct Effect of ESG on SE (H2)					
Effect	se	t	p	LLCI	ULCI
0.2640***	0.0690	3.8244	0.0001	0.1286	0.3994
Direct Effect of SE on GI (H6)					
Effect	se	t	p	LLCI	ULCI
0.4129***	0.1442	2.8642	0.0042	0.1301	0.6957

Follow the Liu and Gal [71]'s implementation process, this study use the PROCESS in SPSS to do the mediating test. The empirical results are shown in Table 6 and 7. This study contains two serial mediators, which are stakeholder engagement and green innovation, so there are 3 mediating paths: path 1 is ESG-SE-FP (H3); path 2 is ESG-GI-FP (H5); path 3 is ESG-SE-GI-FP (H7). The key target of this study is to test the path 3 (H7) is significant or not.

Table 6 and 7 shown the mediating effect results of this research. In details, 1373 samples were selected, and a 95% confidence interval was set. For the direct effect, the result shows that ESG performance has positively impact on financial performance (0.0369, $p<0.0037$). For the indirect effects, the results indicated that the serial mediators path 3: ESG-SE-GI-FP is significant (-0.0003, -0.0001), and the stakeholder engagement and green innovation significantly weaken the ESG's effects on financial performance, although the effect is slightly; the path 1: ESG-SE-FP is not significant (-0.0038, 0.0080) and the path 2: ESG-GI-FP is not significant (-0.0016, 0.0002).

Table 6

Results 1 of Bootstrap test

Serial Multiple Mediators' Effects of SE and GI between ESG and FP (H7)						
Model= 6; Y = FP; X = ESG; M1 = SE; M2 = GI						
SampleSize: 1373						
Total effect of ESG on FP						
Effect	se	t	p	LLCI	ULCI	c_cs
0.0372	0.0126	2.9531	0.0032	0.0125	0.0620	0.0795
Direct effect of ESG on FP						
Effect	se	t	p	LLCI	ULCI	c'_cs
0.0369	0.0127	2.9078	0.0037	0.0120	0.0618	0.0127

Table 7

Results 2 of Bootstrap test

Indirect effect key				
Ind1 ESG -> SE -> FP Ind2 ESG -> GI -> FP Ind3 ESG -> SE -> GI -> FP				
Indirect effect(s) of X on Y				
	Effect	BootSE	BootLLCI	BootULCI
TOTAL	.0004	.0013	-.0022	.0032
Ind1	.0009	.0014	-.0017	.0037
Ind2	-.0004	.0002	-.0008	.0001
Ind3	-.0001	.0001	-.0003	-.0001
(C1)	.0012	.0014	-.0015	.0041
(C2)	.0010	.0014	-.0016	.0039
(C3)	-.0002	.0002	-.0006	.0003

6 Conclusion

Based on the Hong Kong stock market, this study examines the impacts of ESG performance on enterprises' financial performance with the mediating mechanism of stakeholder engagement and green innovation. The empirical results show four main findings. First, ESG performance has positively impacts on financial performance; Second, ESG has a positive effect on stakeholder engagement; Third, stakeholder engagement is positive to green innovation; Last, however, the serial multiple mediating effects of stakeholder engagement and green innovation significantly reduced the effects of ESG on financial performance.

These direct results may imply that, ESG can effectively enhance stakeholder engagement, which help the Social part in ESG can better practice in operation processes, and help mitigate the information asymmetric between firms and stakeholders. This is coordinated with stakeholder theory, and good for protecting various stakeholder rights. Further, there is a positive relation of stakeholder engagement to green innovation, it proved that each single part of ESG has interacting effects to another, so the three parts of ESG should be developed at the same time.

As for the mediating test, the results may shown that, at current stage, the costs and expenditures that firms pay on enhancing activities of stakeholder engagement and improving green innovation are actually over the obtaining from good ESG reputation and brand image. That situation may due to ESG practices are long-term feedback behaviors, it may cause a lost for enterprises in a short-term. Besides, stakeholder engagement and green innovation may interact each other, the former improves ESG from social aspect, the latter mainly effects on the environmental aspect. During the developing process, a competing relationship may exist between the two aspects, because the resources that a company owns are limited.

Hence, how to balance the costs and earnings on building good stakeholder engagement and green innovation is a tough problem for a company to solve, firms need to establish practical strategies to find a balance points.

For the limitations of this study, first, the sample size for this study can be expanded in the future. Second, these is a room to modify the measuring methods for green innovation and retest the mediating function of green innovation. More policies and implementation standards can be introduced in the measurement of green innovation, like ISO 14001. Relevant costs for green innovation, such as R&D expenses should be considered as a measuring standard. Based on the modified on the measurement standards for green innovation, further effects of stakeholder engagement and green innovation serial multiple mediation was required to re-examine in the future.

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Appendix

Appendix 1: Coding Scheme 1

Part 1:Basic information		
Variables	Definition	
Stk_code	Stock code (5 digits)	
Stk_name	Company name	
Year	Fiscal year	
Part 2: Basic categories		
Variables	Definition	
Industry	Industry code based on HSICs (2 digits)	
Listed	If company is listed then 1, otherwise 0 (delisted or not yet listed)	
ESG_rpt	If company published ESG report then 1, otherwise 0 (no ESG report)	
Rpt_form	If company published separate ESG report then 1, otherwise 0 (combined annual report with ESG report)	
Part 3: Standards		
Variables	Definition	
GRI	If company followed GRI (any versions) in SE disclosures then 1, otherwise 0	
AA1000	If company followed AA1000 (any versions) in SE disclosures then 1, otherwise 0	
IIRC	If company followed IIRC (any versions) in SE disclosures then 1, otherwise 0	
Part 4: Characteristics		
Variables	Definition	Reference
SE_sep	Completeness: If company prepared separate SE section then 1; simple descriptions for SE then 0.5; no any description about SE then 0 (no SE section).	Bellucci et al 2019; Venturelli et al 2018
SE_indp	Independence: If company has independent consultant to perform stakeholder engagement then 1, otherwise 0	SEHK, 2015
MA_SE	Materiality: If stakeholders are considered in the materiality assessment then 1, simple descriptions then 0.5, otherwise 0	Accountabiity, 2015 ;
Stakeholder_no	Inclusiveness: Number of stakeholders identified and involved, use "." to represent missing value.	Accountabiity, 2015; Bellucci et al; 2019
Channel_no	Responsiveness: Number of channels of dialogue used (Annual report/ESG report is by default counted as 1 channel)	Accountabiity, 2015; Bellucci et al, 2019; Venturelli et al 2018

Appendix 2: Coding Scheme 2

Types of stakeholder	Terminologies searched	Reference
1 Shareholders	shareholders, stockholders, investors (including institutional investors)	GRI, 2013; Bellucci and Manetti, 2017; Perrini and Tencati, 2011; Bellucci et al., 2019
2 Employees	employees, staff, labor and their representatives, trade unions, potential candidate	
3 Customers	customers, clients, consumers, product responsibility, tenants,end user of product	
4 Suppliers	suppliers, contractors, subcontractors, services providers, user, service vendor, vendor	
5 Government	governments, authorities, regulators, foreign exchange, regulatory body, SASAC, the stock exchange	
6 NGOs	non-government organizations, non-profit organizations, civil society organizations, Environmental charitable organisation, community partner	
7 Local communities	communities, community members, traditional councils, community trusts	
8 Creditors	creditors, lenders, banks	Crane et al., 2019 GRI, 2013; Friedman & Miles, 2006
9 Competitors	competitors, rivalries, peers, industry	
10 Society	citizens, civil society, wider society, anti-corruption, general public	GRI, 2013
11 Media	newspaper, web, TV, and social media	Friedman & Miles, 2006
12 Environment	Materials, energy, water, biodiversity, emissions, effluents and waste, products and services, transport, supplier environment assessment, environmental grievance mechanisms	GRI, 2013
13 Financial analysts	analysts	
14 Professional bodies	external auditors, rating agencies, agent, industry association, academic institution, R&D institution,professional advisors,sustainability professionals,consultant,chambers of commerce, industry group,education institution,scholars	
15 Business partners	collaborating partners, strategy partner,joint-venture,partner,franchisees and licensees,partner institution	
16 Investee	investee, investee companies	Brundtland Commission, 1987

17 Board of directors	board of directors	
18 Others	the next generation, financial institutions, management, market,academia,grantees	

Appendix 3: Coding Scheme 3

Types of channels of dialogue	Terminologies searched	Main reference
1 Standard procedures	e.g. formal channels, presentation of interim and annual reports, compliance reports, announcements, circulars, ESG/CSR/Sustainability reports, press releases,correspondence,newsletter,customer hotline	Bellucci et al., 2019
2 Focus groups	e.g. focus groups and workshops forum, working groups, conference, seminars, symposiums, events, training, training classes, training program,staff activities,staff retreat,road show	
3 Interviews	e.g. interviews and other one-to-one procedures, interview calls,personal contacts,press interview	
4 Surveys	e.g. surveys and polls, snapshot survey, questionnaires,feedback,suggestion box	
5 Meetings	e.g. group meetings, site visits, official meetings, exchange meetings, virtual meeting, in-person meeting, AGM, discussions, briefings,negociation,regular apprasial	
6 Internet communication	e.g. social media and networks, website, intranet, email,Internet memoranda	
7 Other web app	e.g. other technological applications, mobile apps(Whatsapp,Wechat,Instagram),social media platforms,ongoing digital platform	
8 Others	policy consultant	

Appendix 4: Coding Scheme 4

Variables:	Definition:	References:
GI (level-1)	With a literature review and consultation with experts, we regard a patent as 'green patent' if it contains one of the following keywords: 'clean', 'cycling', 'ecology', 'emission reduction', 'energy saving', 'environmental', 'environmental pollution', 'environmental protection', 'green', 'low carbon', 'saving', and 'sustainable'(Cormier and Magnan 2015; Li et al. 2018a). We adopt green patents for inventions to measure green innovation (noted as GI), and use the total of all the three categories of green patents (patent for invention, patent of appearance, and patent of utility model) for our robustness test (Li et al. 2018b).	Li et al. (2019); National Bureau of Statistics of China (NBS) (2018, 2019, 2021)
GI (level-2)	Intellectual property (patent)-intensive industries include those with high patent intensity, market competition, and innovation orientation. These industries include information and communication technology manufacturing, service, new equipment, pharmaceutical, medical, environmental protection, R&D, design, and technical service, with green innovation focusing on environmental protection industry patents.	
GI (level-3)	The strategic emerging industries classification system categorizes industries into nine, with green innovation being the fifth, sixth, seventh, and third categories. Patents in New Energy Automobile, New Energy, or Energy Saving categories are classified as green innovation patents.	
GI (level-4)	Under the classification standard of strategic emerging industries, the industry is divided into nine categories, and the fifth, sixth, seventh and third categories are obviously related to green innovation. Therefore, based on the outcome of first screen level, if a paten conforms to any one of the 5 New Energy Automobile category ; 6 New Energy category or 7 Energy Saving and Environmental Protection categorie, this patent will be classified as a green innovation patent.	
GI (level-5)	A patent is accepted as green innovation patent, if it meets keyword search requirements in level-1, at the same time, it belong to one of the multiple categories in level 2-4. Error terms are eliminated in level 2-4 screening processes.	

The Relationship Between Corporate Climate-related Disclosure and Financial Impacts: An Exploration of the Emerging Chinese Companies in a Global Financial Centre

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Abstract

Climate change has become an important issue worldwide. However, the climate change disclosure poses challenges for companies in Hong Kong. Therefore, this study examines the extent of climate disclosure in Hong Kong listed companies and explores the relationship between corporate climate-related disclosure and financial impacts. This study performs analysis in ESG reports and annual reports of Hong Kong listed companies (2017-2021). There are three initial findings. First, despite an increasing trend in the quality of companies' disclosures regarding the TCFD framework, there exists inconsistency in their reporting of various climate-related risks and opportunities. Second, only limited companies have actually disclosed the four core elements of TCFD compared to those that have mentioned them. Third, a majority of companies adopting to the TCFD framework disclose climate-related information partially rather than fully. The findings can draw the policymakers' attention to make more detailed and targeted climate disclosure recommendations in the Hong Kong context and help companies proactively identify and manage climate risks and opportunities, reducing information asymmetry.

Keyword: Climate-related Disclosure, Financial Impacts, Task Force on Climate-related Financial Disclosures, Hong Kong Listed Companies

1. Introduction

The climate change issue has become an important issue worldwide. Greenhouse gas (GHG) emission is one of drivers of climate change [1]. Companies, the largest emitters of greenhouse gases, are required to play an essential role in mitigating climate change [2]. Because natural disasters caused by climate change may disrupt companies' operations and damage profitability of companies [3]. The companies with business activities that are closer to end consumers have higher levels of climate action, as these companies may face pressure from consumers [4]. Companies that have employees who understand climate issues and companies that have assigned climate change responsibilities to managers or committees are more proactive in addressing climate change [4].

The Financial Stability Board (FSB) established an industry-led task force: the Task Force on Climate-related Financial Disclosures (TCFD) to provide a clearer picture of the risks in the context of climate change. The TCFD includes four core elements which are governance, strategy, risk management, and metrics and targets [5]. However, there are many challenges in relation to the TCFD implementation. These challenges include integrating climate risk into risk management, continued implementation of the TCFD framework, and predicting and reporting significant climate risks across different companies and industries [6].

However, in the Asia, climate-related disclosure is still a new topic. Preliminary studies on TCFD have emerged in Malaysia [7], Taiwan [8] , and India [9]. Hong Kong is one of Asia's financial centres. Although the Hong Kong Stock Exchange was the first in Asia to require listed companies to disclose their greenhouse gas emissions and other ESG indicators in 2015 [10] and the Hong Kong Exchanges and Clearing Limited (HKEX) incorporates some of the TCFD recommendations into the ESG Reporting Guide [11]. However, there are only limited studies focusing on climate-related disclosure in Hong Kong companies [10][12].

Financial impacts are a topic of concern for researchers [13][14]. It is related to investors' estimates of political and social risks [13], corporate reputation [14], and the quality of corporate governance [15]. However, the relationship between climate disclosure and financial impact is unclear [16][17]. For non-carbon-intensive industries, carbon disclosure can improve financial performance in the current period, but this relationship does not apply to carbon-intensive industries [18]. Increased level of climate-related disclosure contributes to mitigating cost of debt for high carbon emitters in the period after the Paris Agreement [19].

In addition, researchers are paying attention to the impact of board and senior management governance on sustainability practices [20][21][22]. Some research has divided sustainability practices into climate-related disclosures [23][24]. A study of Canadian listed companies claims that board effectiveness positively affects climate change disclosures, even if these disclosures are not mandatory [23]. Companies with high female participation on the board are more inclined to join a program to reduce GHG emissions, which increases the transparency of companies' climate change information [24]. The percentage of directors on the board who have industrial or financial knowledge decreases the level of disclosure of GHG information [25]. However, there is a lack of articles explaining the role that board and senior management governance play between climate-related disclosures and the financial impacts.

Therefore, this study intends to answer the following three research questions: First, what is the extent of climate disclosure quality among Hong Kong listed companies? Second, what are the financial impacts of climate-related disclosure? Third, what role does board and senior management governance play in the relationship between climate-related disclosure and financial impacts?

The research contributions of this study are in the following three points. First, this research examines the extent of climate disclosure quality of Hong Kong listed companies. Hong Kong is the gateway of China and western countries. This study provides evidence to compare the climate disclosure in Hong Kong and western countries. Second, this study enriches the research field of climate change. This study responds to the call of previous studies [26], providing evidence of the relationship between climate information disclosure and financial impacts. Third, this study complements research in the field of corporate governance by exploring the role that board of directors and senior management governance play in the relationship between climate-related disclosures and financial impacts. There is a number of previous studies affirming the importance of board and senior management governance in corporate governance [27]. Some studies focus on the effect of board and senior management governance on financial impacts [28][29][30] or environmental disclosure [31], but there is a lack of studies explaining the role that board and senior management governance play between climate-related disclosures and the financial impacts.

After the introduction, the second section is literature review. In this section, we review research on climate-related disclosures, research on climate-related Disclosure and financial Impacts, and research on board of

directors or senior managers. Then, the third part is methodology. We explain the chosen research sample and the process of content analysis performed in this section. The forth section is preliminary results. We show the results of the extent of climate-related disclosures of listed companies in Hong Kong in this section. The final part is the conclusion, summarising the main points, contributions and limitations of this study and providing suggestions for future research.

2. Literature Review

2.1 Research on Climate-related Disclosure

Research on climate-related disclosure mainly focus on the exploration of a single industry [32] or high-carbon industries [33][34], but there is a limited studies to examine climate change disclosure for all industries. High-carbon industries, such as the energy sector [9][34], the air transport sector [33] and chemical industry [33], were usually analyzed by previous researchers. Because these industries are considered to be closely linked to climate change and they might be subject to stricter rules on climate-related disclosure [33]. However, it is not only high-carbon industries that need to be concerned about climate change disclosures. For example, the financial industry is not carbon-intensive, but climate change has the potential to pose risks to the financial industry because they also provide financial support for environmentally sensitive industries [35].

To measure climate-related financial disclosures, the TCFD framework is gradually being used. However, the situation is not satisfactory, neither the academic discussion of the TCFD framework nor the status quo of corporate compliance with TCFD. This is mainly reflected in two aspects. First, although TCFD provides some principles to follow, the company TCFD evaluation systems are still at an early stage. Second, the completeness and balance of compliance with TCFD by companies are largely poor. Despite an increase in corporate disclosure of climate information in the air industry due to the release of the TCFD framework, corporate compliance with TCFD recommendations was unsatisfactory, especially in one of the four core dimensions of the strategic dimension [36]. Some studies use a three-point scale (0–2) for calculating the overall and the four subdivided TCFD scores [9]. They found that companies in the Indian energy sector are more likely to disclose information on the governance dimension, but the scores of matrices and targets are low [9]. Some studies indicate that only 27% of companies disclosed information about TCFD governance [37] . Even in the most communicated strategic area, only 62% of companies disclose relevant information.

Previous TCFD studies are largely based on western countries or developed countries. Researchers established the Climate Risks and Opportunities Reporting Index to assess 40 French companies' compliance with the TCFD from 2015 to 2018 [38]. 15 oil and gas companies in the US had some foundation to help them cover the TCFD content in the year before the TCFD framework was published [39]. In Australia, the Australian Accounting Standards Board supports the voluntary application of TCFD [40], but the Australian healthcare industry ignores the strategic aspect of the TCFD [41]. The IFRS Foundation has assumed responsibility for TCFD and issued two sustainability disclosure standards, IFRS Sustainability Disclosure Standard 1 (IFRS S1) and IFRS Sustainability Disclosure Standard 2 (IFRS S2), that fully embody the TCFD's recommendations and are slated for global implementation in 2024 [42].

Only a few studies focus on TCFD implementation in the Asian context. Climate disclosures of most Malaysian companies do not comply with TCFD recommendations [7]. It is observed that only 18% of top 100 companies in Malaysia adopt climate risk management into their business [7]. Companies in Taiwan hope to understand physical risk assessment information and the methods to assess transition risks [8]. There are literatures examine TCFD scores for 22 energy companies in India and how these scores relate to company performance [9].

By reviewing the previous literature, the following three main findings could be summarised. First, scholars mainly evaluate companies' climate-related disclosure based on a single sector [43] or carbon-intensive sectors [33], rather than all industries. Second, TCFD compliance of companies is inadequate [37]. Third, the TCFD provides a complete framework, but climate-related disclosures are still a new topic in the Asian context [9].

2.2 Research on Climate-related Disclosure and Financial Impacts

Agency theory is one of the most frequently used theories in the literature on the relationship between sustainability practices and financial impacts [26]. According to agency theory, due to the possible inconsistency

of interests between capital providers and company managers, company managers may tend to take their own interests into consideration rather than work diligently for capital providers [44]. This is believed to increase the investment risk for investors. Moreover, due to the information asymmetry between the capital providers and the management, it may be difficult and time-consuming for capital providers to supervise the work of managers [44]. To offset these risks and costs, capital providers may expect higher rates of return.

Some scholars note that corporate climate-related information disclosure may lead to unfavorable results for companies [45][46]. Evidence proves a negative relationship between corporate voluntary carbon disclosure and stock market responses, although frequent carbon communication mitigates this negative effect in the Korean context [45]. The reason would be carbon disclosure provides stakeholders with an understanding of the climate risks companies are facing and the potential costs or resources that companies may pay to address these risks. These additional costs may cause companies forego some opportunities to develop competitive advantages in their industries [45].

However, scholars have recognized the positive impact of climate change disclosure on corporate value and financial performance, including improving corporate return on equity [47], return on assets [48], market capitalization [9] and stock price [49]. This may be because climate change disclosure can mitigate uncertainty in corporate valuations [50].

Cost of equity represents the return percentage that a capital provider gets by investing in a company's stock and it could be measured according to diverse metrics [26]. Financial fraud increases cost of equity in the presence of higher external and internal monitoring [51]. Voluntary disclosure is considered to be a factor to reduce cost of equity [52]. This may be because voluntary disclosure reduces agency conflict, which stimulates information asymmetry [52].

There is a negative relationship between carbon disclosure and the cost of equity [16]. This negative relationship exists when companies choose to use social media for the wider dissemination of carbon information [53]. Companies that disclose more Twitter carbon information have a lower cost of equity, and companies with a concerning environmental status could benefit more from this negative relationship [54]. A possible explanation is that more transparent carbon disclosure would increase information transparency [55], which reduces investment risk. Increased transparency of climate information allows shareholders and other stakeholders to engage with companies in a more informed manner [56]. In regions with a high degree of marketization, the negative relationship between carbon disclosure and the cost of equity is more significant. Because in regions with a high degree of marketization, less government intervention improves the enthusiasm of companies for low-carbon development and the predictability of companies [57]. Evidence suggests the impact of the interaction between carbon performance and carbon disclosure on the cost of equity [58]. High-intensity carbon emissions will have a higher cost of equity, but the degree of carbon disclosure can reduce the premium that investors demand due to poor carbon performance [58].

A small number of scholars explore the impact of climate-related disclosure on corporate risk. Some studies measure the company total risk by the standard deviation of the company’s daily stock return and provide evidence of negative association between carbon disclosure and risk [59]. However, the causal relationship between climate-related disclosure and financial risk is likely to be the opposite [60]. In addition, some researches do not focus on the subdivision dimension of climate-related disclosure but explore the relationship between the broader concept of environmental disclosure and the risk of the company [61][62]. Although there was no significant relationship between environmental disclosures and systematic risk, these disclosures could have negative effects on total risk and idiosyncratic risk [61]. This may be because environmental disclosure increases the reputation of company, thereby reducing the company's reputational risk [61].

Therefore, this study puts forward two following hypothesis:

H1a Climate-related disclosure reduces cost of equity.

H1b Climate-related disclosure reduces corporate risk.

2.3 Research on Board of Directors or Senior Managers

The relationship between the different board and senior management structures and ESG have examined in the previous literature [20][63]. Companies with weak corporate governance are less likely to contribute to stakeholders [64]. Accordingly, scholars emphasize important roles of gender diversity [63], board size [65], board

independence [20], board culture diversity [21], and sustainability board committees [66] on company ESG practices. In addition, corporate governance researchers agree on the importance of past experiences of boards and managers, such as overseas experience [67], political background [22], and military experience [68]. But there is a lack of literature explaining whether and how the board of directors or managers with a financial background affects the relationship between climate-related financial disclosures and the cost of equity.

In existing research, the first view is that boards or managers with financial expertise have stronger traits to address climate change. First, financial capability is a valuable capability in companies. More capable managers are less likely to be constrained by the company's short-term performance [64]. Instead, they might focus on climate change issues related to long-term corporate commitments. Second, top managers with financial backgrounds will be more willing to establish and maintain strong internal control systems [69]. Views from corporate social responsibility reporting indicate that good internal control enables companies to issue more reliable CSR reports [70]. This positive impact might extend to climate-related financial disclosures.

Therefore, this study puts forward the following hypothesis:

H2: Governance on board of directors or senior managers reinforce the negative relationship between climate-related financial disclosure and financial impacts.

3. Methodology

3.1 Research Sample

The Hong Kong Stock Exchange was the first in Asia to require listed companies to disclose their greenhouse gas emissions and other ESG indicators in 2015 [10]. The Hong Kong Exchanges and Clearing Limited (HKEX) incorporates some of the TCFD recommendations into the ESG Reporting Guide [11]. In terms of research samples, this study will select the 2017-2021 ESG reports and ESG sections of annual reports of Hong Kong-listed companies. In total, there are 10,835 observations from 2,167 companies for the 5 years. The study includes all the 12 industries based on Hang Seng Industry Classification System (HSICS). There are three reasons. First, the whole industries data can provide a comprehensive picture of climate-related disclosures in Hong Kong. Second, the industry-wide data a broader benchmark for comparison, helping us to compare climate-related disclosures in Hong Kong and other regions. Third, the industry-wide data will be used to analyse industry heterogeneity in climate-related disclosures and financial impacts in Hong Kong in the future.

There are three reasons for choosing to list companies in the Hong Kong Stock Exchange. First, Hong Kong has long-term goals to address climate change. For example, Hong Kong has formulated the Climate Action Plan 2050, aiming to reduce carbon emissions to half of 2005 levels by 2035 and achieve carbon neutrality by 2050 [71]. Hong Kong listed companies might contribute to the climate goals, since companies are the largest greenhouse gas emitters [2]. Second, TCFD recommendations are included in the Hong Kong-listed company ESG guidelines, but there are only few studies focusing on climate disclosure in Hong Kong [10][12]. Third, Hong Kong, one of the Asian financial centers with a high degree of internationalization and marketization, is also a gateway between China and Western countries. When taking Hong Kong-listed companies as research samples, it could be compared with the research results of climate-related disclosure in other countries.

There are three reasons for choosing this time period from 2017 to 2021. First, the TCFD framework was proposed by Task Force on Climate-Related Financial Disclosures in 2017 [5]. Therefore, it would be not appropriate to use the data before 2017 to analyze whether Hong Kong-listed companies follow the TCFD framework. Second, TCFD recommendations have been included in the ESG guideline in Hong Kong since 2021. Therefore, it could help analyze the TCFD compliance of Hong Kong-listed companies before and after 2021 by using the data from 2017 to 2021. Third, in the literature of TCFD, previous studies use three or four years of data to test the climate disclosure quality. It would be more effective to reveal trends in climate disclosure by using six years of data [32][72][73].

There are three reasons why ESG reports and ESG sections in annual reports are chosen. First, ESG reports and annual reports are more complete and easily accessible than the companies' responses to the CDP Climate Change Questionnaire. Only a small number of companies' responses to the CDP Climate Change Questionnaire are publicly available [72], while ESG reports and annual reports could be downloaded from the company's website or from the Hong Kong Stock Exchange website. Second, climate disclosure from social media is often

used as research data by [54], while the annually published documents would be more structured, comprehensive, and reliable [73]. The possible reason would be ESG reports and annual reports are require to follow guidelines by policymakers. Third, it is consistent with studies on environmental disclosure [74]. Because annual reports and ESG reports are research materials in these studies [74].

3.2 Content Analysis

This study uses content analysis to measure the extent of climate-related disclosure in listed companies in Hong Kong. Content analysis is a method used by previous scholars when interpreting sustainability reports or ESG reports [75][76][77]. There are three reasons for using content analysis. First, the application of content analysis allows the author to gain an in-depth understanding of climate-related information disclosed in sustainability reports or ESG reports. Researchers need to read the documents repeatedly to improve their familiarity with the data [78]. Second, due to the diverse styles of sustainability reports, it is difficult to find a suitable dictionary of keywords that can be directly input into computer-aided text analysis software [77]. Reading by researchers and manual analysis allow researchers to gain a more informed understanding of sustainability reports than computer-aided text analysis. Third, this approach follows substance would be more important than counting disclosures [72].

We design a coding scheme and manually code the ESG reports of listed companies in Hong Kong and collect the data. Table 1 shows the coding scheme.

Table 1 Climate-related Disclosure Coding Scheme

Coding Items	Description
Climate Change	Read ESG reports and collect data manually. If mention the items, code 1; if not, code 0.
HKEX ESG Reporting Guide A.4 climate change	
TCFD	
Climate-related Transition Risks	Read ESG reports and collect data manually. If disclose fully, code 1; if disclose partially, code 0.5; if no disclosure, code 0.
Climate-related Physical Risks	
Climate-related Opportunities	
Governance	
Strategy	
Risk Management	
Metrics and Targets	

4. Preliminary Results

This section presents the preliminary results of content analysis. According to Figure 1, more and more listed companies mention Climate Change, HKEX ESG Reporting Guide A.4 Climate Change, and TCFD in their ESG reports. In 2019, 73 companies mentioned the HKEX ESG Reporting Guide A.4 Climate Change in their ESG reports, which is earlier than when HKEX first officially added A.4 Climate Change to the ESG Reporting Guide [79]. This is because in May 2019 HKEX published A consultation paper on the addition of A.4 Climate Change to the ESG Reporting Guide [80]. Some forward-thinking companies have chosen to add this section to their ESG reports in 2019. There are 6.67 times more companies mentioned TCFD in 2021 than in 2019 (from 73 to 487). These phenomena suggest that climate change is a concern for companies.

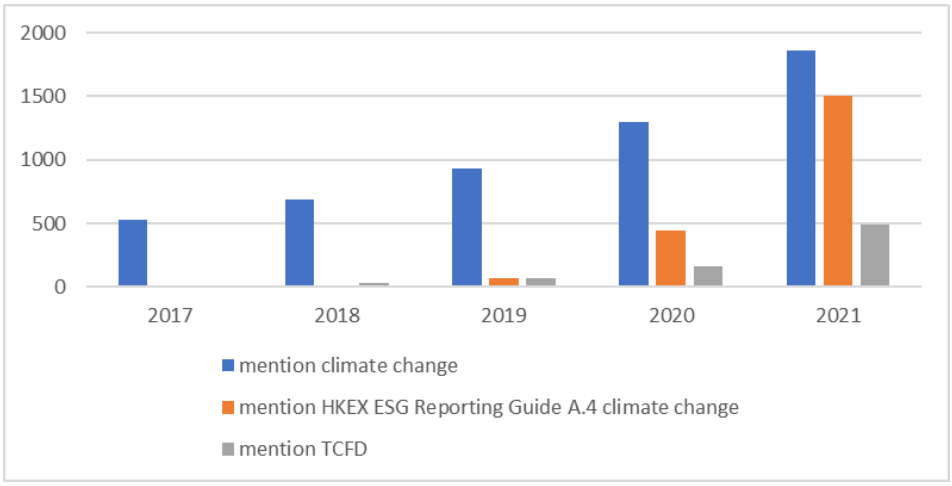

Figure 1 Total Number of Listed Companies in Hong Kong That Mention Climate Change, HKEX ESG Reporting Guide A.4 Climate Change, and TCFD

Figure 2 shows the number of listed companies that disclose transition risks, physical risks and opportunities. There are three findings from the figure 2. First, listed companies in Hong Kong are more concerned about the risks arising from climate change than the opportunities. Second, 2021 is the year with the highest number of companies disclosing climate-related risks and opportunities. Third, there is less full disclosure of transition risk than full disclosure of physical risk, but more companies partially disclose transition risk than partially disclose physical risk. There are three potential reasons why the companies have this disclosure pattern. First, instead of taking active approaches to climate change, companies may be taking reactive approaches, seeing climate change as risks rather than opportunities. Resource-based theory explains this by saying that while active initiatives can create sustainable competitive advantages for companies, such strategies require a long-term commitment to the environment and substantial financial and management resources [81]. Second, the potential positive impacts of climate opportunities may be underestimated, compared to the more direct and measurable negative impacts of climate risks [82]. Therefore, companies disclose more climate-related risks than climate-related opportunities. Third, the reason for more partial disclosure of transition risk than partial disclosure physical risk may come from investors' focus on climate-related transition risk. Investors may even overreact to climate-related transition risk, that is, overestimate the impact of climate-related transition risk [83]. But interestingly, there is more full disclosure of physical risk than full disclosure of transition risk. This may be because transition risk involves longer-term and broader changes, such as policy changes and technological innovations [5]. The impacts of transition risk on companies are complex and difficult to identify.

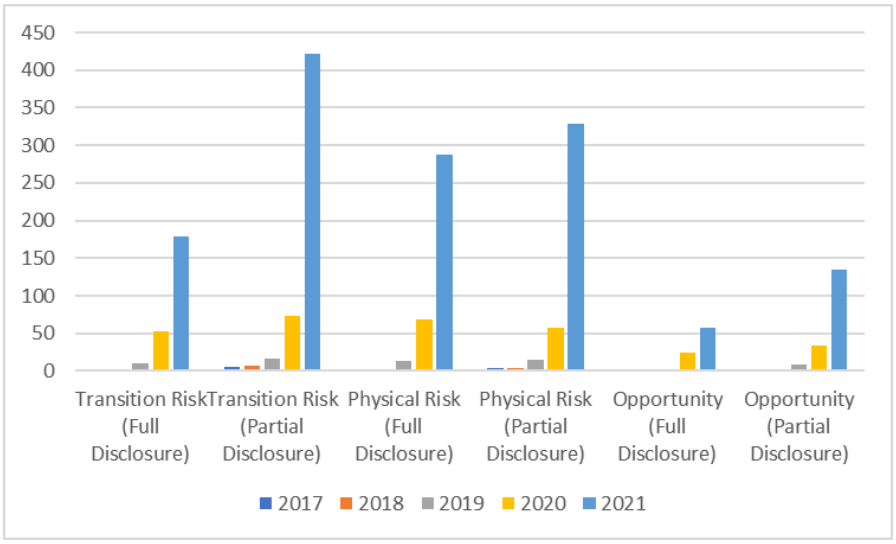

Figure 2 Number of Listed Companies That Disclose Climate-related Risks and Opportunities

Figure 3 presents a finding that the focus of listed companies in Hong Kong on climate-related risks is uneven. In transition risks, policy and legal risk is the biggest concern for companies, while technology risk has received the least attention. In 2020, 98 and 73 companies disclosed policy and legal risk and technology risk respectively. In 2021, the gap in the number of companies disclosing disclosure policy and legal risk and technology risk had widened, with 404 and 258 companies, respectively. In physical risks, more companies disclosed acute risks than chronic risks. The first explanation to the disclosure pattern is companies that face substantial climate-related regulatory risk tend to experience a reduction in their valuation [82]. Therefore, companies may pay more attention to climate-related policy and law risk. The second explanation is regulatory enforcement can promote companies to formulate and implement strategies in tackling climate change [84]. Stricter regulatory requirements to mitigate climate change will increase business operating costs [85]. Companies may disclose more policy and law risk in order to meet the needs of regulators. In addition, the reason why companies disclose more acute risk than chronic risk may be the urgency of acute risk. For example, extreme weather can cause great disruption to transportation in a short period of time [86].

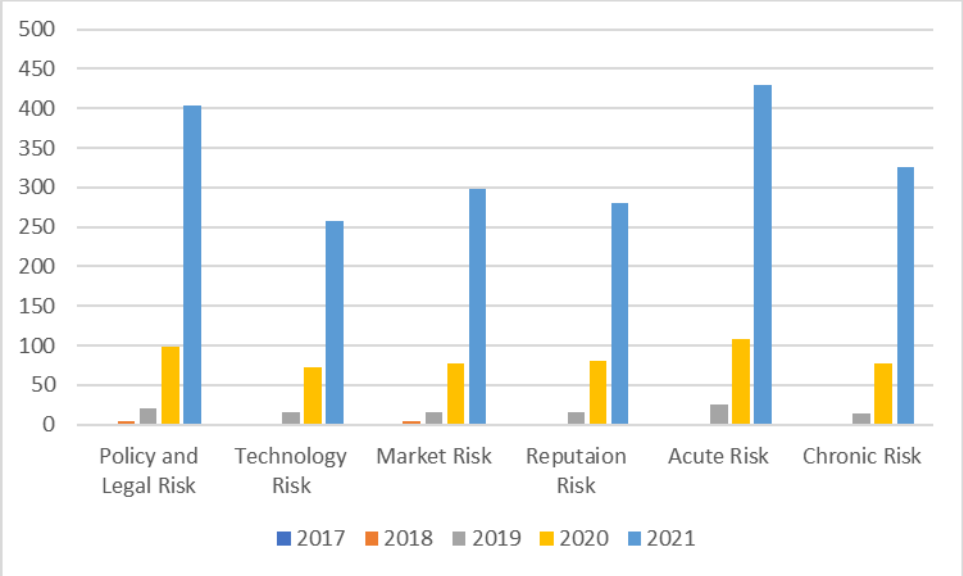

Figure 3 Number of Listed Companies That Disclose Subdivisions of Climate-related Risks

According to Figure 4, there are not many full disclosures of climate-related risks for listed companies in Hong Kong. Compared with Figure 3, although 404 companies disclosed policy and legal risk in 2021, only 86 of them fully disclosed this risk in the same year. One possible reason for less full disclosure is companies cherry-pick to report primarily non-material climate risk information [87]. Until now, Hong Kong Listed companies have not been required to make mandatory disclosures of all climate-related risks, which means some climate-related risk information might be withheld. In addition, full disclosures of market risk and reputation risk are balanced. A rational explanation is consumer preferences and consumption choices are shifting toward low-carbon products [88], prompting companies to disclose more climate-related market risk and reputation risk to reduce information asymmetry.

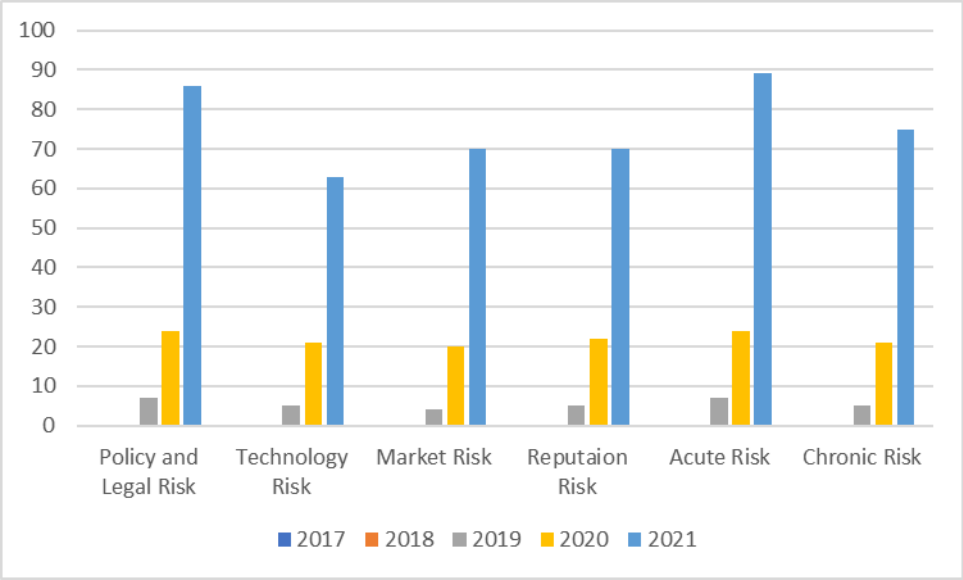

Figure 4 Number of Listed Companies That Fully Disclose Subdivisions of Climate-related Risk

Figure 5 reveals two main findings. The first one is different climate-related opportunities have different extents of disclosure. The largest number of companies disclosed products and services opportunities, while the least disclosed resilience opportunities. One reason is that changing consumer behavior may prompt companies to identify more climate-related opportunities [89]. Evidence suggests that consumers might be willing to pay higher prices for products or services with environmental commitments [90]. Climate-related products and service disclosures are able to demonstrate to consumers their ability to meet market demand and achieve growth. The second finding is identification of climate-related opportunities is not as good as that of climate-related risks. While the largest number of companies disclosed products and services opportunity in 2021, with 117 companies, it is still less numerous than the technology risk, the least disclosed segment of climate-related risks. This may be because awareness of climate-related opportunities varies among companies [91]. In particular, high-performing companies pay more attention to climate-related opportunities, while others are less sensitive to the opportunities [91].

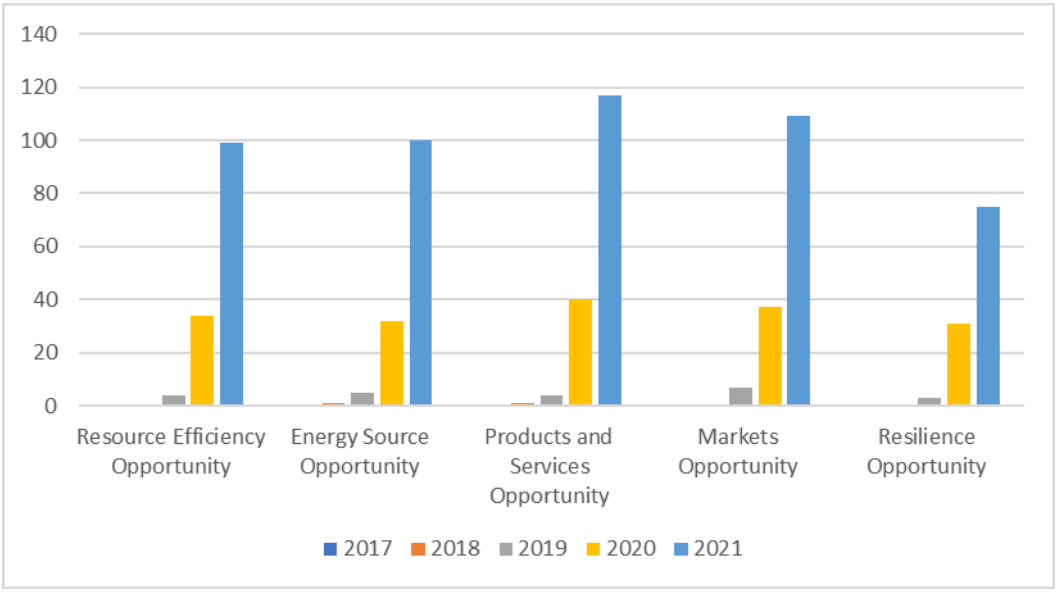

Figure 5 Number of Healthcare Listed Companies That Disclose Subdivisions of Climate-related Opportunities

Figure 6 shows that markets opportunity is the climate-related opportunity with the highest number of fully

disclosed companies. The number of companies with full disclosure of markets opportunity rose from 4 in 2019 to 36 in 2021. However, the number of companies that fully disclose markets opportunity only accounts for about 33% of those disclosing markets opportunity. Climate-related markets opportunities could be captured through underwriting or financing green bonds and infrastructure [5]. Therefore, green bonds in Hong Kong may explain why the listed companies disclose more climate-related market opportunities. the Hong Kong Special Administrative Region (HKSAR) government, the Hong Kong Market Authority (HKMA) and the Securities and Futures Commission (SFC) are actively involved in the development of green bonds in Hong Kong [92]. And green bonds announcements have elicited a positive response from investors in the Hong Kong stock market [92].

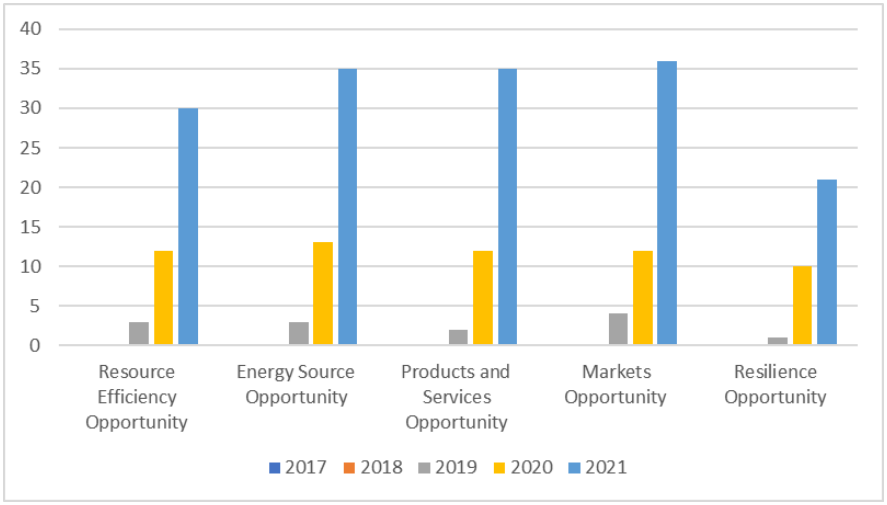

Figure 6 Number of Healthcare Listed Companies That Fully Disclose Subdivisions of Climate-related Opportunity

Figure 7 shows Listed companies in Hong Kong Disclosure of the four core elements of TCFD is balanced. This is perhaps because the Hong Kong ESG Reporting Guide has adopted the TCFD's recommendations, showing a sign of what the regulator expects of companies. Pressure from stakeholders will push companies to disclose more climate-related information [93]. However, compared with Figure 1 and Figure 7, the companies that mentioned TCFD in ESG did not show enough attention to the four core elements of TCFD. In 2021, 487 companies mentioned TCFD, but less than 50% disclosed TCFD four core elements. This may be because TCFD is still a new topic for listed companies in Hong Kong. When performing coding, we notice that some companies claim they will use the TCFD framework as a tool to investigate the impact of climate change in the future, but they had not really disclosed according to the recommendations of TCFD.

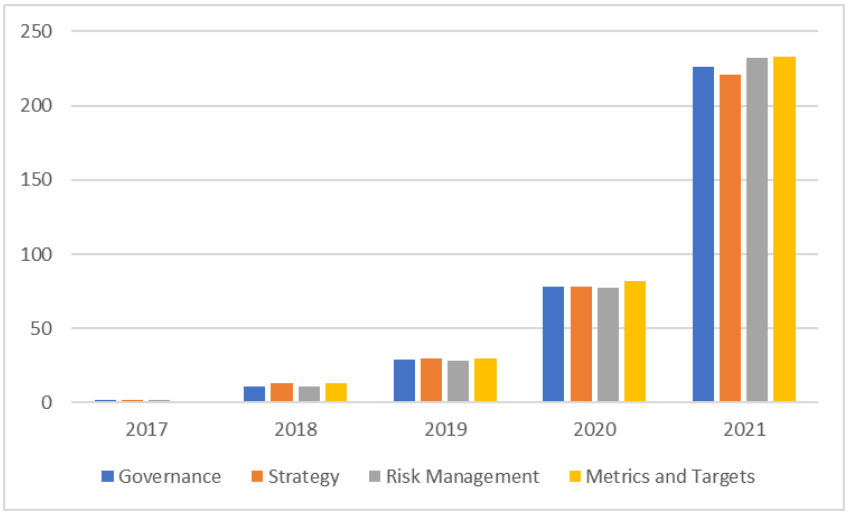

Figure 7 Number of Listed Companies that Disclose Four Core Elements of TCFD

Figure 8 reveals two findings. First, the largest number of companies with full disclosure of the governance element is followed by the number of companies with full disclosure of the metrics and targets element. the fewest companies made full disclosures about the strategy element and the risk management element. These findings are inconsistent with a study of the quality of TCFD disclosure based on the German capital market [72]. German companies have a low level of disclosure of the governance element and the risk management element, but a high level of disclosure of the strategy element and the metrics and targets element [72]. Second, compared with figure 7, most of the companies that disclosed the four core elements did not make full disclosures. For example, 233 companies will disclose metrics and targets elements in 2021, but only 44 do so in full. There are more full disclosures of the governance element, possibly because corporate governance plays an important role in the implementation of climate change mitigation strategies. Good governance structures, such as the establishment of a climate change risk committee, are conducive to enhancing a company's ability to cope with climate change [94]. The reason for less full disclosure of the strategy element may be the complexity of climate scenario analysis [95]. The TCFD recommends that companies apply scenario analysis when disclosing the strategy element [5]. However, the uncertainties inherent in climate predictions can lead to limitations in climate models in predicting future climate scenarios [95]. This is consistent with what we found when we performed content analysis, which is that very limited companies have scenario analysis in their disclosures to the point of not fully disclosing in the strategy element.

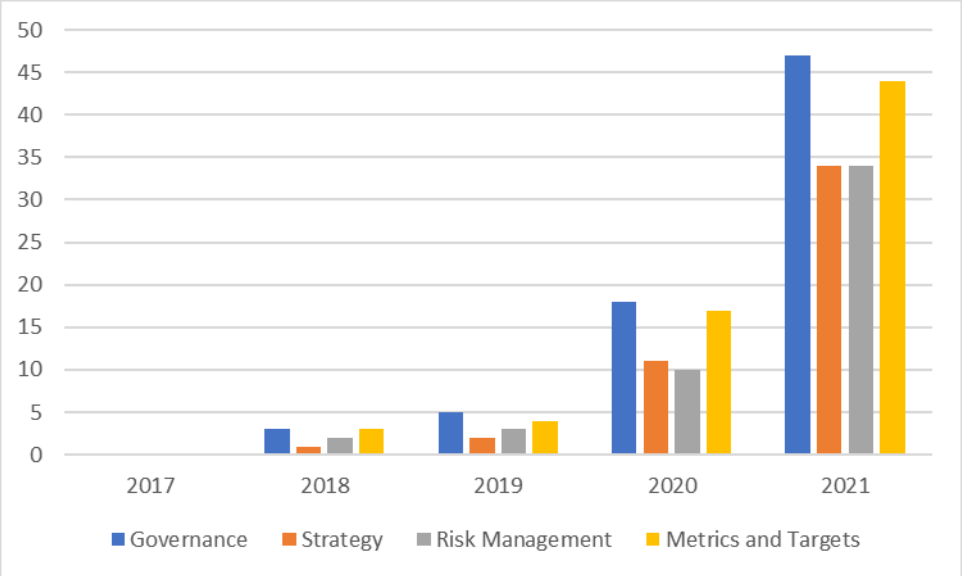

Figure 8 Number of Listed Companies that Fully Disclose Four Core Elements of TCFD

5. Conclusion

There are three main preliminary findings in this paper. The climate disclosure of listed companies in Hong Kong lacks completeness and balance. While the quality of the companies' disclosures on the TCFD framework is on the rise, the companies' disclosures on different climate-related risks and climate-related opportunities are inconsistent. Far fewer companies have disclosed the four core elements of TCFD than have mentioned them. And most companies that follow the TCFD framework choose partial disclosure rather than full disclosure.

The research contributions of this study are in the following three points. First, this research examines the extent of climate disclosure quality of Hong Kong listed companies, filling the research gap in climate-related disclosures in Hong Kong [72]. This study provides evidence to compare the climate disclosure in Hong Kong and western countries. Second, this study enriches the research field of climate change, providing evidence of the relationship between climate information disclosure and financial impacts [16]. Third, this study complements research in the field of corporate governance by exploring the role that board of directors and senior management governance play in the relationship between climate-related disclosures and financial impacts [66].

There are three practical implications for policymakers. First, this study develops a coding scheme of climate disclosure quality that policymakers can use in the future to continuously monitor the level of TCFD compliance of listed companies. Second, from this research, Hong Kong policymakers could understand the current status of climate change financial disclosures by Hong Kong-listed companies, making more detailed and targeted recommendations in the Hong Kong context. Third, this study explores the relationship between climate-related disclosures and financial impacts, which can provide ideas for policymakers to encourage companies to disclose climate-related information in their annual reports or ESG reports.

There are three practical implications for industry practitioners. First, this study helps Hong Kong-listed companies to assess the extent to which they are following the TCFD framework, which can find out whether Hong Kong-listed companies follow the TCFD recommendations in a balanced manner and where they could work towards climate-related disclosures. Second, this study highlights the role of climate information for shareholders and other stakeholders, by examining the impact of climate-related financial disclosures on the financial impacts. Companies could be more proactive in identifying and managing climate change risks and opportunities, reducing information asymmetry. Third, this study explores the role of the board and senior management governance on the relationship between climate disclosure and financial impacts, providing ideas for companies to enhance the relationship through corporate governance.

This study has the following three limitations and direction for future study. First, this study does not discuss factors that constrain or improve climate-related disclosure. Future research can adopt a combination of quantitative and qualitative methods to assess the impact of different factors on climate-related disclosure. Second, this study does not explore the degree of disclosure of the 11 subdivision recommendations under the four core elements of the TCFD. Future research could consider using content analytics to assess the quality of disclosure by companies on these subdivision recommendations, as well as the differences between companies of different industries, regions, and sizes. Third, this study did not analyse the disclosure of companies in the scenario analysis of TCFD. Future researchers may consider selecting representative companies as case study objects to analyse in depth how they conduct TCFD scenario analysis.

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Does Technological Diversity in M&A Network have better ESG Performance?

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Does Technological Diversity in M&A Network have better ESG Performance?

ABSTRACT: This study breaks through the homogeneity of mergers and acquisitions (M&A) and the dyadic relationship between the acquirer and the target firm. We consider the network content of technological diversity that reflects both acquirers-target firms and target firms-target firms. The study empirically explores the impact and mechanism of technological diversity in M&A network on the ESG. Our study reveals that technological diversity in M&A network has an inverted U-shaped effect on ESG. Mechanism analysis shows that the technological diversity in M&A network affects ESG through corporate social responsibility and agency costs. In addition, heterogeneous analysis indicates that ESG performance is more likely to be affected by the technological diversity in M&A network for firms with high quality of internal control and firm growth. The findings provide novel insights to enable acquirers to select appropriate target firms and enhancing corporate social responsibility and corporate governance, thus improving corporate ESG performance.

Keywords: technological diversity in M&A network; corporate social responsibility; agency costs; ESG performance

1. Introduction

ESG is a key indicator for evaluating a company's sustainable development capabilities and plays a crucial role in comprehensive corporate assessments (Li and Li, 2024). ESG comprehensively evaluates a company's performance in the areas of environment, social, and corporate governance, emphasizing the importance of companies focusing on environmental protection, assuming social responsibility, and enhancing governance standards (Su and Guan, 2024). As the microfoundation of economic development, companies need to shoulder environmental, social, and governance responsibilities. By embracing a development philosophy that complements economic and social values, maintaining positive interactions, continuously optimizing ESG performance, unleashing corporate strengths and potentials, companies can promote value creation.

Despite the increasing global emphasis on ESG practices, according to current ESG rating trends, Chinese companies still have room for improvement in their ESG performance . Several factors constrain companies' active enhancement of their ESG performance (Yan et al., 2024). Improving ESG performance has become an important objective driving companies to engage in merger and acquisition (M&A) activities (Franklin, 2019; Barros et al., 2022). Companies executing M&A transactions are increasingly focusing on their ESG ratings and how stakeholders perceive their sustainable behaviors. Scholars have proposed that the sustainability of a company's development is an important factor in assessing its M&A motives and measuring the success of M&A transactions (Gillan et al., 2021). M&A enables companies to acquire core resources such as heterogeneous technologies from target companies, reducing research and development risks and investment costs, thereby allocating more resources to ESG initiatives. Additionally, acquiring firms can generate synergies, increase their willingness to assume corporate social responsibilities, and improve their

ESG performance.

However, there is limited literature exploring the impact of M&A transactions on company ESG performance, with only a few studies focusing on the effect of M&A transactions on the ESG performance of acquiring firms (Tampakoudis and Anagnostopoulou, 2020; Barros et al., 2022). Companies can use M&A as a strategy to enhance ESG performance, thereby increasing their corporate value. Barros et al. (2022) examined whether M&A transactions affect a company's ESG level by decomposing ESG into three components. The sample covers 41 countries and 12 economic sectors from 2004 to 2019, with 8843 annual observations of companies. The results indicate that M&A transactions increase a company's ESG score.

Currently, most scholars approach M&A as a unified concept, considering M&A activities to be homogenous, and characterizing M&A transactions using dummy variables (Bartov, Cheng, and Wu 2021). However, when the acquirer undertakes multiple M&As or the target has different patented technologies, existing approaches cannot accurately reflect the M&A behavior. In reality, firm undertake multiple M&A deals based on a strategic and holistic perspective, and it is not merely the summation of the number of M&A transactions. Focusing solely on the M&A activities themselves and neglecting the relationships between acquiring and target firm, as well as among different target firm, could lead to biased conclusions. A few scholars emphasize the technological differences between the acquirer and target firms (Yao, Xu, and Ling 2022), categorizing technological mergers and acquisitions into technological similarity M&A and technological complementarity M&A. Technological similarity reflects the similarity between acquirers and targets in specific technology sectors, while technological complementarity measures the degree to which the acquirers and targets complement each other in terms of technology and knowledge (Yao, Xu, and Ling 2022). Nevertheless, these investigations solely examine the dyadic relationship between the acquiring firm and the target firm, overlooking the M&A network involving multiple target firms.

Further, heterogeneous technology possessed by network members is the core resource of the network. Increasingly, emerging market firms are relying on multiple R&D alliances, referred to as R&D alliance portfolios, which help them share risks and costs of R&D and access complementary knowledge and capabilities (Shukla et al. 2020). Strategic alliances and M&As present latecomers in emerging markets with opportunities to acquire foreign technologies at a reduced cost (Zhang et al. 2023). Based on the research of Jaffe (1986), Sampson (2007), Rodan and Galunic (2004), Phelps (2010) proposed the concept of "network-level technological diversity," which refers to the technological differences between a firm and its partners and among the partners. Most of the existing scholars have taken joint research and development activities and patent applications as the basis for the construction of enterprise cooperative networks, and studied "technological diversity in R&D alliance network" (Sampson 2007; Zeng, Zhang, and Wen 2015) and "technological diversity in innovation network" (Zhao, Ye, and Han 2022). Some scholars put forward "technological diversity in supplier network," that is, the degree of technological differences between firms and their suppliers, and between suppliers (Gao, Xie, and Zhou 2015; Yu and Sun 2020). For M&A, in addition to considering the homogeneity of M&As and the dyadic relationships between the acquirers and targets, it is essential to conduct a joint examination of network content such as technological diversity that reflects both acquirers-target firms and target firms-target firms relationships. Accordingly, we propose the concept of "technological diversity in M&A network," which is defined as the level of technological difference between the acquirer and the target firm and among target firms. In the emerging market transition from high-speed growth to high-quality

development, advancing enterprises towards high-quality development is the top priority. This leads to the following research questions. How can acquirers choose target firms to improve corporate ESG performance ? What is the impact of technological diversity in M&A network on corporate ESG performance? What are the mechanisms underlying this phenomenon, and is the effect heterogeneous? Addressing these questions entails significance for strategically creating a full play to the M&A value and improving ESG performance.

Based on the synergy effect theory, this study uses a sample of Chinese A-share listed firms that implemented M&A deals during the period from 2010 to 2019 over a moving five-year window to establish the M&A network. The International Patent Classifications (IPC) of the acquirers and target firms are collected and sorted manually through the China National Intellectual Property Administration and verified repeatedly. We examine the influence of technological diversity in M&A network on ESG performance and explore the potential mechanism from the dyadic perspective of corporate social responsibility and agency costs, which provides an effective reference for acquirers to choose the target firms, thus improving ESG performance. Our study finds that there is an inverted U-shaped relationship between technological diversity in M&A network and ESG performance. The micro mechanism of technological diversity in M&A network affecting ESG performance are corporate social responsibility and agency costs. Heterogeneous analysis indicates that ESG performance is more likely to be affected by the technological diversity in M&A network for firms with high quality of internal control and firm growth.

The major contributions of this study are as follows. First, we break through the “homogeneity” of M&A activities and the “dyadic relationship” between the acquirer and target firms, proposing the research theme “technological diversity in M&A network,” building and measuring this index. Most Scholars regard M&A as an “event,” characterized by homogeneity, that is, M&A activities are considered to be homogeneous and M&A behaviors are characterized through dummy variables. Some scholars divide M&As into technology-similarity M&As and technology-complementarity M&As based on the technological differences between the acquirer and the target. Nevertheless, these studies only explore the dyadic relationship between the acquiring firm and the target firm, ignoring the M&A network comprising the acquiring firm and multiple target firms. This study takes into full consideration the technological differences between both acquirers-target firms and target firms-target firms and proposes the research theme “technological diversity in M&A network.”

Second, this study enriches the research perspective on ESG performance influencing factors by examining the impact and mechanisms of technological diversity in M&A network on ESG performance. While a few scholars have investigated the effects of M&A transactions on the ESG performance of acquiring firms (Barros et al., 2022; Tampakoudis and Anagnostopoulou, 2020), Tampakoudis and Anagnostopoulou (2020). Tampakoudis and Anagnostopoulou (2020) argue that M&A transactions contribute to enhancing ESG performance. However, the majority of prior research has focused on M&A events. In contrast, this study extends the literature on corporate M&A behavior beyond M&A events to the technological diversity in M&A network, a comprehensive technical factor involving both internal and external influences on firms. It explores the impact of technological diversity in M&A network on corporate ESG, thereby providing theoretical references for enhancing ESG practices in the real economy.

Third, drawing on external and internal perspectives, this study reveals the underlying logic through which technological diversity in M&A network affects corporate ESG performance, and constructs a theoretical framework of “technological diversity in M&A network - corporate social

responsibility (external) and agency costs (internal) - corporate ESG performance."

2. Hypotheses Development

2.1. Technological Diversity in M&A Network and corporate ESG performance

The technological diversity in M&A network enhances corporate ESG performance. First, firms can create value through M&A, primarily via long-term capability transfer, necessitating the integration of technology, knowledge, organizational structure, and corporate culture of both acquiring and target firms (Angwin and Meadows, 2015). M&A serves as an effective means for firms to access external technological resources, and diversifying M&A network technologies can avoid redundant investments, optimize resource allocation, effectively absorb and integrate external technologies, leverage the technical advantages of various entities within the M&A network, enabling firms to allocate more resources to ESG and enhance ESG performance. Second, technological diversity in M&A network can establish strategic alliances among M&A parties, fully harnessing synergistic effects, maximizing the utilization of technological resources among firms, strengthening inter-firm connections and collaborations, reducing the costs of ESG practices, and enhancing corporate ESG advantages. Third, the establishment of M&A networks through technological diversification can reduce the information search costs for M&A parties, decrease ESG practice costs, and strengthen ESG development. Firms with high levels of diversification in M&A network technologies play a crucial role in promoting the adoption of ESG principles among M&A parties, increasing ESG investments, optimizing ESG performance, and thereby enhancing corporate sustainability. Fourth, diversifying M&A network technologies can alleviate firms' financing constraints and promote active corporate social responsibility. In recent years, corporate ESG performance has become a significant criterion for investors in making long-term investments and is also one of the key indicators for assessing corporate value and sustainability. Technological diversity in M&A network enables firms to not only acquire heterogeneous technologies and knowledge, enhancing their innovation capabilities and competitiveness but also leverage M&A network advantages to better achieve resource integration and synergy effects, improve management levels and operational efficiency, adopt a more proactive approach towards social responsibility, and optimize corporate ESG performance. Fifth, engaging in technological diversification within M&A networks facilitates the optimization of product production modes, updates in product production processes, enhancement of production efficiency across various business modules, promotion of technological innovation, and thus improvement in corporate ESG performance.

However, excessive technological diversity in M&A network also hampers the improvement of corporate ESG levels. On one hand, engaging in technological diversification through M&A entails the high allocation of limited corporate resources, including the required direct costs of M&A implementation and the opportunity costs lost due to M&A participation. Excessive technological diversity in M&A network increases costs, reduces funds available for ESG investments, and is unfavorable for enhancing ESG levels. On the other hand, absorbing heterogeneous technologies becomes more challenging, requiring M&A parties to incur additional costs to integrate the knowledge and technologies of target firms, thereby crowding out ESG investments and leaving M&A parties with insufficient resources to enhance corporate ESG levels. Hence, we propose the following hypotheses:

H1: Technological diversity in M&A network has an inverted U-shaped effect on corporate ESG performance.

2.2. The Mechanism of Corporate Social Responsibility

The Technological diversity in M&A network facilitates corporations in fulfilling their corporate social responsibility (CSR). Firstly, it enhances resource integration and optimization. By engaging in diversified technological mergers, corporations can access resources and technologies from different fields, thereby improving the efficiency of resource integration and utilization, offering more social welfare projects, and assisting corporations in more effectively fulfilling their social responsibilities. Secondly, it mitigates technical and operational risks. Through technological mergers in diverse fields, corporations can reduce the impact of risks in particular domains on overall operations, diversifying technical and operational risks, maintaining stable operations, and effectively fulfilling corporate social responsibilities. Thirdly, technological diversity in M&A network enhances corporate competitiveness. A high level of technological diversification in merger networks implies that corporations delve deeply into multiple fields and markets, enabling them to enhance product quality through technological innovation, meet consumer demands, enhance corporate competitiveness, and thus better fulfill their social responsibilities. Fourthly, it facilitates cross-border collaboration and technology sharing. The establishment of diversified technological merger networks promotes cross-border collaboration, technological integration, and resource sharing for corporations. Mergers in different technological fields can facilitate the exchange of technology and knowledge, thereby enhancing innovation capabilities and problem-solving abilities, contributing to better fulfillment of social responsibilities. Consequently, technological diversification in merger networks provides corporations with richer avenues for resource acquisition, more opportunities for technological integration and cross-innovation, and broader development space, enabling corporations to more effectively fulfill their social responsibilities.

However, mergers represent a strategic behavior involving two or more organizations, which may lead to mutual exchanges and collisions in terms of markets, resources, and technologies. When the diversification of merger network technologies exceeds a certain threshold, it can inhibit corporations from fulfilling their social responsibilities. Firstly, excessive technological diversification in mergers may redefine corporate boundaries and scale, providing space for managerial self-interest and opportunistic behavior, exacerbating the severity of agency problems. This may lead managers to focus on maximizing their own interests, thereby undermining the interests of suppliers, investors, customers, and employees, reducing the willingness and level of corporate social responsibility, and neglecting the goals of maximizing corporate value and long-term sustainable development (Souder and Shaver, 2010). Secondly, dispersion of focus leads to the marginalization of social responsibilities. When the level of technological diversification in merger networks is high, merging parties need to concentrate on addressing the technological and operational challenges in multiple domains, relegating social responsibility to a secondary position. This dispersion of focus may result in a lack of focus when fulfilling social responsibilities, leading to the marginalization of corporate social responsibility. Thirdly, prioritization of short-term economic benefits. As a crucial means for corporations to acquire resources and technologies, mergers raise concerns about the allocation of resources among relevant stakeholders (Chen et al., 2023). During the process of technological diversification in mergers, corporations may prioritize short-term economic benefits to swiftly recoup investment costs and realize profits, making it

difficult to comprehensively consider the interests of stakeholders and take measures to ensure fair and reasonable distribution of benefits. This may result in corporations making short-sighted decisions when fulfilling social responsibilities, being unwilling to invest time and resources in fulfilling longer-term and comprehensive social responsibilities.

The fulfillment of corporate social responsibility embodies the long-term value of an enterprise and can enhance its ESG performance. Firstly, companies demonstrate their concern for stakeholders by actively fulfilling social responsibilities, which constitutes both a moral act and a strategic initiative. Active CSR practices transmit positive signals to the market, showcasing the company's sense of responsibility towards society and the environment, thereby gaining external support, attracting more ESG investments, effectively alleviating financing constraints, and further promoting the company's development and growth. This enhances the proactiveness and flexibility of managerial decisions. Secondly, such practices also strengthen a company's resilience to risks. By actively fulfilling social responsibilities, companies can better address challenges brought about by environmental and social changes, thereby assisting companies in realizing long-term value and optimizing ESG performance. Thirdly, companies actively fulfilling social responsibilities towards internal employees, by practicing corporate responsibilities and commitments in areas such as employee health, safety, welfare, and value enhancement, can enhance employee loyalty, attract more talented individuals to join in the company's development, and lay a talent foundation for creating corporate value. This not only serves as a significant source for companies to achieve sustainable development and enhance competitiveness but also provides support for strengthening internal supply and long-term value creation, thus aiding companies in optimizing ESG performance. Through actively fulfilling social responsibility, it is possible to establish more robust and profound network relationships with stakeholders, enhancing information exchange among stakeholders, and deepening communication and collaboration among them (Albuquerque et al., 2019). Hence, we propose the following hypotheses:

H2: Technological diversity in M&A network affects corporate ESG performance through corporate social responsibility.

2.3. The Mechanism of Agency Costs

Technological diversity in M&A network can reduce corporate agency costs. Firstly, following the implementation of diversified technological M&A, firms will optimize their human resource structures, potentially leading to changes or adjustments for underperforming managers, thereby exposing managers to the risk of dismissal. This, to a certain extent, increases managers' risk perception, thereby constraining their inefficient behaviors, consequently enhancing managerial efficiency, reducing managerial agency costs, improving internal corporate governance, and optimizing corporate governance performance. Secondly, diversified technological M&A also generates governance spillover effects. After engaging in diversified technological M&A, acquiring firms will optimize and enhance the institutional systems of target firms, achieving organizational management uniformity, while transferring good management practices and governance experiences to target firms, thus inducing governance spill-over effects in target firms, enhancing the governance efficiency of target firm managers, and reducing managerial agency costs (Zhu and Wang, 2024). Therefore, reducing corporate agency costs not only promotes managers' pursuit of long-term sustainable development and enhances their competitiveness but also facilitates the enhancement of overall market governance levels, contributing to the sustainable development of

the entire industry chain. Thirdly, diversified technological M&A can leverage information transmission effects. Collaborative mechanisms established by M&A networks facilitate information transmission, reduce information collection costs, enhance information transparency, effectively supervise management's short-sighted behaviors, prevent resource misappropriation, and reduce agency costs.

However, the excessive technological diversity in M&A network can also increase agency costs for firms. Firstly, it increases the difficulty of supervision and management. Excessive pursuit of technological diversification through mergers and acquisitions often allows controlling shareholders to exploit their equity advantage within the firm, leading to unauthorized use of corporate resources, private transactions, interest transfers, and related-party transactions, aimed at fulfilling the controlling shareholders' own economic interests. This is detrimental to the firm's sound operation and long-term development, resulting not only in poor corporate governance and internal control deficiencies, damaging the overall interests of the firm, but also causing concerns and distrust among investors, thereby reducing the firm's market value and reputation, consequently affecting fair resource allocation and the firm's long-term development. In the context of technological diversification and the merger network environment, management needs to expend more time and effort to supervise the operations of different departments and businesses, thus increasing the difficulty of supervision and adding to agency costs. Secondly, it increases the complexity of management structure and decision-making. The technological diversification of the merger network may lead to a more complex corporate management structure, requiring more manpower and resources to manage various business technologies, thereby increasing corporate management costs. Moreover, in a diversified technological and network environment, there are more factors to consider, making decision-making more complex and time-consuming. Thirdly, it brings about resource dispersion and information asymmetry. High levels of technological diversification in merger networks may scatter the focus and resource allocation of the firm. Management needs to spend more time and effort focusing on different technological areas, thus increasing agency costs for the firm. Additionally, managing technologies in different business areas requires different professional knowledge and skills. Failure to effectively communicate and understand relevant technologies will increase information asymmetry and reduce decision-making efficiency, thereby increasing agency costs. Based on the above analysis, there is an inverted U-shaped relationship between the diversification of network technologies in mergers and acquisitions and firm agency costs.

The reduction of agency costs by enterprises is conducive to improving corporate ESG performance. Firstly, by enhancing reporting mechanisms and information transparency, reducing information asymmetry contributes to lowering agency costs. Investors and stakeholders can better understand the ESG practices of enterprises, prompting management to pay more attention to corporate ESG performance, thereby reducing uncertainty regarding the management of enterprises (Lu et al., 2024). This encourages enterprises to allocate more resources towards ESG practices, thus improving corporate ESG performance. Secondly, reducing agency costs and refining incentive mechanisms ensure alignment of interests between corporate management and shareholders, particularly concerning ESG-related objectives. Linking ESG performance to management compensation incentivizes management to focus more on and drive corporate ESG practices, thereby enhancing corporate ESG performance. Thirdly, establishing a robust, independent, and professional board of directors capable of effectively supervising corporate management ensures

compliance with ESG standards. A well-structured board of directors helps mitigate agency problems, enhances corporate attention to ESG practices, and improve corporate ESG performance. Thus, we propose the following hypothesis:

H3: Technological diversity in M&A network affects corporate ESG performance through agency costs.

In summary, the theoretical model refer to Figure 1.

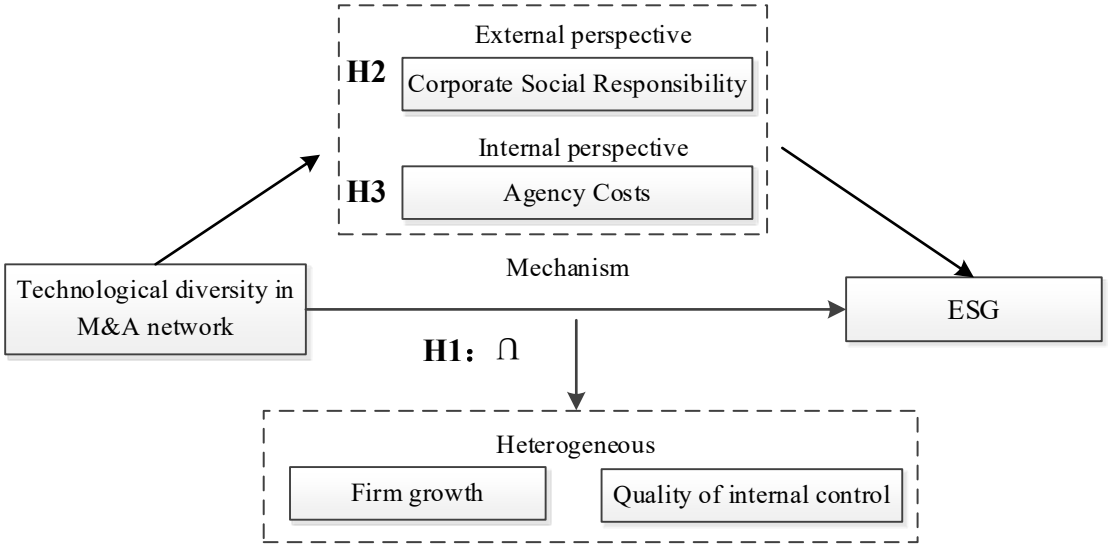

Figure 1. Theoretical model

3. Research Design

3.1. Data and Sample Selection

We use a sample of Chinese A-share listed firm engaged in M&A transactions over the period from 2010 to 2019. Consistent with previous studies (Lebedev et al. 2015; Yao, Xu, and Ling 2022), the samples are screened as follows: (1) M&A events in which the listed firm are acquirers are retained; (2) financial firms and ST firms are excluded; (3) samples of asset divestiture, asset replacement, debt restructuring, share repurchase, tender offer, and equity transfer are rejected; (4) samples wherein M&A transactions failed are excluded; (5) samples of overseas firms as the target firms are removed; and (6) samples with incomplete information are excluded. Financial and M&A data are obtained from the China Stock Market & Accounting Research (CSMAR) database. Drawing on existing research (Cao et al. 2022), patent data of acquirers are derived from the China Research Data Service (CNRDS), which is the leading comprehensive data platform for economic, financial, and business research in China. The International Patent Classifications (IPC) of the acquirers and target firms are collected and sorted manually through the China National Intellectual Property Administration[1] and verified repeatedly. The final sample comprised 810 firms with 2,812 firm-year observations over the period from 2010 to 2019.

[1]http://www.cnipa.gov.cn/

3.2. Variable Definitions

3.2.1. ESG performance (ESG)

Most scholars currently characterize a firm's sustainable development capacity through ESG performance indicators (Song et al., 2022). The Huazhong ESG rating data are widely recognized and utilized by academia. Given the reliability and broad coverage of this metric across listed companies, this study adopts the Huazhong ESG rating data as a measure of corporate ESG advantage. The Huazhong ESG rating categorizes all listed companies into nine tiers, assigning values from 1 to 9 to firms' ESG ratings, with higher values indicating superior ESG ratings.

3.2.2. Technological Diversity in M&A Network (NTD)

Technological diversity in M&A network (*NTD*) formed the independent variable. This study uses a moving five-year window to capture the M&A network from 2010 to 2019, and the data are divided into six-time windows. The first four digits of the IPC are used to identify different patent types, that is, the technological diversity in M&A network constructed from 2010 to 2014 is used to measure that of 2014. Following Sampson (2007), Phelps (2010), and Zhao et al. (2022), we construct the multidimensional vector $F_i = (F_i^1, ..., F_i^s)$, where F_i^s represents the number of patents assigned to firm i in the patent class s. The measure to calculate the technological diversity between a pair of firms is given as follows: $NTD_{ij} = 1 - \frac{F_i F_j^{'}}{\sqrt{(F_i F_i^{'})(F_j F_j^{'})}} (i \neq j)$. We calculate this measure for every combinatorial pair of firms in the M&A network, including an acquirer and target and two target firms, and take the average, namely technological diversity in M&A network. Using Matlab2019b, we calculate the technological diversity in M&A network, and the variable that could range from 0 to 1.

3.2.3. Corporate Social Responsibility (CSR)

Drawing on the study by Gu et al. (2020), this paper utilizes the total score from listed firm' social responsibility reports on the Hexun website as a measure of the level of corporate social responsibility. A higher total score indicates greater corporate responsibility and better CSR performance.

3.2.4. Agency Costs (Agency)

Following the measurement approach of Luo et al. (2017), Agency costs as variables for the mechanism analysis, we use the ratio of other receivables to total assets to obtain variables *Agency*. A higher proportion of other receivables within total assets suggests more severe agency problems and higher agency costs.

3.2.5. Control Variables

Based on the relevant literature (Yu and Sun 2020; Xue et al. 2022), we control for the following

variables: (1) R&D investments (R&D Growth), measured by the growth rate of R&D investments; (2) Firm leverage (LEV), measured by total liabilities divided by total assets; (3) Cash holding (Cash), measured by cash flow divided by total assets; (4) Profitability (ROA), measured by net income scaled by total assets; (5) Firm size (Size), measured by the total number of employees(thousands); (6) Ownership structure (Top), measured by the shareholding of the largest shareholder.

3.3. Model

3.3.1. Baseline Model

The following model is constructed to examine the influence of technological diversity in M&A network on corporate ESG performance:

$$ESG_{it} = \beta_0 + \beta_1 NTD_{it} + \beta_2 NTD_{it}^2 + \sum_{j=1}^{6} \beta_j controls_{jit} + \varepsilon_{it} \quad (1)$$

where ESG_{it} represents the corporate ESG performance, NTD_{it} denotes technological diversity in M&A network, $controls_{jit}$ denotes control variables, and ε_{it} denotes the stochastic disturbance term.

3.3.2. Mechanism Verification

To examine if the technological diversity in M&A network has an impact on corporate ESG performance by influencing the corporate social responsibility and agency costs, based on Model (1), we construct simultaneous equations Models (2) and (3) to examine whether both the corporate social responsibility and agency costs play a mediating effect;—specifically, whether H2 and H3 are valid.

$$CSR_{it} \,/\, Agency_{it} = \beta_0 + \beta_1 NTD_{it} + NTD_{it}^2 + \sum_{j=1}^{6} \beta_j controls_{jit} + \varepsilon_{it} \quad (2)$$

$$ESG_{it} = \beta_0 + \beta_1 NTD_{it} + \beta_2 NTD_{it}^2 + \beta_3 CSR_{it} \,/\, Agency_{it} + \sum_{j=1}^{6} \beta_j controls_{jit} + \varepsilon_{it} \quad (3)$$

where CSR_{it} and $Agency_{it}$ represent the corporate social responsibility and agency costs, respectively. The other variables remain constant.

4. Empirical Results and Discussion

4.1. Descriptive Statistics

Table 1 reports the summary statistics for the variables used in this study. ESG has a maximum value of 87.850 and minimum value of 48.920. The average value of NTD is 0.691, which indicates a higher level of technological diversity in M&A network. Regarding control variables, there are some differences in the debt structure, profitability level, scale, and ownership concentration of the sample.

Table 1. Summary statistics. This table reports the sample size, mean, standard deviations, median, minimum, and maximum values of the sample variables. The sample covers 2,812 firm-year observations and 810 Chinese listed

firms from 2010 to 2019.

Variables	N	Mean	Sd	Min	Median	Max
ESG	2812	73.174	5.296	48.920	73.410	87.850
E	2812	61.533	8.259	34.440	61.380	92.300
S	2812	75.586	9.260	26.300	75.850	100.000
G	2812	77.572	7.309	34.830	79.170	92.510
NTD	2812	0.691	0.300	0.000	0.773	1.000
CSR	2812	21.033	12.441	-12.760	20.295	85.800
Agency	2812	0.015	0.020	0.000	0.009	0.299
R&D	2812	0.439	2.696	-1.000	0.196	115.571
Lev	2812	0.405	0.179	0.026	0.393	1.352
Cash	2812	0.137	0.092	0.002	0.113	0.594
ROA	2812	0.048	0.079	-0.836	0.050	0.767
Size	2812	4.793	11.735	0.158	2.215	285.405
Top	2812	31.280	13.553	4.760	29.360	87.460

4.2. Baseline Regression Results

Table 2 presents the results of the primary regression. Column (1) regresses technological diversity in M&A network on ESG, E, S, and G with no control variables, controlling only for industry-year fixed effects. The results show that technological diversity in M&A network (*NPD*) is a positive predictor of ESG, S, and G, whereas the square of technological diversity in M&A network (NPD^2) is a negative predictor. Based on column (1) to (4), the control variables are added to column (5) to (8). The estimated coefficients of *NPD* and NPD^2 are positive and negative, respectively. Overall, an inverted U-shaped relationship exists between technological diversity in M&A network and ESG, regardless of whether the control variable is added, which is consistent with H1. This indicates that the level of technological diversity in M&A network can promote the ESG, S, and G within a certain range; however, when it exceeds a certain degree, it will inhibit the ESG. Therefore, appropriate technological diversity in M&A network is beneficial. Excessively high or low levels of technological diversity in M&A network are not conducive to supporting the enterprises in improving ESG performance.

The findings reveal that the regression analysis between the technological diversity in M&A network and environmental (E) outcomes yielded non-significant results, implying a lack of discernible impact of technological diversity in M&A network on the environmental of enterprises. This phenomenon can be attributed to the limited influence exerted by the technological diversity in M&A network on the realization of corporate green development principles and the attainment of "dual carbon" objectives. Conversely, it does exert a certain influence on meeting the demands of relevant stakeholders, enhancing corporate governance, and fostering sustainable development of business.

Table 2. Baseline regression results. This table presents the baseline regression results of the effects of technological diversity in M&A network on the ESG performance of enterprises in column (1) to (4) with no control variables and in column (5) to (8) with control variables. Year-, and industry-fixed effects are included in all regressions. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ESG	E	S	G	ESG	E	S	G
NTD	3.953***	0.642	4.638*	4.970**	3.308**	0.367	4.108*	4.040**
	(2.70)	(0.28)	(1.88)	(2.49)	(2.31)	(0.17)	(1.68)	(2.11)
NTD^2	-3.944***	-0.742	-4.408**	-5.090***	-3.122**	-0.264	-3.752*	-3.972**
	(-3.19)	(-0.39)	(-2.12)	(-3.02)	(-2.57)	(-0.14)	(-1.81)	(-2.45)
R&D					0.019	-0.081	0.052	0.048
					(0.55)	(-1.46)	(0.85)	(1.01)
Lev					-1.209*	7.445***	1.204	-7.402***
					(-1.96)	(7.78)	(1.14)	(-8.97)
Cash					3.526***	-0.457	-3.078	9.716***
					(3.13)	(-0.26)	(-1.60)	(6.46)
Roa					6.593***	3.349*	8.037***	7.279***
					(5.14)	(1.68)	(3.67)	(4.25)
Size					0.078***	0.078***	0.067***	0.087***
					(9.12)	(5.90)	(4.54)	(7.55)
Top					-0.015**	-0.047***	-0.054***	0.027***
					(-2.06)	(-4.15)	(-4.30)	(2.71)
Constant	72.934***	58.164***	75.219***	78.158***	72.581***	55.596***	75.969***	78.321***
	(76.51)	(39.37)	(46.86)	(60.11)	(71.23)	(35.22)	(43.65)	(57.55)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,812	2,812	2,812	2,812	2,812	2,812	2,812	2,812
R^2	0.044	0.056	0.114	0.066	0.088	0.100	0.130	0.146

This study uses the U-test method to further verify the test results (Lind and Mehlum 2010). The results show that the slope of the relationship between technological diversity in M&A network and ESG performance is initially positive (3.3079, p=0.01) and later negative (-2.9363, p<0.01). The 95% confidence interval is between 0.2886 and 0.6442, and the extreme point of technological diversity in M&A network (0.5298) falls within this interval. The overall t-value is 2.31 (P <0.01), indicating the existence of a U-shape at the 1% level. Above all, we can conclude that an inverted U-shaped relationship exists between technological diversity in M&A network and ESG performance.

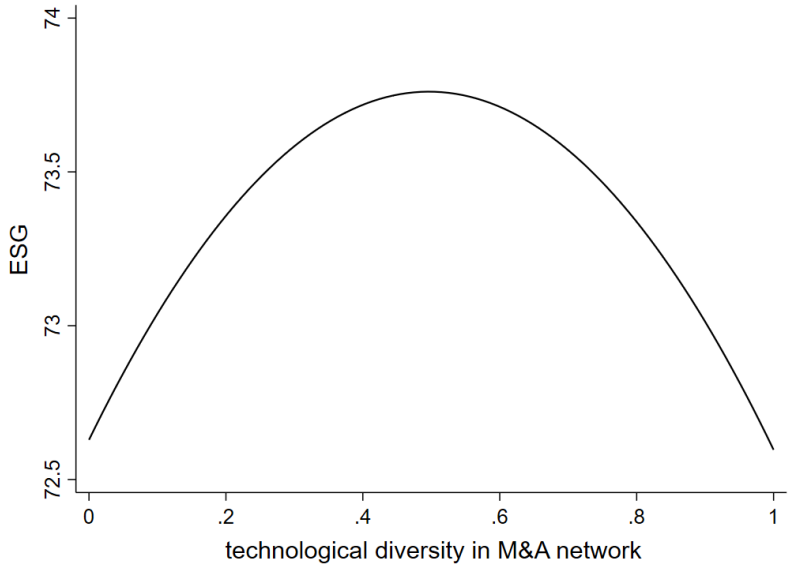

Figure2. Inverse U-shaped relationship between technological diversity in M&A network and ESG performance

4.3. Robustness and Endogeneity Tests

4.3.1. Fixed Effect Model

To solve the endogeneity problem caused by omitted variables, we employed the two-way fixed effects model with reference to Zhang and Yang (2022). Based on Model (1), fixed effects at the firm and year levels are controlled. As shown in column (1) of Table 3, the relationship between technological diversity in M&A network and ESG performance follows an inverted U-shaped pattern.

4.3.2. Replace Dependent Variable

Drawing upon extant literature, this study uses Wind database's comprehensive ESG composite score (ESG_Wind) are used to measure ESG performance and reruns Model (1). Column (2) of Table 3 results support our primary findings.

4.3.3 Alteration of Sample Rolling Period

The rolling period, originally set at 5 years, was adjusted to 3 years. Following the methodology outlined by Sampson (2007) and Phelps (2010), the technological diversity in M&A network was recalibrated to examine its relationship with corporate ESG performance (ESG_3Year) over a 3-year rolling period. As depicted in Table 3, Column (3), the estimated coefficients of NPD and NPD^2 are 4.185 and -3.663, respectively, and both are statistically significant at the 1% confidence level, consistent with the primary empirical findings of this study, thus supporting the validity of Hypothesis 1.

4.3.4 Heckman Two-stage Model

As not all firms undertake M&As with diversified technologies, the Heckman two-step method is

used to address the issue of sample self-selection. Considering A-share listed firm as samples, a dummy variable indicating whether a firm has technological diversity in M&A network is constructed and regressed using a probit model. The estimated Inverse Mills Ratio (IMR) is then added to the regression. The result in Column (4) of Table 3 reveals that the coefficient of the IMR is non-significant, indicating that no sample self-selection problem exists. The estimated coefficients of NTD and NTD^2 are 0.601 and -0.256, respectively, which indicates that our main findings are robust.

Table 3. Robustness and endogeneity Tests. This table presents the results of the robustness and endogeneity tests. Column 1 reports estimates from the two-way fixed effects model. Columns 2 consider the Wind database's comprehensive ESG composite score as dependent variables. The third column focuses on a moving three-year window to capture technological diversity in M&A network. Column 4 presents results from Heckman two-stage models. The estimated coefficients for control variables are omitted to save space. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Variables	(1)	(2)	(3)	(4)
	INV_Year_Firm	ESG_Wind	ESG_3Year	ESG_Heckman
NTD	3.450**	0.297	4.185***	0.601**
	(2.39)	(1.02)	(3.26)	(2.05)
NTD^2	-3.245***	-0.407*	-3.663***	-0.256**
	(-2.65)	(-1.65)	(-3.34)	(-2.30)
IMR				5.345
				(0.88)
R&D	0.023	-0.002	0.000	0.039
	(0.65)	(-0.37)	(0.31)	(1.32)
Lev	-1.048*	-0.349***	-1.461**	-2.483**
	(-1.69)	(-2.72)	(-2.46)	(-2.32)
Cash	3.460***	0.863***	2.435**	-1.594
	(3.06)	(3.48)	(2.37)	(-1.17)
Roa	7.045***	0.489***	7.924***	-0.551
	(5.43)	(2.59)	(5.80)	(-0.47)
Size	-0.018**	-0.003**	-0.020***	-0.014
	(-2.37)	(-1.98)	(-2.93)	(-0.73)
Top	0.076***	0.001	0.069***	0.052*
	(8.67)	(0.91)	(8.11)	(1.76)
Constant	71.146***	6.028***	68.759***	74.632***
	(8.79)	(27.35)	(36.17)	(75.93)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes

Firm	Yes	NO	NO	NO
N	2,812	1,107	2,801	2,812
R^2	0.101	0.125	0.084	0.024

4.5. Mechanism Analysis

This section describes our attempt to reveal the impact mechanism of technological diversity in M&A network on corporate ESG performance. Column (1) of Table 4 shows the regression results for model (1), in which the coefficients of *NPD* and NPD^2 are significant. As shown in Columns (2) of Table 4, in which the coefficients of *NPD* and NPD^2 are positive and negative, respectively, and significant at the 1% level, indicating that a too-high or too-low level of technological diversity in M&A network is not conducive to improve corporate social responsibility. The regression results reported in Columns (3) of Table 4 show that the coefficients on *CSR* is 0.092, with a significance level of 1%, H2 is supported. As shown in Columns (4) of Table 4, in which the coefficients of *NPD* and NPD^2 are 0.013, respectively, and significant at the 1% level, suggesting agency costs partially mediate the relationship between technological diversity in M&A network and corporate ESG performance. Therefore, H3 is supported.

Table 4. Mechanism verification: corporate social responsibility and agency costs. This table presents the results for the mechanism of how technological diversity in M&A network affects the corporate ESG performance. The total score from listed firm' social responsibility reports on the Hexun website as a measure of the level of corporate social responsibility, and we use the ratio of other receivables to total assets to obtain agency costs. The estimated coefficients for control variables are omitted to save space. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Variables	(1) ESG	(2) CSR	(3) ESG	(4) Agency	(5) ESG
NTD	3.308**	8.242***	2.546*	-0.017***	3.121**
	(2.31)	(2.75)	(1.81)	(-3.10)	(2.17)
NTD^2	-3.122**	-9.061***	-2.284*	0.013***	-2.992**
	(-2.57)	(-3.58)	(-1.91)	(2.83)	(-2.45)
CSR			0.092***		
			(10.38)		
Agency					-11.978**
					(-2.37)
R&D	0.019	0.031	0.017	0.000	0.021
	(0.55)	(0.42)	(0.47)	(0.25)	(0.59)
Lev	-1.209*	-0.017	-1.207**	0.019***	-0.978
	(-1.96)	(-0.01)	(-1.99)	(8.26)	(-1.55)
Cash	3.526***	9.571***	2.641**	0.007	3.640***

	(3.13)	(4.07)	(2.38)	(1.55)	(3.22)
Roa	6.593***	63.012***	0.767	-0.015***	6.173***
	(5.14)	(23.50)	(0.56)	(-3.04)	(4.76)
Size	0.078***	0.097***	0.069***	-0.000	0.078***
	(9.12)	(5.40)	(8.19)	(-0.25)	(9.11)
Top	-0.015**	0.029*	-0.018**	-0.000***	-0.018**
	(-2.06)	(1.85)	(-2.46)	(-6.06)	(-2.38)
Constant	72.581***	16.684***	71.038***	0.017***	72.819***
	(71.23)	(7.84)	(70.27)	(4.38)	(71.18)
Year	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes
N	2,812	2,812	2,812	2,782	2,782
R^2	0.088	0.279	0.122	0.093	0.090

5. Heterogeneity Analysis

The influence of technological diversity in M&A network on corporate ESG performance varies at different levels. We conduct additional tests to analyze the heterogeneous impact in firm growth and quality of internal control.

5.1. Firm growth

The firm growth reflects its production and operational status, as well as its future development direction. It serves as a driving factor for value creation and a key indicator for assessing the market competitiveness of a firm. Under the influence of M&A networks, the level of firm growth reflects the integration of resources such as personnel, finances, and materials, which constitutes the intrinsic growth potential for achieving strategic objectives, sustainable development, and optimizing ESG performance. Variations in firm growth lead to different impacts of technological diversity in M&A network on corporate ESG performance. In this study, tobinQ is employed to represent firm growth, where values above the median indicate high-growth firm, and values below the median indicate low-growth firm. Empirical analysis reveals that in high-growth firm, technological diversity in M&A network exhibits an inverted U-shaped impact on corporate ESG performance, initially promoting it before restraining it. This suggests that technological diversity in M&A network can enhance corporate ESG performance up to a certain threshold but becomes detrimental beyond that point. Conversely, in low-growth firm, technological diversity in M&A network shows no significant impact on ESG performance.

Analyzing the reasons behind this phenomenon, firstly, high-growth firm are more prone to harnessing the momentum and potential for growth through the technological diversification effects of M&A networks. This strengthens organizational learning and technological innovation within the company, fully leveraging the innovative thinking and problem-solving methods brought about by diversified M&A network technologies. This enables firm to overcome challenges, drive sustainable development, and elevate their ESG performance. Secondly, during the process of

implementing technological diversification through M&A and resource integration, high-growth firm demonstrate enhanced absorptive capacity. They are more adept at integrating and applying the technologies and resources acquired from target firm (Ahuja and Katila, 2001). Firm with robust growth can identify acquisition targets possessing heterogeneous technologies aligned with their own innovation strategic goals, facilitating more effective technological diversification through mergers and acquisitions. Post-acquisition, they can effectively absorb and integrate the technologies of the acquired entities, thereby enhancing their ESG performance (Lu and Chen, 2023). Thirdly, high-growth firm can effectively utilize diversified technologies and network resources to help diversify risks, reduce reliance on single resources or markets, and enhance adaptability to external environmental changes. Simultaneously, confident management in these firm leads to the development of more new products and creation of long-term value, thus enhancing ESG performance. Fourthly, when the acquirer exhibits high growth, they often possess stronger resource integration, coordination capabilities, and extensive market experience. This typically allows them to better attract and integrate diversified technologies and M&A network resources, expanding their business scope and influence, entering new markets, or strengthening their competitive position in existing markets, thereby optimizing their ESG performance. Fifthly, high-growth firm engaged in technological diversification through M&A can create more employment opportunities, offer broader services and support to society, contribute to a positive corporate image, enhance their performance in social responsibility, and consequently improve their ESG performance. Hence, high-growth firm can enhance their ESG performance and achieve sustainable development and long-term value growth through diversified M&A network technologies.

However, excessive technological diversity in M&A network can also inhibit value creation for high-growth firms. When the degree of technological diversity in M&A network is excessively high and does not align with the firm's growth trajectory, it may hinder the promotive effects of technological diversification through M&A networks on firm growth. High costs associated with acquiring heterogeneous firms can suppress the investment and financing capabilities crucial for firm growth, thereby reducing the flow rate of production factors and profitability levels, which is detrimental to value creation and ESG performance.

5.2. Quality of internal control

As a vital mechanism of corporate governance, internal control serves as a core driver for firms to enhance their Environmental, Social, and Governance (ESG) performance, playing a crucial role in elevating corporate ESG performance (Guo et al., 2023). The quality of internal control forms the foundation and safeguard for companies to effectively engage in strategic diversification through mergers and acquisitions (M&A), enhancing the transparency and credibility of information during the M&A process, mitigating managerial opportunism, and preventing irrational M&A decisions. Such comprehensive internal control not only contributes to addressing conflicts within corporate governance structures but also ensures operational efficiency, the accuracy of financial reporting, and compliance maintenance, thereby enhancing overall ESG performance. Therefore, this study, building upon the analysis of the impact of M&A network technological diversification on corporate ESG performance, further investigates the heterogeneity of internal control quality. Internal control quality is measured logarithmically using the DiBo Internal Control Index, with its mean serving as a standard to categorize companies into high and low-quality internal control groups. Empirical analysis reveals that in firms with high internal control quality, technological diversity in M&A

network plays a promotional role in corporate ESG performance and exhibits an optimal level; moderate technological diversity in M&A network can enhance corporate ESG performance. However, non-significant in low internal control quality firms.

There are three possible reasons for these regression results. Firstly, high-quality internal control can enhance the quality of M&A-related information, reduce information asymmetry, and optimize corporate ESG performance. In M&A transactions, information asymmetry between management and investors may lead to agency problems, thereby exposing investors to value loss. During the disclosure of diversified M&A information, management often tends to selectively disclose positive information, sending out positive signals to the external environment while avoiding negative information. This behavior to some extent aligns with the expectations of regulatory bodies and public opinion, maintaining corporate image and interests. However, selective information disclosure seriously diminishes the objectivity, accuracy, and reliability of information disclosure, hindering the transparency and quality improvement of information disclosure, thus affecting market participants' true understanding of the enterprise and increasing investors' risk. High quality of internal control not only alleviates information asymmetry but also serves as an important mechanism of corporate governance, conveying signals. By enhancing the transparency and credibility of corporate information, it increases the likelihood of M&A decision success. Simultaneously, it helps alleviate information asymmetry, mitigate agency problems, effectively restrain inefficient investment behavior of enterprises, improve the quality of social responsibility information disclosure, and optimize corporate ESG performance.

Secondly, internal control plays a crucial role in corporate management, effective internal control can constrain management's short-sighted behavior, making them focus more on long-term development and ESG performance in decision-making. However, in the diversified and technological M&A process, managers may focus on pursuing short-term benefits and overlook corporate social responsibility and long-term development, not only exposing the company to increasing social responsibility risks and agency costs but also harming the interests of various stakeholders. The quality of internal control is crucial in constraining management's opportunistic tendencies and irrational behavior, and plays a certain inhibitory role in the blind M&A behavior that may occur in diversified and technological M&A. High-quality internal control can optimize the M&A decision-making process, effectively restrain management's self-interested behavior, enhance stakeholders' supervisory capabilities, reduce management's moral risks, control the risks in diversified and technological M&A decision-making, and improve ESG performance.

Lastly, internal control is not just a supervisory mechanism but also a normative and guiding force for corporate management behavior. High-quality internal control can promote corporate compliance, reduce the incidence of violations, and thus enhance corporate ESG performance. Effective implementation of internal control helps promote transparency in environmental information for enterprises and encourages them to assume environmental protection responsibilities, which contributes to strengthening corporate governance mechanisms, assisting enterprises in formulating sustainable development strategies, and thus enhancing corporate ESG performance (Guo et al., 2023).

Table 6. Heterogeneous analysis. This table reports the results for the heterogeneous effect of technological diversity in M&A network on corporate ESG performance under different firm

growth and quality of internal control. The estimated coefficients for control variables are omitted to save space. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Variables	(1) High firm growth	(2) Low firm growth	(3) High quality of internal control	(4) Low quality of internal control
NTD	4.882**	0.185	4.394**	1.501
	(2.58)	(0.08)	(2.47)	(0.67)
NTD^2	-4.256***	-0.792	-3.684**	-1.908
	(-2.60)	(-0.43)	(-2.40)	(-1.02)
R&D	0.046	-0.048	-0.037	0.040
	(1.13)	(-0.70)	(-0.59)	(0.90)
Lev	-3.186***	-0.785	-0.402	-1.862**
	(-3.56)	(-0.85)	(-0.49)	(-2.04)
Cash	2.869**	5.165***	2.396*	3.919**
	(2.06)	(2.72)	(1.66)	(2.31)
Roa	6.317***	6.093***	8.773***	2.688*
	(3.56)	(3.24)	(3.23)	(1.67)
Size	-0.023**	-0.010	-0.022**	-0.016
	(-2.21)	(-0.92)	(-2.32)	(-1.38)
Top	0.243***	0.067***	0.070***	0.093***
	(6.18)	(7.27)	(7.79)	(5.10)
Constant	73.455***	72.587***	72.815***	72.800***
	(43.43)	(51.49)	(49.86)	(49.84)
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
N	1,406	1,406	1,368	1,444
R^2	0.114	0.086	0.129	0.068

6. Conclusions

6.1. Findings

Using unique data, this paper studies the relationship between technological diversity in M&A network and corporate ESG performance. The conclusions are as follows: first, technological diversity in M&A network has a positive effect on corporate ESG performance; however, after reaching a certain level, further increases in technological diversity in M&A network could have a negative effect. Second, the influence mechanisms of technological diversity in M&A network on corporate ESG performance are corporate social responsibility and agency costs. In addition,

heterogeneity analysis reveals that the influence of technological diversity in M&A network on ESG performance manifests prominently in high growth and quality of internal control firm.

6.2. Managerial Implications

These findings have important implications for policymakers and regulators. First, government departments, especially local governments, should prioritize the role of technological diversity M&As in improving corporate ESG performance. Policymakers should consider the essence of enterprise development as the basis and actively guide enterprises in implementing technologically diversified M&A deals for improving corporate ESG performance. They must provide adequate policy support to help enterprises overcome corporate ESG performance dilemmas and barriers. Additionally, cross-border M&A must be strengthened through restraint and supervision to prevent deviation from the main business and for unilateral diversification.

Second, governments should actively promote the innovation of corporate performance evaluation mechanisms by integrating Environmental, Social, and Governance principles into long-term corporate development strategies. This entails embedding ESG standards into corporate management assessment criteria to enact sustainable development strategies and fulfill comprehensive environmental, social, and governance responsibilities. Enhancements to the ESG disclosure mechanism, alongside the formulation of more standardized and explicit ESG criteria, should be pursued to enforce mandatory ESG disclosure regulations, thereby improving the accuracy and transparency of ESG disclosures. Simultaneously, through the establishment of a regulatory framework and the implementation of effective incentive measures, investor and corporate behaviors and values should be transformed to prioritize long-term corporate value, enabling ESG to positively influence the high-quality development of enterprises.

Third, priority should be given to incorporating enterprises with strong ESG performance into the scope of policy support, leveraging their exemplary role. Providing certain policy preferences to enterprises with strong ESG performance can alleviate financing constraints, offering robust support for high-quality corporate development. By formulating incentivizing policies and providing financial support, governments can create favorable operating environments for enterprises exhibiting outstanding ESG performance, thereby reducing costs associated with enterprise transformation and upgrading and facilitating high-quality corporate development.

Our findings are equally compelling for firms. On the one hand, technological diversity in M&A network should be maintained at a moderate level that is conducive to improving corporate ESG performance. Target selection must be comprehensive and from a strategic perspective in the long term. The acquirer must give due consideration to the technological differences among the target firms in addition to the acquirer-target firms. In addition, acquirers pursuing a target must avoid blindly acquisitions with technologies that differ among themselves and other target firms to prevent a reduction in their ability to share and integrate the target firms' technologies, which will increase the cost of resource acquisition and hamper enterprises' ESG performance.

Second, enhancing the quality of internal controls and refining internal control systems are essential to strengthen control activities. This involves intensifying supervision and constraints on the behavior of major shareholders to mitigate information asymmetry issues among internal and external stakeholders, thereby enhancing the transparency and effectiveness of information disclosure to enable stakeholders to gain comprehensive insights into the production and operation status of enterprises. Simultaneously, fostering employees' social responsibility awareness, reducing

short-sighted behaviors among management, mitigating production and operational risks, and optimizing ESG performance are imperative. Moreover, overcoming enterprise growth bottlenecks and enhancing growth potential are vital. Rapidly acquiring heterogeneous technologies through mergers and acquisitions, effectively absorbing and integrating them, converting them into core technologies and optimizing enterprise ESG performance.

Third, instilling ESG principles and reinforcing ESG accountability awareness are crucial. From an internal perspective, enterprises should leverage the leadership and supervisory role of the board of directors to ensure the integration of sustainable principles into significant corporate decisions. Although diversification through mergers and acquisitions of network technologies may offer some advantages, it may also increase agency costs for enterprises, necessitating cautious deliberation by management and the adoption of effective management measures to reduce agency costs and enhance corporate governance standards. From an external perspective, enterprises should actively fulfill social responsibilities and protect the rights and interests of stakeholders such as suppliers and customers. Through internal and external collaboration, enterprises should drive ESG construction. Enterprises should regard ESG principles and practices as long-term value elements in high-quality corporate development, progressively enhancing the driving effect of ESG on high-quality corporate development. By acquiring advanced environmental protection technologies and abundant resources through mergers and acquisitions, mitigating environmental safety risks, strengthening ESG capacity building, and enhancing sustainable competitiveness.

6.3. Limitations and Further Research

There are also some deficiencies in this paper. Theoretical models, particularly game theory and complex network methods, can be deployed to explore the intrinsic mechanism of the influence of technological diversity in M&A network on enterprise innovation and quality development, as it has received little attention. Additionally, in practice, some cases respond well to this issue. We can further perform the case study, thus revealing the internal mechanism of various factors in the process of technologically diverse M&As.

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The Relationship between Knowledge Workers' Organizational Commitment and Their Innovative Behaviors: Taking Employee Job Satisfaction as the Mediator

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Abstract

The paper explored the relationship among organizational commitment, employee job satisfaction and innovative behaviors of knowledge workers, taking organizational commitment of knowledge workers as the independent variable, innovative behaviors of knowledge workers as the dependent variable, and employee job satisfaction as the mediating variable. By collecting 530 sample data and using tools as SPSS23.0 and AMOS21.0, the relationship between organizational commitment, employee job satisfaction and innovative behaviors of knowledge workers was verified. The results showed that: (1) organizational commitment had a positive impact on the innovative behaviors of knowledge workers, and the three dimensions of organizational commitment (affective commitment, continuance commitment, and normative commitment) had a positive impact on the innovative behaviors of knowledge workers respectively; (2) Organizational commitment had a positive impact on employee job satisfaction of knowledge workers, and the three dimensions of organizational commitment had a positive impact on job satisfaction of knowledge workers respectively; (3) Employee job satisfaction had a positive impact on the innovative behaviors of knowledge workers; (4) Employee job satisfaction played a partial mediating role in the relationship between organizational commitment and innovative behaviors of knowledge workers, and employee job satisfaction played a partial mediating role in the relationship between the three dimensions of organizational commitment and innovative behaviors of knowledge workers respectively.

Key words: Knowledge Workers, Organizational Commitment, Innovative Behaviors, Employee Job Satisfaction

1. Introduction

Innovation is not only the core spirit of a nation's development, but also the eternal power of a country's sustained prosperity and development, as well as the most profound ethnic traits of the Chinese nation. It has been shown that knowledge workers played a key role in promoting the innovative activities of enterprises. Therefore, how to stimulate the enthusiasm of knowledge workers has become the core issues to promote the sustainable innovation, development of enterprises and the whole society.

Organizational commitment was reflected in the actual attitude of employees towards the company, or their sense of belonging to the business. The degree of organizational commitment could practically reflect employees' dedication, loyalty and satisfaction. In the past, most studies have focused on the relationship between organizational commitment, employees' motivation to quit and job performance, etc. In recent years, many scholars have focused on the relationship between organizational commitment and job performance. In recent years, Many scholars have gradually shifted their research focus to areas such as organizational commitment and employee innovative behaviors. Knowledge workers has become the most valuable assets of organizations because of their high level of productivity and creativity (Drucker P. F., 1959) in the 21 century. Hence, it was undoubtedly of great significance to explore how organizational commitment affected innovative behaviors in modern enterprises where the proportion of knowledge workers was increasing.

2. Literature review

A systematic review of the existing literature revealed that many scholars have explored the relationship between organizational commitment, employee job satisfaction and employee innovative behaviors.

2.1 The relationship between organizational commitment and employee job satisfaction

Yujing Pei and Shuming Zhao (2015) selected 981 knowledge workers to explore their innovative behaviors. The results showed that knowledge workers had a very clear understanding of their profession, and career calling had a great influence on individual factors such as employees' job satisfaction and played a good role in promoting it. Meanwhile, career commitment was also an important factor affecting employee job satisfaction, played a fully mediating role between separation and satisfaction, and a partially mediating role between career calling and organizational commitment.

Ning Sun and Haiyan Kong (2016) conducted a study on 413 employees by constructing a structural equation model, and the results showed that job tasks and job duties had some effects on the improvement of employee job satisfaction. Meanwhile, pay incentives had a positive effect on job satisfaction, but the effect on affective commitment was not significant. In addition, work time and workplace flexibility had insignificant effects on both job satisfaction and affective commitment.

Haitao Nie and Xiaojie Wang (2018) explored the association and interaction mechanism between job satisfaction, organizational commitment and job performance of employees in asset evaluation agencies. The results showed that job satisfaction and job performance interacted with each other, and organizational commitment played a partial mediating role.

2.2 The relationship between organizational commitment and employee's innovative behaviors

Wenhua Wu (2011) studied the work behavior of knowledge workers in the technology industry and found that affective and continuance commitment could enhance employee's motivation, which in turn promoted innovative behaviors; whereas normative commitment posed some constraints on innovative behaviors to a certain extent. In addition, different demographic characteristics would also have a differential impact on the relationship between organizational commitment and innovative behaviors. Through regression analysis, Yi Han, Baiyin Yang, et al. (2011) found that affective commitment promoted employees' innovative behaviors positively; continuance commitment affected employees' innovative behaviors negatively; and normative commitment did not affect employees' innovative behaviors significantly.

Using organizational commitment as a mediating variable, Yongmei Tao and Yu Kang (2012) explored the mechanism of organizational innovation climate on employees' innovative behaviors, aiming to find the path that could improve employees' innovative behaviors effectively and promote organizational innovation and development.

Ruijuan Zhang, Jianmin Sun, et al. (2014) analyzed the impact of human resource management on employees' work innovation with 658 employee samples based on social exchange theory and cross-level analysis techniques. The results showed that commitment human resource management practices had a significant positive impact on employee's innovative behaviors. Based on the self verification theory, Qingjin Wang, Yufeng Wei, et al. (2020) explored in depth the mechanism of workplace ostracism on employees' innovative behaviors. Through a study of 193 employees, it was found that workplace ostracism had a significant negative impact on employee's innovative behaviors; organizational commitment and organizational identity played a mediating role between workplace ostracism and innovative behaviors. Specifically, workplace ostracism inhibited innovative behaviors by weakening employees' organizational commitment and organizational identity.

2.3 The relationship between employee job satisfaction and employee innovative behaviors

After a study of 247 employees in pharmaceutical enterprises, Jiantao Pang and Ke Wen (2016) found that the employees' own personality had an impact on their innovative behaviors, and the employees with proactive personality were more willing to devote themselves to innovative activities. At the same time, a "U-shape" relationship between the job satisfaction and the innovative behaviors of the employees was found. And the job satisfaction higher than average played a key moderating role in the influence mechanism of employees' proactive personality on their innovative behaviors. Jiantao Pang and Hui Shi (2016) conducted a survey on 59 biomedical companies, aiming to analyze the effects of proactive personality, job satisfaction, job level and organizational tenure on employees' innovative behaviors. The results showed that employees with proactive personalities would be more willing to engage in innovative activities, and high job satisfaction would also promote employees with proactive personalities to participate in innovative activities actively. In addition, job level and organizational tenure played an important moderating role in employees' innovative behaviors. Zhengde Xiong, Zhu Yao, et al. (2018) selected the cenozoic knowledge workers as samples and explored the relationship between the three major capitals, job satisfaction, and innovative behaviors. It was found that the three major capitals could promote job satisfaction; job satisfaction played a certain mediating role in the three major capitals; and the mutual cooperation of the three major capitals could enhance the innovative performance of employees and employee job satisfaction.

2.4 Research summary

The above scholars' studies mainly focused on the two-by-two correlations between organizational commitment, employee satisfaction and employee innovative behaviors. The main research results showed that there was a positive correlation between organizational commitment and employee satisfaction, organizational commitment and employee innovative behaviors, and employee satisfaction and employee innovative behaviors. However, few scholars have explored the relationship among organizational commitment, employee satisfaction and employee innovative behaviors. In this paper, organizational commitment, employee satisfaction and employee innovative behaviors were placed under a unified research framework, and the influence mechanism among the three was explored in depth, which helped to better understand the innovative behaviors of knowledge workers.

3. Research hypotheses and research design

3.1 Research hypotheses

3.1.1 Hypotheses on the relationship between knowledge workers' organizational commitment and their innovative behaviors

Creative psychology analyzed the nature and process of innovation, and convinced that an individual's creativity depended not only on their quality and intelligence, but also on their personality, motivation, etc. Yong Huang, Jie Yang, et al. (2020) found that positive emotions could help entrepreneurs develop their thinking and stimulate creativity. Organizational commitment was not only a verbal commitment of staff to the organization, but also a kind of recognition of organizational values. Employees with higher organizational commitment were more likely to be actively involved in organizational innovative activities. As a result, the following research hypothesis was proposed:

H1: Knowledge workers' Organizational commitment had a positive effect on their innovative behaviors

Allen & Meyer (1991) classified organizational commitment into three categories: affective commitment, sustained commitment, and normative commitment. In the process of business innovation, the positive emotion of

affective commitment came from the deep emotion of knowledge workers towards the company, which could increase the motivation of knowledge workers, thus promoting the generation of creative activities (Liuyuan Chen, 2023). The positive emotion of continuance commitment came from knowledge employees' reasonable consideration of the cost and risk of resignation. Knowledge workers mostly invested in professional knowledge resources in enterprises, and maintaining the sustainability of innovation activities was better than bearing high turnover risks (Ying Wang and Shengtai Zhang, 2009). The positive emotion of normative commitment came from the knowledge workers' strong sense of responsibility, which could help them actively participate in the organization's innovative behaviors and promote the positive development of the enterprise (Hongmei Xia, 2015). Therefore, the research hypotheses were proposed as follows:

H1a: Knowledge workers' affective commitment had a positive effect on their innovative behaviors

H1b: Knowledge workers' continuing commitment had a positive effect on their innovative behaviors

H1c: Knowledge workers' normative commitment had a positive effect on their innovative behaviors

3.1.2 Hypotheses on the relationship between knowledge workers' organizational commitment and their job satisfaction

Organizational commitment was an emotional attachment and sense of responsibility of employees to the organization, reflecting the degree of recognition and devotion. Employee job satisfaction was a subjective evaluation of the work environment, job content, compensation and benefits. Generally speaking, as employees' organizational commitment increased, their job satisfaction also increased (Ling Ma, Yu Wang, et al., 2013). As a result, the following research hypothesis was proposed:

H2: Knowledge workers organizational commitment had a positive effect on their job satisfaction

Among the three types of organizational commitment, with the increase of affective commitment, employees would develop a deep emotional attachment for the business and identify more with the philosophy and values of the enterprise, thereby improving job satisfaction (Mingjiao Zhang and Zhongkai Yin, 2016). Once employees were satisfied with the company's benefits and potential for growth, job satisfaction would be increased. In order to keep employees better, enterprises would also provide better benefits and development space, thereby improving employee job satisfaction. In other words, employees might have a certain tolerance for their current dissatisfaction in order to achieve personal goals, thereby maintaining satisfaction (Hu Li, 2017). Employees who had a strong sense of belonging and responsibility to the enterprise would work harder and set higher expectations for themselves, thereby improving job satisfaction (Jianhui Liu, 2021). Therefore, the research hypotheses were proposed as follows:

H2a: Knowledge workers' affective commitment had a positive effect on their job satisfaction

H2b: Knowledge workers' continuance commitment had a positive effect on their job satisfaction

H2c: Knowledge workers' normative commitment had a positive effect on their job satisfaction

3.1.3 Hypotheses on the relationship between knowledge workers' job satisfaction and their innovative behaviors

Employees with high satisfaction tended to be passionate about their work, and creative behaviors and ideas were more likely to occur, (Xiaohong Chen, Ke Zhao, et al., 2009). At the same time, employees with higher job satisfaction were more likely to be trusted and supported by their peers and leaders, thereby creating a more harmonious personal relationship and group atmosphere, and providing a favorable environment for innovative activities (Shenran Zhao, Dongdong Gao, et al., 2015). As a result, the following research hypothesis was proposed:

H3: Knowledge workers' job satisfaction has a positive effect on their innovative behaviors

3.1.4 Hypothesis on the mediating role of knowledge workers' job satisfaction between Organizational commitment and innovative behaviors

Employees with high organizational commitment were also affected by factors such as work environment, salary, personal emotions, and organizational culture when they were involved in organizational innovative activities (Ling

Ma, Shuo Liu, et al., 2023). When employees were satisfied with their work, their motivation and initiative would also increase. As a result, the following research hypothesis was proposed:

H4: Knowledge workers' job satisfaction mediates the relationship between organizational commitment and innovative behaviors

In the relationship between employee affective commitment and innovative behaviors, employee job satisfaction affected employee's commitment and loyalty to the business, thereby influencing their innovative behaviors. If employees were satisfied with their jobs, they would be more likely to have positive emotional responses to the business, which could further motivate employees to be creative (Fei Yang, 2019). In the relationship between employee continuance commitment and their innovative behaviors, employee job satisfaction affected employee mobility, thereby influencing employees' innovative behaviors. Employees with high satisfaction tended to be more stable and had a positive emotional response to the business, which encouraged employees to try various new ideas (Yunyu Sha, 2021). In the relationship between employees' normative commitment and their innovative behaviors, employee job satisfaction affected the sense of obligation, responsibility, and morality. Employees with high satisfaction paid more attention to the quality of work and were more responsible, hereby stimulating employees' creativity (Chao Yan, Qian Yang, et al., 2010). Therefore, the research hypotheses were proposed as follows:

H4a: Knowledge workers' job satisfaction mediates the relationship between affective commitment and innovative behaviors

H4b: Knowledge workers' job satisfaction mediates the relationship between continuance commitment and innovative behaviors

H4c: Knowledge workers' job satisfaction mediates the relationship between normative commitment and innovative behaviors

3.2 Research design

3.2.1 Design of the scale

Likert scale (Likert, R., 1932) provided reference for the design of scale in the paper. Regarding the organizational commitment scale, Agarwal & Sajid's (2017) 3-Dimensional organizational commitment scale was taken for reference, in which a total of 15 options were designed, including 5 options for emotional commitment, continued commitment, and normative commitment respectively.

Regarding the employee job satisfaction scale, a revised Minnesota satisfaction questionnaire developed by Xiaoning Zhang and Ying Gu (2010) was taken for reference, in which a total of five options were designed.

Regarding the employee innovative behavior scale, a employee innovative behavior scale developed by Bjorn Willy Amo (2006) was taken for reference, in which a total of five options were designed.

3.2.2 Questionnaire distribution and recovery

The questionnaires were distributed in the form of paper and electronic ones. The research areas covered Beijing, Tianjin, Hebei, Shanxi and other places, and the research industry included manufacturing, construction, IT services, finance, etc. The target employees held a college degree or above (knowledge workers). This survey lasted for more than two months, and a total of 588 questionnaires were collected, with 530 valid questionnaires and an effective response rate of 90.14%. See table 1 for details.

Table 1 Distribution of sample characteristics (N=530)

Characteristic variables	Attributes	N	Proportion
Gender	Male	280	52.83%
	Women	250	47.17%
Age	Under 25	118	22.26%
	25-35 years old	316	59.62%
	35-45 years old	88	16.60%
	45 years and over	8	1.51%
Experience	Less than 1 year	96	18.11%
	1~3 years	80	15.09%
	3~5 years	96	18.11%
	5~10 years	184	34.72%
	More than 10 years	74	13.96%
Educational attainment	Junior college degree	30	5.66%
	Undergraduate	356	67.17%
	Master degree or above	144	27.17%
Job level	Operatives	184	34.72%
	First line Manager	190	35.85%
	Middle manager	13	24.91%
	Senior Managers	24	4.53%
Nature of work	Technology/R&D	136	25.66%
	Manufacturing	48	9.06%
	Financial affairs	92	17.36%
	Market	94	17.74%
	Administration/HR	122	23.02%
	Other	38	7.17%
Nature of business	State owned enterprises	88	16.60%
	Government sectors	28	5.28%
	Private enterprises	322	60.75%
	Foreign enterprises	76	14.34%

Characteristic variables	Attributes	N	Proportion
Industry	Joint ventures	16	3.02%
	Service sector	188	35.47%
	Building sector	68	12.83%
	IT services	110	20.75%
	Financial sector	88	16.60%
	Other	76	14.34%

4. Empirical analysis

4.1 Reliability and validity test

The reliability and validity of the questionnaire was tested by using software SPSS23.0 and the results were as follows.

Table 2 Reliability analysis

Cronbach's α	Cronbach's α based on standardized terms	Items
.727	.724	33

Table 2 showed that the Cronbach's α value was greater than 0.700, indicating a good internal consistency of the scale test.

Table 3 KMO and Bartlett's test

KMO and Bartlett's test		
KMO Sampling Suitability Quantity		.766
Bartlett's test of sphericity	Approximate chi-square	1674.632
	Degrees of freedom	528
	Significance	.000

Table 3 showed that the KMO value was greater than 0.700 and the p-value was less than 0.05, indicating that the data validity of the scale was high and suitable for factor analysis.

4.2 Regression analysis

Taking software SPSS23.0, regression analysis of knowledge workers' organizational commitment and their innovative behaviors, knowledge workers' organizational commitment and their job satisfaction, and knowledge workers' job satisfaction and their innovative behaviors were carried out respectively, and the results were as follows.

4.2.1 Regression analysis of knowledge workers' organizational commitment and their innovative behaviors

Organizational commitment, affective commitment, continuance commitment and normative commitment were set as independent variables, and innovative behavior was set as the dependent variable, and the regression results were shown in table 4.

Table 4 Regression results of knowledge workers' organizational commitment and their innovative behaviors

Model	Unstandardized coefficient		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	1.366	.175		7.802	.000		
Organizational commitments	.156	.048	.144	3.227	.001	.882	1.134
Affective commitment	.106	.042	.109	2.559	.011	.959	1.043
Continuance commitment	.102	.046	.096	2.197	.028	.920	1.087
Normative commitments	.135	.054	.108	2.484	.013	.919	1.088

Note: N=530, * indicates P<0.05, ** indicates P<0.01, *** indicates P<0.001

Table 4 showed that the F-value was significant at the level of 0.000, and the regression coefficient of organizational commitment on innovative behaviors was 0.156 (P<0.05), which indicated that knowledge workers' organizational commitment had a significant positive effect on their innovative behaviors. In other words, with the increase of knowledge workers' organizational commitment, their innovative behaviors would be improved, and H1 is verified.

Meanwhile, the F-values of the regression of affective commitment, continuance commitment, normative commitment and innovative behaviors were all significant at the level of 0.000. The regression coefficient between affective commitment and innovative behaviors was 0.106 (P<0.05), the regression coefficient between continuance commitment and innovative behaviors was 0.102 (P<0.05), and the regression coefficient between normative commitment and innovative behaviors was 0.135 (P<0.05), which indicated that the knowledge workers' affective, continuance, and normative commitment would have some positive effects on the innovative behaviors, and H1a, H1b, and H1c were verified.

4.2.2 Regression analysis of knowledge workers' organizational commitment and their job satisfaction

Organizational commitment, affective commitment, continuance commitment and normative commitment were set as independent variables, and employee job satisfaction was set as dependent variable, and the regression results were shown in table 5.

Table 5 Regression results of knowledge workers' organizational commitment and their job satisfaction

Model	Unstandardized coefficient		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF

(Constant)	1.483	.167		8.905	.000		
Organizational commitments	.114	.046	.110	2.473	.014	.882	1.134
Affective commitment	.122	.040	.132	3.077	.002	.959	1.043
Continuance commitment	.109	.044	.108	2.473	.014	.920	1.087
Normative commitments	.112	.052	.095	2.165	.031	.919	1.088

Note: N=530, * indicates P<0.05, ** indicates P<0.01, *** indicates P<0.001

Table 5 shows that the F-value was significant at the level of 0.000 and the regression coefficient of organizational commitment and employee job satisfaction was 0.114 (p<0.05), which indicated that knowledge workers' organizational commitment had a significant positive effect on their job satisfaction. In other words, with the increase of knowledge workers' organizational commitment, the employee job satisfaction would be increased, and H2 was verified.

Meanwhile, the F-values of the regression of affective commitment, continuance commitment, normative commitment and innovative behaviors were all significant at the level of 0.000. The regression coefficient between affective commitment and employee job satisfaction was 0.122 (P<0.05), the regression coefficient between continuance commitment and employee job satisfaction was 0.109 (P<0.05), and the regression coefficient of normative commitment on employee job satisfaction was 0.112 (P<0.05), which indicated that the knowledge workers' affective commitment, continuance commitment, and normative commitment would have some positive effects on employee job satisfaction, and H2a, H2b, and H2c were verified.

4.2.3 Regression analysis of knowledge workers' job satisfaction and their innovative behaviors

Employee job satisfaction was set as the independent variable and innovative behavior was set as the dependent variable, and the regression results were shown in table 6.

Table 6 Regression results of knowledge workers' job satisfaction and their innovative behaviors

Model	Unstandardized coefficient		Standardized coefficient	t	Significance	Collinearity statistics	
	B	Standard error	Beta			Tolerances	VIF
(Constant)	2.135	.127		16.861	.000		
Employee job satisfaction	.142	.045	.135	3.122	.002	1.000	1.000

Note: N=530, * indicates P<0.05, ** indicates P<0.01, *** indicates P<0.001

Table 6 showed that the F-value was significant at the level of 0.000 and the regression coefficient of employee job satisfaction and innovative behaviors was 0.142 (p<0.05), which indicated that knowledge workers' job

satisfaction had a positive effect on their innovative behaviors. In other words, the higher the job satisfaction of knowledge workers, the more it could stimulate their innovative behaviors, and H3 was verified.

4.2.4 Analysis of the mediating role of knowledge workers' job satisfaction between organizational commitment and innovative behaviors

Based on the two variables of organizational commitment and innovative behavior, employee job satisfaction was introduced as a mediating variable to establish a mediation model, as shown in figure 1.

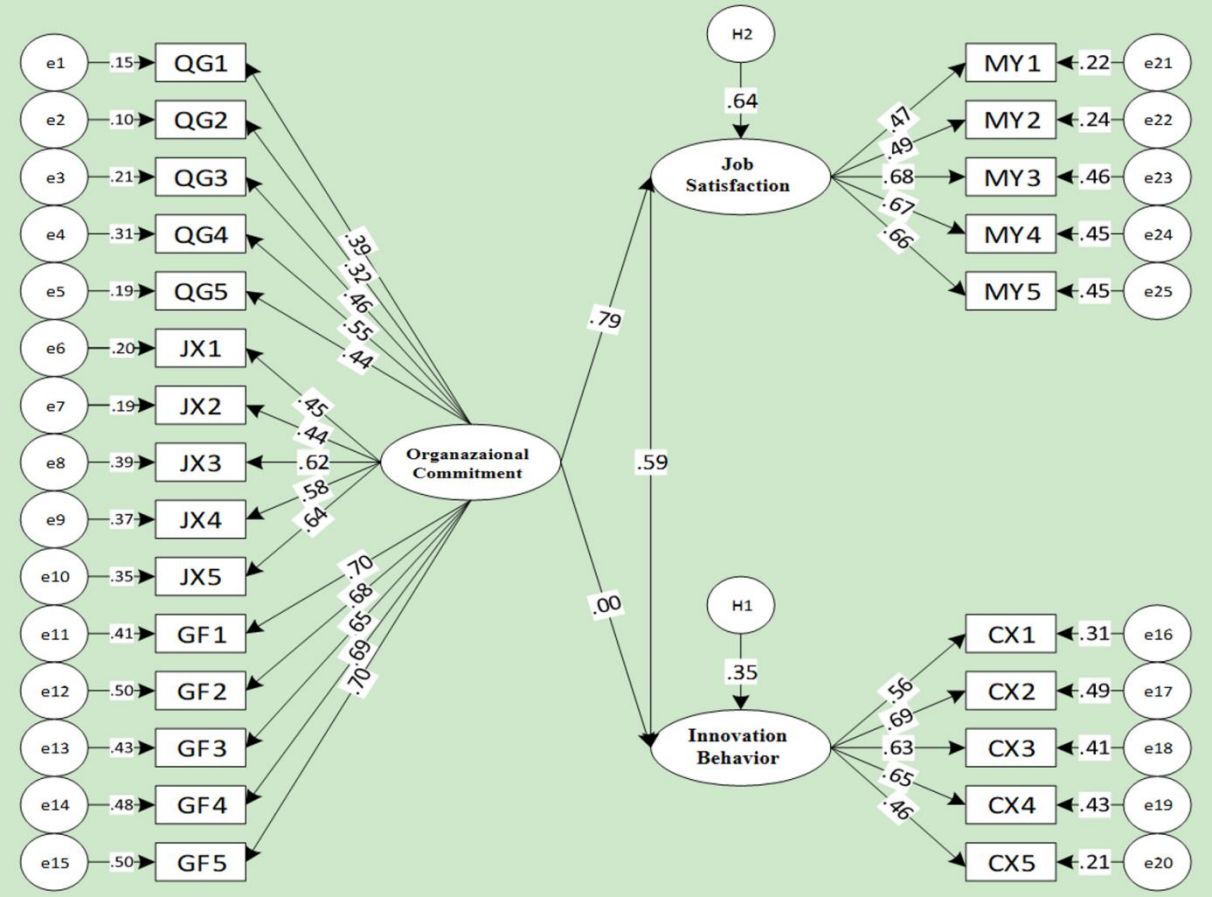

Figure 1 The mediating model of the effects of knowledge workers' organizational commitment on their innovative behaviors

The standardized path coefficients and fitting indicators of the mediation model were obtained and shown in table 7.

Table 7 The mediating model path coefficients and fitting results of the effects of knowledge workers' organizational commitment on their innovative behaviors

Path	Standardized path	S.E.	C.R.	P
Organizational commitment → Employee satisfaction	.810	.093	6.365	***
Employee satisfaction → Innovative behavior	.609	.205	3.439	***

Organizational commitment → Innovative behavior	.001	.123	.002	.995
Fitness index	X^2 /df=1.246, GFI=0.904, NFI=0.904 TLI = 0.966, CFI = 0.975, RMSEA = 0.028			

Note: *** indicates p<0.001

Table 7 showed that in the mediation model of the impact of knowledge workers' organizational commitment on innovative behaviors, X2 /df=1.246, GFI=0.904, NFI=0.904, TLI=0.966, CFI=0.975, RMSEA=0.028, which met the the judgment criteria, indicating that the model fitted well. After adding the mediating variable of employee job satisfaction, the standardized path coefficient of knowledge workers' organizational commitment on innovative behaviors was 0.001, P>0.05, the indirect effect was significant, and the direct effect was not significant, which indicated that the knowledge workers' job satisfaction played a fully mediating role in organizational commitment and innovative behaviors, and H4 was verified.

Similarly, based on the two variables of affective commitment and innovative behavior, employee job satisfaction was introduced as a mediating variable to establish a mediation model, as shown in figure 2.

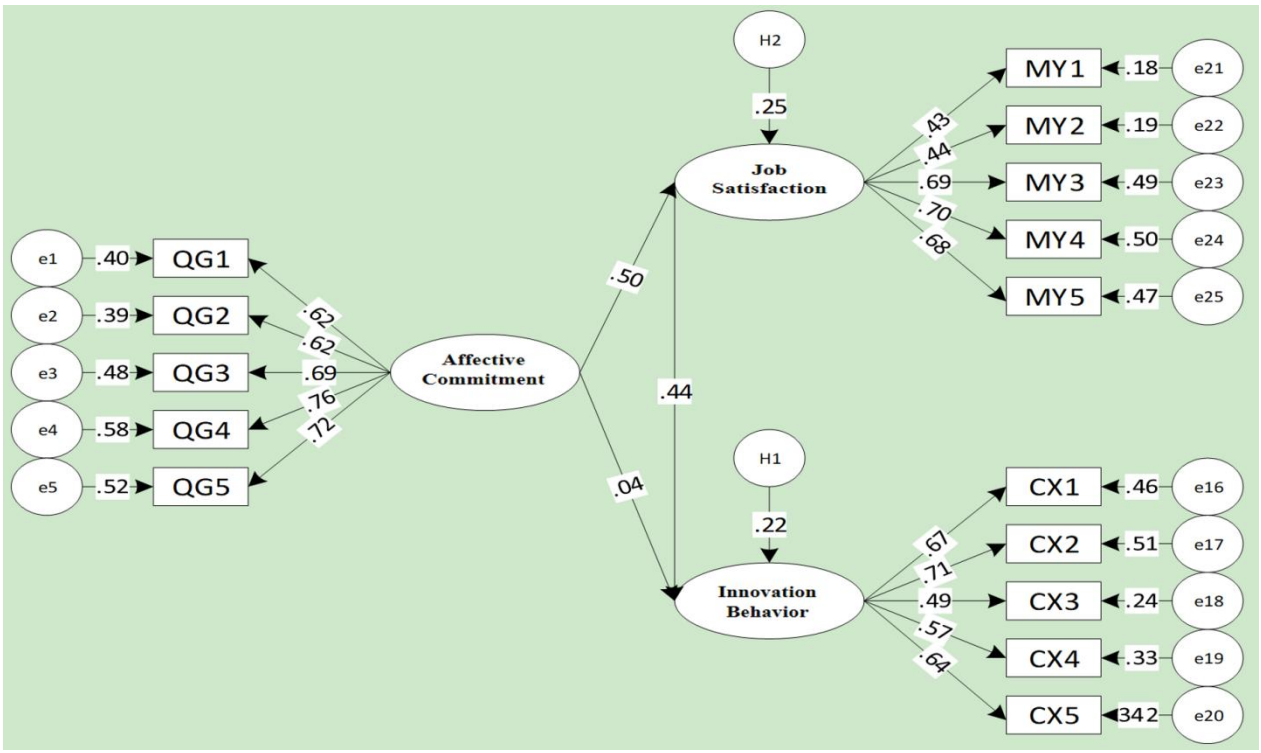

Figure 2 The mediating model of the effects of knowledge workers' affective commitment on their innovative behaviors

The standardized path coefficients and fitting indicators of the mediation model were obtained and shown in table 8.

Table 8 The mediating model path coefficients and fitting results of the effects of knowledge workers' affective commitment on their innovative behaviors

Path	Standardized path	S.E.	C.R.	P
Affective commitment →	.517	.052	5.118	***

Employee satisfaction → Innovative behavior	.456	.168	4.068	***
Affective commitment → Innovative behavior	.062	.068	0.738	.457
Fitness index	X^2 /df=1.273, GFI=0.960, NFI=0.944 TLI = 0.986, CFI = 0.985, RMSEA = 0.030			

Note: *** indicates p<0.001

Table 8 showed that in the mediation model of the impact of knowledge workers' affective commitment on innovative behaviors, X2 /df=1.273, GFI=0.960, NFI=0.944, TLI=0.986, CFI=0.985, RMSEA=0.030, which met the the judgment criteria, indicating that the model fitted well. After adding the mediating variable of employee job satisfaction, the standardized path coefficient of knowledge workers' affective commitment on innovative behaviors was 0.062, P>0.05, the indirect effect was significant, and the direct effect was not significant, which indicated that the knowledge workers' job satisfaction played a fully mediating role in affective commitment and innovative behaviors, and H4a was verified.

Similarly, based on the two variables of continuance commitment and innovative behavior, employee job satisfaction was introduced as a mediating variable to establish a mediation model, as shown in figure 3.

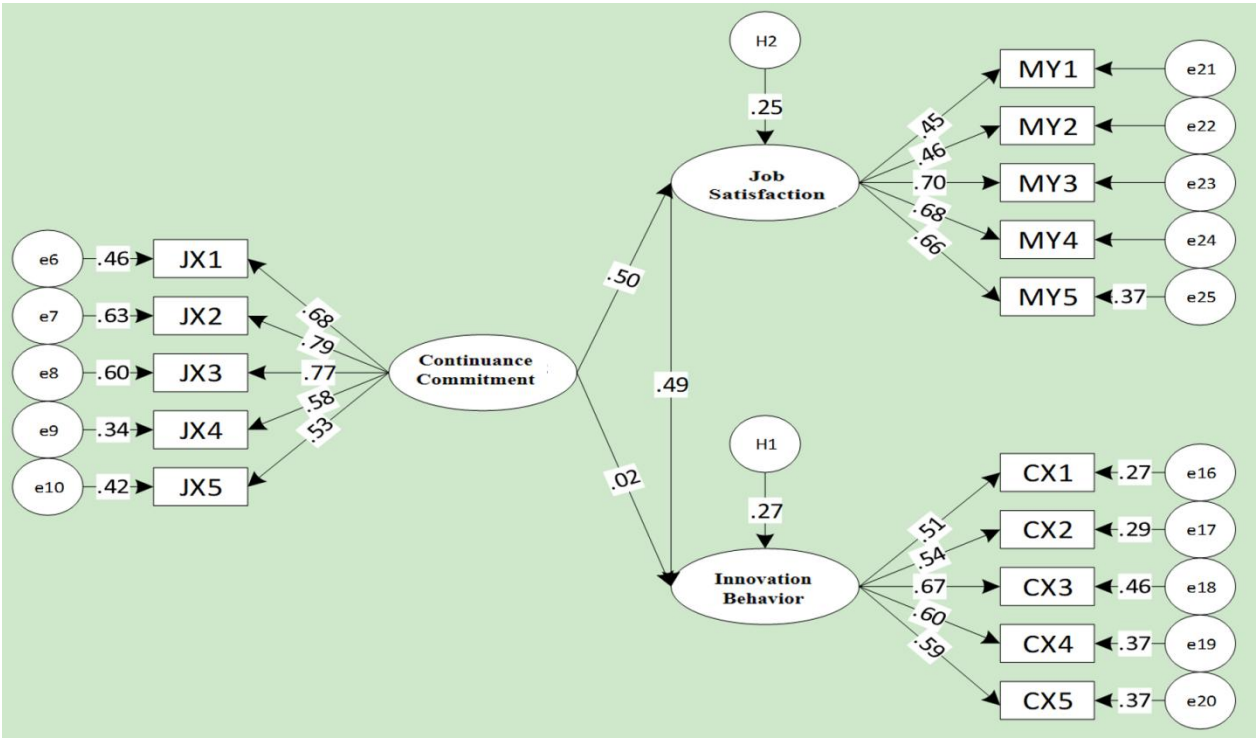

Figure 3 The mediating model of the effects of knowledge workers' continuance commitment on their innovative behaviors

The standardized path coefficients and fitting indicators of the mediation model were obtained and shown in table 9.

Table 9 The mediating model path coefficients and fitting results of the effects of knowledge workers'

continuance commitment on their innovative behaviors

Path	Standardized path	S.E.	C.R.	P
continuance commitment → Employee satisfaction	.520	.050	5.208	***
Employee satisfaction → Innovative behavior	.511	.159	4.126	***
Continuance commitment → Innovative behavior	.040	.058	0.474	.632
Fitness index	X^2 /df=2.089, GFI=0.944, NFI=0.912 TLI = 0.915, CFI = 0.950, RMSEA = 0.041			

Note: *** indicates p<0.001

Table 9 showed that in the mediation model of the impact of knowledge workers' continuance commitment on innovative behaviors, X2 /df = 2.089, GFI = 0.944, NFI = 0.912, TLI = 0.915, CFI = 0.950, RMSEA = 0.041, which met the the judgment criteria, indicating that the model fitted well. After adding the mediating variable of employee job satisfaction, the standardized path coefficient of knowledge workers' continuance commitment on innovative behaviors was 0.040, P>0.05, the indirect effect was significant, and the direct effect was not significant, which indicated that the knowledge workers' job satisfaction played a fully mediating role in continuance commitment and innovative behaviors, and H4b was verified.

Similarly, based on the two variables of normative commitment and innovative behavior, employee job satisfaction was introduced as a mediating variable to establish a mediation model, as shown in figure 4.

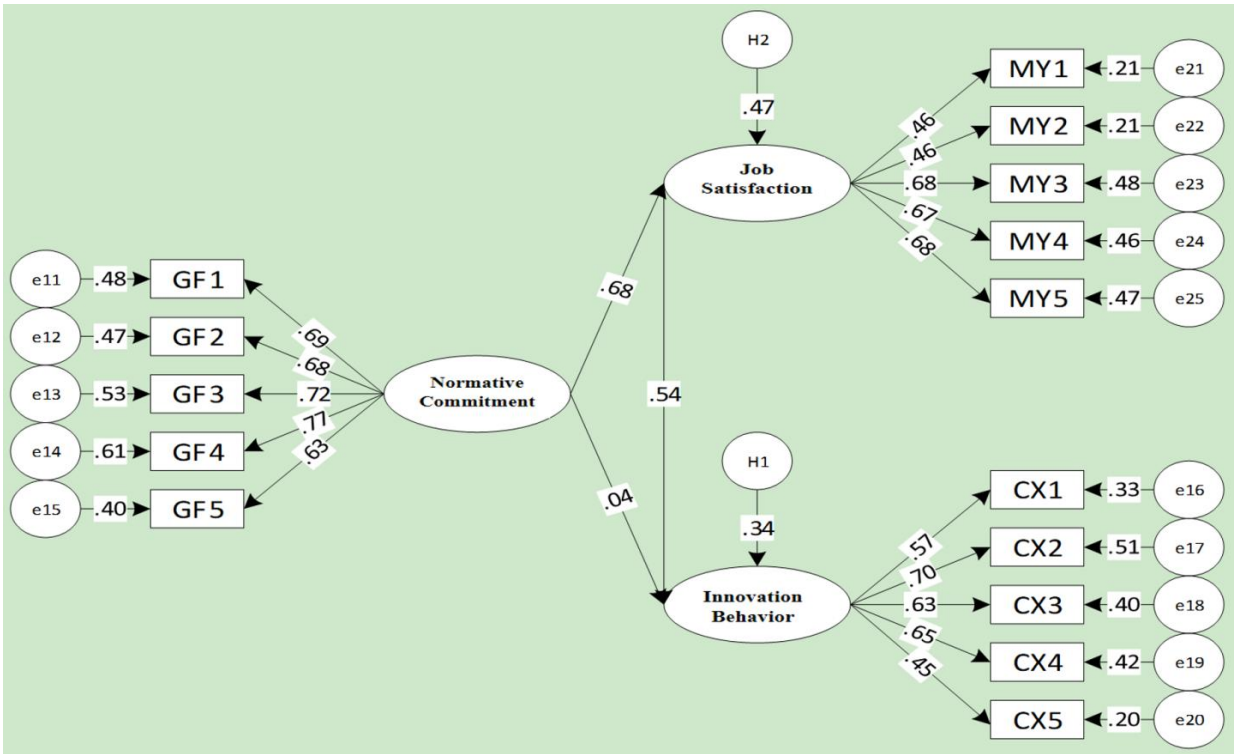

Figure 4 The mediating model of the effects of knowledge workers' normative commitment on their innovative behaviors

The standardized path coefficients and fitting indicators of the mediation model were obtained and shown in table 10.

Table 10 The mediating model path coefficients and fitting results of the effects of knowledge workers' normative commitment on their innovative behaviors

Path	Standardized path	S.E.	C.R.	P
Normative commitment → Employee Satisfaction	.681	.061	6.235	***
Employee satisfaction → Innovative behavior	.558	.170	3.928	***
Normative commitment → Innovative behavior	.055	.073	0.506	.609
Fitness index	X^2 /df=1.603, GFI=0.952, NFI=0.935 TLI = 0.954, CFI = 0.973, RMSEA = 0.025			

Note: *** indicates p<0.001

Table 10 showed that in the mediation model of the impact of knowledge workers' normative commitment on innovative behaviors, X2 /df = 1.603, GFI = 0.952, NFI = 0.935, TLI = 0.954, CFI = 0.973, RMSEA = 0.025, which met the the judgment criteria, indicating that the model fitted well. After adding the mediating variable of employee job satisfaction, the standardized path coefficient of knowledge workers' normative commitment on innovative behaviors was 0.055, P>0.05, the indirect effect was significant, and the direct effect was not significant, which indicated that the knowledge workers' job satisfaction played a fully mediating role in normative commitment and innovative behaviors, and H4c was verified.

4.3 Hypotheses verification

All the 13 research hypotheses proposed were verified , and the summary of results was shown in Table 11.

Table 11 Results of hypotheses verification

Symbols	Contents	Results
H1	Knowledge workers' Organizational commitment had a positive effect on their innovative behaviors	Yes
H1a	Knowledge workers' affective commitment had a positive effect on their innovative behaviors	Yes
H1b	Knowledge workers' continuing commitment had a positive effect on their innovative behaviors	Yes
H1c	Knowledge workers' normative commitment had a positive effect on their innovative behaviors	Yes
H2	Knowledge workers organizational commitment had a positive effect on their job satisfaction	Yes
H2a	Knowledge workers' affective commitment had a positive effect on their job satisfaction	Yes

H2b	Knowledge workers' continuance commitment had a positive effect on their job satisfaction	Yes
H2c	Knowledge workers' normative commitment had a positive effect on their job satisfaction	Yes
H3	Knowledge workers' job satisfaction has a positive effect on their innovative behaviors	Yes
H4	Knowledge workers' job satisfaction mediates the relationship between organizational commitment and innovative behaviors	Yes
H4a	Knowledge workers' job satisfaction mediates the relationship between affective commitment and innovative behaviors	Yes
H4b	Knowledge workers' job satisfaction mediates the relationship between continuance commitment and innovative behaviors	Yes
H4c	Knowledge workers' job satisfaction mediates the relationship between normative commitment and innovative behaviors	Yes

5. Conclusions and Suggestions

5.1 Main conclusions

Taking questionnaires and tools as SPSS23.0 and AMOS21.0, this paper provided an in-depth analysis of the relationship between knowledge workers' organizational commitment, job satisfaction and innovative behaviors, and drew some main research conclusions as follows.

Firstly, knowledge workers' organizational commitment had a significant positive effect on their innovative behaviors. Organizational commitment of knowledge workers was a reflection of their attitude towards the whole organization, and the more positive the attitude was, the more it could stimulate their innovative consciousness and behaviors. Among which, knowledge workers' affective commitment, continuance commitment and normative commitment also had some significant positive effects on innovative behaviors. Affective commitment was the employee's recognition and dependence on the organization, when employees highly recognized the organization, they tended to enhance the willingness to invest, thus stimulating innovative behaviors.

Secondly, knowledge workers' organizational commitment had a significant positive effect on job satisfaction. Knowledge workers often had some strong desires to realize their self-worth and were more enthusiastic about challenging and creative tasks. When they recognized their organization and believed that it could bring value to them and realized their wishes. And they would be more satisfied with their work and more willing to commit themselves. Similarly, knowledge workers' affective commitment, continuance commitment and normative commitment had some significant positive effects on job satisfaction. The more the knowledge workers identified with and relied on the organization, the lower their willingness to resign, and the higher their job satisfaction. In addition, knowledge workers were usually more ethical and responsible, and would be more positive and proactive in their work, which would also increase job satisfaction.

Thirdly, knowledge workers' job satisfaction had a significant positive effect on their innovative behaviors. The results of the study showed that the regression coefficient of knowledge workers' job satisfaction and innovative behaviors was 0.140, $P<0.05$. The value was high, reflecting that knowledge workers' job satisfaction would have some positive impacts on their innovative behaviors. As mentioned earlier, knowledge workers were usually a group with higher level of needs, and had the enthusiasm and motivation to work without raising the whip. When knowledge workers recognized the organization and had high job satisfaction, they would undoubtedly release greater work potential and burst more innovative vitality.

Fourthly, knowledge workers' job satisfaction played a fully mediating role between organizational commitment and innovative behaviors. The structural equation model showed that the path of knowledge workers' organizational commitment to innovative behaviors has changed after adding the mediating variable of job satisfaction. The direct effect was no longer significant, and the indirect effect became significant, which indicated that knowledge workers' job satisfaction played a fully mediating role between organizational commitment and innovative behaviors. Only when the knowledge workers were satisfied with the work environment, job content, etc., they would develop a positive work attitude and attitude, thereby demonstrating a stronger intention and motivation for innovation. Similarly, knowledge workers' job satisfaction played a fully mediating role between affective commitment,

continuance commitment, normative commitment and innovative behaviors respectively. It was not difficult to understand that knowledge employees' emotion, recognition, and commitment to the organization were largely built on the basis of job satisfaction to a large extent. According to two-factor theory (Herzberg F., Mausner B., et al., 1959), motivating factors were related to the work itself or the content of the work, including achievement, appreciation, the meaning and challenge of the work itself, responsibility, promotion, development, etc., which also happened to be the contents of knowledge workers cared about and valued the most. Therefore, It was the best way to stimulate knowledge workers' innovative behaviors by enhancing the job satisfaction.

5.2 Countermeasures and suggestions

The conclusions provided a new understanding of the relationship among knowledge workers' organizational commitment, job satisfaction, and innovative behaviors, and also provided a solid basis for how enterprises treated them and stimulated their innovative behaviors. In the context of fierce market competition and fast changing environment, innovation has become a key factor for the survival and development of enterprises. Knowledge workers possessed a vast amount of professional knowledge and skills, playing a core role in promoting enterprise innovation and enhancing core competences. Based on the above, the following countermeasures and suggestions were proposed.

Firstly, to design a clear career development path. In the workplace, employees in enterprises had a desire and demand for growth, development, and satisfaction from their work, especially for knowledge workers. They belonged to self actualizing talents, and had a stronger desire for growth and development. It was crucial for attracting, motivating, and retaining excellent knowledge workers to establish an effective career development path,which not only helped them achieve personal value and growth, but also enhanced their loyalty and sense of belonging to the business.

Secondly, to provide more opportunities for learning and training. In today's fiercely competitive business environment, continuous learning and improvement of one's abilities have become very necessary for employees to pursue career success. Knowledge workers often had a strong self motivation and expected to update their knowledge and skills constantly. Therefore, enterprises should meet the growth needs of knowledge workers by providing various learning opportunities, thereby achieving overall sustainable development of the enterprise.

Thirdly, to establish effective incentive mechanisms. Knowledge workers often had a high level of demand. Except for material incentives such as salary, bonuses, and benefits, enterprises should also offer some non-material incentives such as praise, recognition, and promotion to stimulate their enthusiasm and creativity.

Fourthly, to create a good working environment and corporate culture. On the one hand, enterprises should stimulate knowledge workers' innovation enthusiasm by paying attention to their psychological feelings, improving their work environment, alleviating their work pressure, and enhancing their job satisfaction. On the other hand, enterprises should insist on the employee oriented policy, enhance their sense of belonging, and create a work atmosphere of "chasing after each other and striving for excellence".

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Beyond the clock: Investigating work connectivity behavior after-hours and its influence on newcomers' organizational socialization

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Abstract

Purpose - Based on the job demands-resources (JD-R) model, we construct a moderated mediation model to examine the impact of work connectivity behavior after-hours (WCBA) on newcomers' organizational socialization and clarify the role of intrinsic motivation and emotional labor. Different from the previous negative or double-edged views, this study focuses on the possible positive impact of WCBA on newcomers in China. This study discusses the possible positive impact of WCBA to provide guidance and suggestions on effectively using WCBA with highly developed information and communication technology.

Design/methodology/approach - Data was collected from 296 newcomers in the service, education, finance, and other industries employed for less than one year. Then, we used SPSS and AMOS to process and analyze the data through regression analysis and bootstrap approach.

Findings - The findings demonstrate that frequent use of communication devices, supported by advanced information technology, allows newcomers to handle work matters over time effectively. WCBA has a significant and positive influence on newcomers' organizational socialization, with intrinsic motivation playing a mediating role. Specifically, surface acting negatively moderates the positive impact of WCBA on newcomers' organizational socialization, reducing the meditating role of intrinsic motivation between them. In contrast, deep acting has the opposite moderating effect.

Originality/Value - This study explores the positive impact of WCBA on newcomers' organizational socialization, emphasizes the role of intrinsic motivation and emotional labor, and expands the research perspective and field of WCBA.

Keywords Work connectivity behavior after-hours (WCBA), Organizational socialization, Intrinsic motivation, Surface acting, Deep acting

Paper type Research type

1. Introduction

As the digital trend strengthens, the popularity of social media has also grown (Obeso et al., 2023). Corporate social media is rapidly changing how employees work and

collaborate within the organization (Deng et al., 2020), with remote work becoming a part of everyday work (Yao et al., 2023). For example, we can still use mobile phones, computers and other devices to deal with work-related information after work. This typical work connectivity behavior after-hours (WCBA) refers to the behavior that employees still keep working state after work (Richardson and Benbunan-Fich, 2011). There is no consensus on the impact of WCBA (Yang et al., 2023). Many studies have focused on the negative impact or double-edged sword effect of WCBA (Dong et al., 2022, Liu et al., 2023, Yang et al., 2022b). Regrettably, few studies in the Chinese context have examined the potential positive effects of the WCBA on newcomers' organizational socialization, its internal mechanisms, and boundary conditions.

Newcomers have been recognized as the new driving force of an organization (Wu et al., 2022), and their socialization attracts researchers and practitioners, a prevalent subject of academic research (Jiang et al., 2022, Saks and Gruman, 2021). Organizational socialization refers to the process of how newcomers adjust their attitudes and behaviors to fit the organization's values, goals, and behavioral norms (Dai and Fang, 2023). Understanding newcomers' socialization process after they join the organization is of great significance. However, for newcomers who enter the organization, the new working environment is full of pressure (Tang et al., 2022), which will affect the newcomers to match with the organization, adapt to the new environment and complete the organizational socialization (Li et al., 2006). With the development of information technology, convenient communication devices have integrated work scenes and social factors, breaking the time-space barrier in organizations and promoting the establishment of employee relationship networks (Jeong et al., 2016). These advancements allow new employees to acquire social resources and offer more paths for newcomers to achieve organizational socialization. For example, employees are now able to accomplish their tasks anywhere and anytime without spatial and temporal constraints by using information and communication technology(Suh and Lee, 2017). The distinction between an employee's home and workplace has become increasingly blurred as individuals can continue working after leaving the office (Boswell and Olson-Buchanan, 2016, Yang et al., 2022b). Technology has changed how, where and when employees work (Seedoyal Doargajudhur and Hosanoo, 2022), allowing newcomers to handle work-related matters outside of regular working hours and increasing WCBA (Boswell and Olson-Buchanan, 2016, Jarvenpaa and Lang, 2005). This behavior serves as an individual complement to extra work (Ma and Tang, 2022), enhancing professional autonomy and flexibility (Zhang and Luo, 2022). For employees, using mobile devices to work after hours increases their capacity, expands their work resources, and provides good experiences (Ohly and Latour, 2014). Especially for newcomers, this extended after-hours work behavior gives them more opportunity to adapt to the position and thus adjust themselves better and faster to the new environment.

Newcomers may not fully understand the organizational culture and goals when they enter the organization, and they may only have a superficial grasp of the business skills required for the job role. On the contrary, telecommunication technologies allow newcomers to fit into the new organization and adapt to the new environment (Yang et

al., 2022b). According to the JD-R model, job resources can effectively support individuals in attaining their professional objectives (Yi et al., 2018) while mitigating the possible adverse consequences arising from job-related obligations (Bakker and Demerouti, 2007). Through using mobile devices, WCBA assists newcomers in establishing connectivity between the workplace and non-workplace (Davis, 2010), enhancing work communication and interaction with colleagues and customers (Edmondson, 2016) , and fostering a sense of job control and role integration (Mazmanian, 2013). This creates more work resources (Carmeli et al., 2009). At the same time, WCBA provides newcomers with access to additional organizational support to address job demands, helping them cope with the challenges and costs of job requirements (Cheng et al., 2021) and increasing job satisfaction (Reinke and Ohly, 2021). This will help to enhance the role identity of newcomers (Rau and Hyland, 2002) and organizational identity (van Zoonen et al., 2020), thus assisting newcomers in constructing an explicit self-concept in the new environment and realizing socialization (Yi et al., 2018).

However, previous research has focused on the negative effects of WCBA, especially on non-work domain, such as marital burnout (Wang et al., 2023b), reducing life satisfaction (Ohly and Latour, 2014), and causing work-family conflict (Barber and Jenkins, 2014, Ma et al., 2016, Richardson and Thompson, 2012, Wang et al., 2019, Wu et al., 2018). On the contrary, in the context of China, the "996" working regime (i.e. working from 9 am to 9 pm, six days a week) is ubiquitous in modern enterprises. It is common to work overtime at the company or continue to work after returning home. The continued use of cellphones to handle work during non-working hours, especially at home, represents an intrusion into family resources, thus making employees spend more time and energy on their work, and allowing more resources to flow into the work domain (Ragsdale and Hoover, 2016). Therefore, it is necessary to discuss the positive impact of WCBA in the work domain. Second, WCBA is becoming more common in organizations (Wang et al., 2021a), and there is still insufficient research in this area. Therefore, there is a need for more literature investigating the impact of WCBA on employees' role requirements in specific contexts (Yuan and Tang, 2018, Ren et al., 2022). However, there is still a lack of research on the impact of WCBA on employees' organizational socialization. Third, although there are studies investigating the negative effects of continued use of communication technologies on employees after work (Bauwens et al., 2020, Khalid et al., 2021, Yang et al., 2022b, ten Brummelhuis et al., 2021), few research has focused the perspective on new employees at present. However, we believe newcomers are more likely to take the initiative to accept WCBA and use that behaviour effectively to achieve better socialization. Taking other specific situations as the scope of the study is conducive to a comprehensive understanding of the particular role of WCBA in different situations to provide practical suggestions for effectively dealing with the impact of WCBA. In conclusion, this study aims to investigate whether WCBA will benefit newcomers' work and explain the underlying mechanism.

Previous research suggests that when newcomers are connected with work after working hours, they may increase their work autonomy, flexibility, and connectedness

(Fujimoto et al., 2016), enhancing their intrinsic motivation (Zhang and Luo, 2022). High intrinsic motivation is associated with employees being immersed in and enjoying their work (Yu et al., 2022). Consequently, we argue that newcomers with high intrinsic motivation are more likely to accept WCBA and regard it as a resource for integration into the organization. They will exhibit higher levels of empathy and pro-social behavior, contributing to socialization (Oh and Roh, 2019). Additionally, organizations are gradually focusing on the mental health of their employees (Zhu et al., 2023). The diverse emotional states of employees can significantly impact their actions and attitudes (Duan et al., 2011). Newcomers will engage in emotional labor for self-regulation, as mandated by the organization's criteria (Grandey, 2000). According to the two manifestations of emotional labor, newcomers doing deep acting will actively comply with organizational decisions and experience more positive emotions. With the continuous satisfaction of individuals' basic psychological needs, the regulation of positive emotions will further strengthen the path of intrinsic motivation at work (Yang et al., 2022a) and promote employees' sense of work accomplishment, job satisfaction, and organizational citizenship behavior (Scott and Barnes, 2011). On the contrary, newcomers who engage in surface acting consume many psychological resources and exhibit more negative emotions (Bartels et al., 2023), thus hampering organizational socialization. This research builds a moderated mediation model to investigate the impact of WCBA on newcomers' organizational socialization by using intrinsic motivation as the mediating variable and surface-acting and deep-acting as the moderating variables, which has made many contributions to the research of WCBA. First, we introduce organizational socialization and emotional labor into the study of WCBA, enriching the relevant literature on WCBA and expanding its research perspective. Second, different from the previous negative research perspective or the double-edged sword perspective based on Western countries, we discuss the positive effects of WCBA on employees in the Chinese context. Third, we conducted an empirical study on newcomers to provide practical guidance in using information technology to promote the positive impact of WCBA. It also offers reasonable suggestions for the long-term development of employees to deal with such behavior. The concept model of this study is presented in Figure 1.

[Insert Figure 1 here]

2. Theory and hypotheses

2.1 Job demand-resource model

The JD-R model assumes that all job characteristics can be modelled into demands and resources in the workplace (Bakker et al., 2014). Job demands and resources lead to job burnout and engagement (Demerouti et al., 2001). Excessive or high job demands can negatively impact employees' physical and mental well-being, deplete their resources, cause role conflicts and increase turnover intentions (Bakker and Demerouti, 2007). Conversely, job resources have a motivating effect, buffering the negative impact of job demands, promoting employee growth, enhancing job performance, and increasing work engagement (Ong and Johnson, 2023). WCBA gives newcomers a fresh work

experience, improves their control over their jobs, makes it easier for resources to flow into the work domain, and speeds up their integration into the organization. Therefore, this study explores the impact mechanism of WCBA on newcomers' organizational socialization based on the JD-R model.

2.2 Work connectivity behavior after-hours and organizational socialization

WCBA describes that employees use their cell phones for work-related purposes or to contact co-workers outside work hours (Richardson and Benbunan-Fich, 2011). Mobile devices have blurred the seamless move between non-work and work domains, with WCBA enabling employees to switch frequently between life and work roles (Barber and Jenkins, 2014). Meanwhile, WCBA, as a flexible working arrangement for employees, helps them to stay on top of their work (Mazmanian, 2013), which can increase the flexibility of newcomers' work and break down the boundaries of their work, thus enhancing their work autonomy. Due to WCBA, newcomers may have a better understanding of the role requirements the organization has for them (Mazmanian, 2013) and gain access to more resources (Carmeli et al., 2009), thereby reducing the uncertainties associated with their initial entry into the organization and increasing their understanding of the organization.

According to the JD-R model, adequate resources can promote intrinsic motivation, keep employees motivated, and help individuals grow and learn (Meena and Sarabhai, 2023). Organizational socialization is how employees transition from outsiders to insiders (Tang et al., 2022).Regarding newcomers, they may have challenges while attempting to engage in meaningful interactions with their colleagues inside the profession (Van Laethem et al., 2018). However, mobile devices have facilitated employee connectivity and provided them with more social and emotional support. WCBA helps employees overcome temporal and spatial constraints, promotes the flow of resources among diverse fields (Duxbury et al., 2014), enhances the flexibility of resource acquisition and internal work autonomy of new employees at the initial stage of entering the organization (Fujimoto et al., 2016). This facilitates newcomers to complete work tasks and enhance role identity (Rau and Hyland, 2002). On the other hand, it also improves employee communication and interaction (Fonner and Roloff, 2012). Thus, this behavior can help newcomers obtain work-related resources such as information (Nie et al., 2021) and enhance organizational identity (Zhang et al., 2020). In summary, WCBA represents an organizational citizenship behavior in which employees perform their duties outside regular working hours (Wang et al., 2023a). At the same time, WCBA provides work resources, reducing the confusion of new employees in the early stage and connecting newcomers with job responsibilities and colleagues. This enables newcomers to understand organizational-related information and learn relevant knowledge and skills more quickly (Yan and Ding, 2007), thus accelerating their organizational socialization process. Hence, we propose the following hypothesis:

Hypothesis 1. WCBA positively affects newcomers' organizational socialization.

2.3 The mediating effect of intrinsic motivation

Intrinsic motivation is linked to various positive outcomes (Kuvaas et al., 2017), such as high-performance levels, creative behavior, job persistence, job satisfaction, and psychological well-being (Amabile et al., 1994). Maintaining and enhancing intrinsic motivation requires supportive conditions (Organ and Ryan, 1995). According to Yi et al. (2018), due to the varying nature of stress, intrinsic motivation can have a differential effect on the basic psychological needs of employees, such as competence, independence, and interpersonal connections, which can either motivate or inhibit their intrinsic motivation. WCBA, as a flexible work behavior, enables employees to allocate their work time rationally and gives them more autonomy in their work (Sripirabaa and Maheswari, 2015). Therefore, WCBA can reduce stress in balancing the demands of work-nonwork domains, which motivates the individual to move forward. Moreover, this work connectivity behavior helps to enhance employees' sense of control and enhance their perception of their self-worth(Sun et al., 2024). Thus, this autonomous work arrangement can stimulate employees' intrinsic motivation (Qi, 2017, Yuan et al., 2022). Based on the above discussion, we propose the following hypothesis:

Hypothesis 2. WCBA positively affects intrinsic motivation.

Intrinsic motivation has a substantial and positive relationship with various work attitudes and behaviors among employees (Tu and Lu, 2013). When intrinsic motivation increases to a higher level, employees tend to make more efforts at work and further promote organizational citizenship behavior (Hai and Park, 2021). For newcomers, higher-level intrinsic motivation prompts them to engage in more information-seeking behaviors, which helps them achieve role clarity, task mastery, and social integration (Saks et al., 2011). This enhances newcomers' organizational identity and role identity, thus showing higher organizational commitment and task performance (Chen and Liu, 2019), and promotes organizational socialization. As such, we propose the following hypothesis:

Hypothesis 3. Intrinsic motivation positively affects newcomers' organizational socialization.

WCBA enables newcomers to deal with the relationship between work and life more flexibly. For instance, newcomers can handle urgent work tasks at home, potentially improving their efficiency, job satisfaction and work engagement (Cheng et al., 2023). WCBA also aids newcomers in obtaining more resources as their subjective initiative increases (Zhang and Xiao, 2016). According to the JD-R model, the support of job resources can subsequently stimulate newcomers' intrinsic motivation, which encourages them to increase work commitment (Yu et al., 2022). At the same time, WCBA can promote interpersonal interactions within the organization to satisfy their relational needs (Ohly and Latour, 2014). Furthermore, the satisfaction of competence, autonomy, and relational needs can trigger positive emotions and stimulate intrinsic motivation (Cheng et al., 2023). On the other hand, the JD-R model believes that high job requirements will make individuals emotionally vulnerable. To alleviate the emotional loss caused by workplace events, individuals tend to be more motivated to

innovate and change to ensure the consistency of cognition and behavior (Li et al., 2022). WCBA makes employees still unable to get away from their work after work. In the case of being unable to change the work situation, it can strengthen individuals' intrinsic motivation to actively adapt to this work mode to complete the job requirements better. Organizational socialization represents the process by which new employees reshape their organizational roles and become members of various groups when they enter an organization (Yan et al., 2011). Communication with organizational insiders and customers or handling work tasks through mobile devices outside of working hours can help newcomers integrate into the organization more quickly and improve their work performance. While access to organizational resources helps satisfy their perceived competence, newcomers with high intrinsic motivation demonstrate higher levels of empathy and pro-social behaviors (Oh and Roh, 2019), resulting in more organizational citizenship behaviors and promoting organizational socialization. Therefore, we propose the following hypothesis:

Hypothesis 4. Intrinsic motivation mediates the relationship between WCBA and newcomers' organizational socialization.

2.4 The moderating effect of emotional labor

The concept of "emotional labor" was initially used by Hochschild (1979), who also noted that it is a type of labor that is separate from mental and physical labor and is frequently utilized in daily life (Hochschild, 1983). According to Morris and Feldman (1996), emotional labor encompasses the exertion, strategic preparation, and regulation required to display emotions that align with the expectations of an organization during interpersonal exchanges. Emotional labor has two distinct manifestations: deep acting, which entails the internal adjustment of genuine emotions to align with outward expressions, and surface acting, which involves the deliberate fabrication of affective displays (Hochschild, 1983). Deep acting is strongly associated with expressing positive emotions and surface acting with hiding negative emotions (Kammeyer-Mueller et al., 2013).

Emotional labor, as part of an employee's duties (Silard et al., 2022), requires constant changes in the emotions felt or displayed by employees to comply with workplace rules that can reduce workers' emotional resources (McGinley and Wei, 2020). Thus, employees need to regulate their emotions and present a positive and kind attitude at every moment to complete their work tasks (Wang et al., 2021b). According to Affective Event Theory (AET), the work environment affects individual emotions and behavior (Duan et al., 2011). Positive emotions are strongly linked to positive work attitudes, encouraging employees to actively complete tasks and concentrate on acquiring resources for their jobs. In contrast, negative emotions make employees more stressed out, more likely to quit their jobs, and less satisfied with their jobs (Zhang et al., 2020). When engaging in WCBA, newcomers who adopt surface acting will consume many psychological resources due to the blurring of the boundary between work and life, making it difficult for them to maintain positive emotions. Therefore, they need to frequently adjust the difference between inner feelings and external expressions and carry out fake or false performances (Park and Hur, 2023). As a result, this causes

internal disharmony and leads to a decline in intrinsic motivation (Rui and Song, 2020). On the contrary, deep-acting behavior can alleviate newcomers' negative emotions to a certain extent and even generate positive emotions (Liu et al., 2014) and identify with their work from the inside when WCBA occurs, prompting them to focus on the work itself and maintain long-term enthusiasm for the work. Deep acting can make an individual's emotional expression consistent with their inner experience and effectively stimulate and maintain higher internal motivation (Rui and Song, 2020). In summary, we propose the following hypotheses:

Hypothesis 5. Surface acting negatively moderates the positive relationship between WCBA and intrinsic motivation.

Hypothesis 6. Deep acting positively moderates the positive relationship between WCBA and intrinsic motivation.

The working environment for newcomers is entirely new to them and full of uncertainty. Maintaining a positive mood is especially important for newcomers (Chi and Wang, 2018). Therefore, employers must encourage them to take initiative and perform tasks with long-lasting intrinsic motivation from the heart (Luo et al., 2016). When participating in the WCBA, newcomers adopt surface acting and constantly display emotions that are appropriate to the demands of the job, which will consume a large number of psychological resources and energy (Yi and Chen, 2021) and reduce their intrinsic motivation, making new employees less likely to engage in information-seeking behaviors, reducing their role identity and organizational identity, and thereby weakening the degree of their organizational socialization. On the contrary, newcomers who engage in deep acting behaviors also maintain higher intrinsic motivation when taking WCBA (Wang et al., 2009), enhance their self-beliefs and sense of significance in adapting to the job and completing tasks (Shen et al., 2012), and facilitate their socialization process. In summary, we propose the following hypotheses:

Hypothesis 7. Surface acting negatively moderates the mediating role of intrinsic motivation between WCBA and newcomers' organizational socialization.

Hypothesis 8. Deep acting positively moderates the mediating role of intrinsic motivation between WCBA and newcomers' organizational socialization.

3. Methods

3.1 Samples and procedure

Based on the previous analysis, we believe that investigating the influence of WCBA on newcomers' organizational socialization holds both practical and theoretical significance. In the process of sample collection, a pre-survey was conducted before the formal research to ensure the accuracy of survey data. Since the questionnaires were mainly translated from English, this was done to enhance the reliability of the study. The formal survey was conducted through online platforms. Second, our research objects are mainly new employees from the service, education, and finance industries who have been working for less than one year. Because in these industries, it is more common to use mobile devices to do work at any time. Meantime, new employees are

more likely to accept the organization's disguised overtime behavior than old employees. Finally, before handing out the questionnaire, we made it clear to participants that the questionnaire was for academic purposes only and committed to protecting any information on the participants' data. Ultimately, we have recovered 330 questionnaires. After excluding the invalid questionnaires with too short response time and too high a frequency of continuous occurrence of the same answer, 296 valid questionnaires remained, with an effective questionnaire recovery rate of 89.7%. Demographic information is shown in Table 1.

[Insert Table 1 Here]

3.2 Measures

We assessed each variable based on modifications of well-established scales, all self-assessed by the employees and measured using a five-point Likert scale.

3.2.1 Work connectivity behavior after-hours. This variable was measured by seven items from Richardson and Thompson (2012), including frequency of occurrence and duration dimensions. The frequency of occurrence dimension includes three items, with item answers ranging from 1 (never) to 5 (very often). The duration dimension had four components, where "1" represented a period of 0-15 minutes, "2" represented a period of 16-30 minutes, "3" represented a period of 31-60 minutes, "4" represented 1-2 hours, and "5" represented a period beyond 2 hours. The value of Cronbach's alpha is 0.807.

3.2.2 Intrinsic motivation. Intrinsic motivation was adapted from the job preference scale developed by Amabile et al. (1994), in which the intrinsic motivation subscale consists of six items such as "I want my job to increase my knowledge and skills" (1 = strongly disagree, 5 = strongly agree). The value of Cronbach's alpha is 0.891.

3.2.3 Emotional labor. We measured emotional labor from Grandey's (2003) two-dimensional. Based on the findings in this study, specific topics are appropriately altered. Questions 1-3 refer to surface acting, such as "I pretend to be in a good mood at work, even if I am not", and Cronbach's alpha is 0.707; questions 4-7 refer to deep acting, such as "I try to overcome my negative emotions at work and work in a good mood from the bottom of my heart," (1 = strongly disagree, 5 = strongly agree) and the Cronbach's alpha value is 0.714.

3.2.4 Newcomers' organizational socialization. This variable was adapted from Yan's (2018) findings and adopted his scale designed for the Chinese context, which was modified to meet the needs of this study and retained a total of 14 question items, such as "I am clear about the job content and responsibilities I have to undertake at work" (1 = strongly disagree, 5 = strongly agree). The value of Cronbach's alpha is 0.916.

4. Results

4.1 Confirmatory factor analysis and common method bias

This study utilized AMOS 26.0 software to conduct a factor analysis that was previously verified. This analysis aimed to evaluate the discriminant validity of the

variables, and the results are shown in Table 2. They demonstrated that compared with other models, the indicators of the five-factor model were the superior fit ($\chi^2/df = 1.984, \text{CFI} = 0.902, \text{RMSEA} = 0.058, \text{SRMR} = 0.0615$), and the discriminant validity among variables meets the standard, which supports the hypothesis test and provides support for the use of the five-factor model in the subsequent argumentation of the following study.

[Insert Table 2 Here]

To guarantee the reliability and validity of the findings, this study employed Harman's one-factor test to examine the common method bias of the questionnaire questions, which were self-assessed by the newcomers. The findings revealed that the initial common factor explained 34.70% of the overall loadings in the absence of rotation, falling below the critical threshold of 40%. This suggests that the common method bias in this study is rather minor and warrants additional investigation.

4.2 Descriptive statistics and correlation analysis

Table 3 displays the standard deviations, correlation coefficients, and means of the variables. Among them, WCBA is significantly and positively related to newcomers' organizational socialization ($\beta = 0.491$, $p < 0.01$), WCBA is positively and significantly ($p < 0.01$) related to intrinsic motivation ($\beta = 0.596$), as well as intrinsic motivation is significantly and positively related to newcomers' organizational socialization ($\beta = 0.662$, $p < 0.01$). Hypotheses 1, 2, and 3 is preliminarily tested.

[Insert Table 3 Here]

4.3 Hypothesis testing

We used SPSS 26.0 to assess the mediation model's hierarchical regression and the bootstrap test method to test the mediation impact of intrinsic motivation. The particular findings are shown in Table 4.

[Insert Table 4 Here]

According to model 2, WCBA has a high positive predictive impact ($\beta = 0.605$, $p < 0.001$) on intrinsic motivation, supporting hypothesis 2. The results of Model 4 indicate that WCBA has a statistically significant beneficial impact on newcomers' organizational socialization. The beta coefficient for this relationship is 0.495, with a p-value of less than 0.001, providing support for hypothesis 1. Hypothesis 3 is supported by model 5 that intrinsic motivation positively affects newcomers' organizational socialization ($\beta = 0.679$, $p < 0.001$). Combining models 4 and 6 results in a decrease in the coefficient of the influence of WCBA on newcomers' organizational socialization from 0.495 ($p < 0.001$) to 0.132 ($p < 0.05$), indicating that the impact of WCBA on newcomers' organizational socialization is weakened due to the mediating role of intrinsic motivation, and thus Hypothesis 4 is initially tested.

This study continues the test using the bootstrap test method, with the participant number set to 5000 times and the confidence interval set to 95%, and the results are shown in Table 5. When the indirect effect of intrinsic motivation is significant ($\text{BootLLCI} = 0.2523, \text{BootULCI} = 0.4017$) and the direct effect of WCBA on newcomers' organizational socialization is significant ($\text{BootLLCI} =$

$0.029, \text{BootULCI} = 0.2037$), intrinsic motivation plays a partially mediating role, and Hypothesis 4 is supported.

[Insert Table 5 Here]

Based on the findings shown in Model 9 of Table 6, it can be observed that the interaction between WCBA and surface acting has a statistically significant and adverse impact on intrinsic motivation ($\beta = -0.100,\ p < 0.05$), indicating that surface acting plays a negative moderating role in the relationship between WCBA and intrinsic motivation. Figure 2 further validates the moderating effect of surface acting. According to Figure 2, the effect of WCBA on intrinsic motivation can be weakened to a greater extent when surface acting is higher than lower surface acting. Therefore, Hypothesis 5 is supported.

[Insert Table 6 Here]

[Insert Figure 2 Here]

Similarly, in Model 11, the interaction term between WCBA and deep acting has a notable and favorable impact on intrinsic motivation ($\beta = 0.112, p < 0.05$), and deep acting strengthens the positive correlation between WCBA and intrinsic motivation. Figure 3 shows that as the degree of deep-acting increases, the relationship between WCBA and intrinsic motivation becomes stronger compared to individuals with lower levels of deep-acting. Therefore, Hypothesis 6 is supported.

[Insert Figure 3 Here]

This study used the bootstrap method to test the mediating effect when intrinsic motivation is moderated to further verify whether the moderated mediating effect is valid or not. The setting is the same as above, and the results are shown in Table 7. When intrinsic motivation is moderated by surface acting, Index = -0.0683, with a 95% confidence interval of [-0.1082, -0.0115], excluding 0. Therefore, surface acting negatively moderates intrinsic motivation in WCBA and newcomers' organizational socialization, and hypothesis 7 is supported. When intrinsic motivation is moderated by deep acting, Index = 0.0886, with a 95% confidence interval of [0.0264, 0.01477], excluding 0. Therefore, deep acting strengthens the mediating role of intrinsic motivation between WCBA and newcomers' organizational socialization, and the finding supports hypothesis 8.

[Insert Table 7 Here]

5. Discussion and implications

5.1 Discussion

Drawing upon the JD-R model, this study investigates the correlation between WCBA and newcomers' organizational socialization. The findings of our study indicate that the WCBA has a notable and favorable impact on newcomers' organizational socialization. This is mainly because WCBA, as a flexible way of working, provides many work resources for newcomers, promotes a positive experience, and gives newcomers more opportunities to learn about the organization and complete job responsibilities. Thus, it can enhance newcomers' organizational and role identities and promote organizational

socialization. In doing so, we shed light on the debates regarding the positive or negative impact of WCBA on employee outcomes (Wang et al., 2023b).

Second, according to the JD-R model, WCBA is not only a work resource but also a work requirement so newcomers can maintain a high degree of autonomy and flexibility. This encourages employees to continue to perform their job duties during off-hours and will naturally exert considerable effort (Wang et al., 2023a), thus enhancing the intrinsic motivation of newcomers. Motivated by high intrinsic motivation, employees may adopt positive, self-driven behaviors (Grant, 2007). While connecting with work and work-related colleagues during non-working hours, newcomers will maintain a high level of engagement and improve the degree of socialization.

Besides, the unique nature of newcomers makes their emotional labor more prominent (Chi and Wang, 2018). When engaging in WCBA activities, they need to adjust the difference between their true feelings and behavior constantly. Maintaining positive emotions for newcomers who adopt surface acting is difficult. This will reduce their intrinsic motivation and further decrease the initiative of newcomers to explore and understand the organization through the behavior of keeping work after hours when they first join the organization, thus reducing the degree of organizational socialization. Conversely, newcomers who engage in deep acting can identify with their work from the bottom of their hearts and maintain their enthusiasm for it. Meanwhile, they can use the working resources brought by WCBA to adapt to the organization better and faster. Specifically, deep acting can positively regulate the relationship between WCBA and organizational socialization and strengthen the mediating role of intrinsic motivation.

5.2 Theoretical implications

This study makes several theoretical contributions. First, WCBA is a behavior prevalent in contemporary enterprises and the current research is insufficient. Most of the previous scholars explored the mechanism of this behavior from the perspective of a negative or double-edged sword. However, in fact, in China, overtime culture prevails, and it has become common for employees to keep in touch with their work after hours. Especially, newcomers are eager to integrate into the organization in various ways, so it is easier for them to accept WCBA. According to the JD-R model, we examine the positive impact of WCBA on the newcomers' organizational socialization under the specific background of China's industry, thus making up for the shortcomings of previous research on WCBA in the field of work (Yuan and Tang, 2018) and enriching the positive ways of WCBA (Park et al., 2020).

Second, most of the previous research emphasized the influence of WCBA at the family level, while this study responded to the call of scholars Shi and Zheng (2021), taking newcomers' organizational socialization as the outcome variable to explore the specific behavioral performance of employees at the work level. This is also an expansion of the research field of WCBA.

Third, researchers have produced more fruitful results from current research on newcomers' organizational socialization, primarily from the perspectives of teams, colleagues, and leaders. Wang et al. (2021c) believe that with the emergence of new

office forms, such as telecommuting and temporary workers, it is necessary further to study organizational socialization methods suitable for these new situations. Based on this, we introduce WCBA as a new organizational situation into the study of newcomers' organizational socialization, which will expand the thinking perspective on and enrich the antecedent variables of newcomers' organizational socialization.

Finally, using affective events theory, this study has examined the moderating effects of two emotional labor techniques between WCBA and newcomers' organizational socialization for the first time. When taking WCBA, newcomers who use surface acting struggle to maintain positive emotions, causing internal dissonance and impeding organizational socialization. On the contrary, newcomers who use deep acting can maintain their work enthusiasm, focus on the work itself, and promote organizational socialization. Through empirical study, this work validates the influence of emotional labor on job performance, which will further enhance the relevant research on emotional labor.

5.3 Practical implications

We have also developed several practical implications for school leaders and newcomers.

Managers should capitalize on the benefits of mobile Internet and create more adaptable and rational policies to use the positive effects of WCBA fully. Thus, it can improve the work autonomy, internal motivation and the growth of work resources of newcomers to meet their psychological needs. Managers must be fully aware that the WCBA is both a job resource and a job demand. As a job resource, managers should make full use of the off-work time of newcomers to gain more knowledge related to the organization and customers through continuous work and stimulate their initiative. This, in turn, will make newcomers understand the effectiveness of WCBA and increase their intrinsic motivation. Furthermore, as a job demand, managers should carefully gauge new employees' participation level in WCBA to prevent internal psychological conflicts. They should encourage immersion in WCBA and convert this obligation into motivation effectively.

In addition, the impact of WCBA on employees using different emotional labor techniques varies due to the positive emotional response it triggers. To avoid potential negative consequences, managers should pay attention to the mental health of newcomers, reduce overtime work, increase training, help newcomers reduce superficial behaviors, and design a harmonious working environment to satisfy autonomy. Encourage new employees to participate in the work from the heart. When employees first join the organization, the unfamiliar working environment will aggravate their sense of tension. Supervisors need to meet the emotional needs of employees promptly. Managers should understand the emotional changes of newcomers from the heart so that they can feel the organization's care, maintain a positive mood, and take deep action. When newcomers are involved in WCBA, they unexpectedly have to continue to perform their duties after work. Therefore, managers should take timely measures to take care of newcomers, monitor their emotional changes, help them replenish resources in time, minimize the damage caused by surface acting, and help them obtain recovery

experience.

At the same time, as newcomers, it is essential to maintain an optimistic attitude, effectively manage time, and adapt to the changes brought by WCBA. First, newcomers should leverage the potential positive impact of WCBA to maximize work resources, gain valuable experience, deepen organizational understanding, and strengthen the perception of organizational support. By doing so, newcomers can use technology better, stay current and improve their capabilities. For example, when receiving a client's message after hours, newcomers should treat it as an opportunity to enhance their performance or ability to work.

In addition, newcomers should focus on deep acting rather than surface acting to mitigate the loss of resources caused by emotional labor and minimize work stress. When entering the organizations, newcomers should identify with and integrate into the employer's culture from the bottom of their hearts. Furthermore, in the face of excessive WCBA, newcomers should turn pressure into inspiration, seize the opportunities that WCBA may provide, encourage the realization of personal goals, and support the strengthening of spiritual values.

5.4 Limitations and future research directions

The present study is characterized by several limitations that indicate possible areas for further investigation. The study utilized a cross-sectional design, requiring employees to self-assess question items. Future studies could employ a longitudinal design to enhance data accuracy, collect data at multiple time intervals, and explore using logbook techniques. Second, while this paper focused on the positive role of WCBA on new employees, it is essential to acknowledge that previous studies have demonstrated the double-edged sword effect of non-working connectivity behavior on employees' work levels. Therefore, future studies can investigate the negative impact of WCBA on newcomers' organizational socialization of and its underlying mechanisms in other contexts. Lastly, it is worth noting that WCBA affects newcomers and involves colleagues, leaders, and other. Future research should explore the impact of WCBA on the degree of socialization among colleagues, leaders, and others engaging in WCBA.

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Table 1. Demographic profile of respondents.

Variables	Category	Number	Percent
Gender	Male	132	44.59%
	Female	164	55.41%
Age	25 or below	150	50.68%
	26-30	47	15.88%
	31-35	33	11.15%
	36-40	27	9.12%
	41 or above	39	13.18%
Education background	high school education or below	4	1.35%
	junior college	15	5.07%
	Bachelor	217	73.31%
	Postgraduate	60	20.27%
Job category	Technical personnel	55	18.58%
	Production personnel	46	15.54%
	Financial personnel	29	9.80%
	Marketing staff	39	13.18%
	Human resource personnel	34	11.49%
	Other	93	31.42%
Managerial positions	Frontline employees	131	44.26%
	Junior managers	74	25.00%
	Middle managers	37	12.50%
	Senior managers	20	6.76%
	Other	34	11.49%

Table 2. Confirmatory factor analysis.

Model	χ^2	df	χ^2/df	CFI	RMSEA	SRMR
Five-factor model	1005.756	507	1.984	0.902	0.058	0.0615
Four-factor model	1680.175	521	3.225	0.772	0.087	0.0727
Three-factor model A	1812.739	524	3.459	0.747	0.091	0.077
Three-factor model B	1835.851	524	3.504	0.742	0.092	0.0756
Two-factor model	1912.887	526	3.637	0.728	0.095	0.0765
One-factor model	2371.847	527	4.501	0.638	0.109	0.0914

Notes: N=296; five-factor model (WCBA, intrinsic motivation, surface acting, deep acting, newcomers' organizational socialization)；four-factor model (WCBA + intrinsic motivation, surface acting, deep acting, newcomers' organizational socialization)；three-factor model A (WCBA + intrinsic motivation + surface acting， deep acting, newcomers' organizational socialization)；three-factor model B (WCBA + intrinsic motivation + deep acting, surface acting, newcomers' organizational socialization)； two-factor model A (WCBA + intrinsic motivation + surface acting + deep acting, newcomers' organizational socialization；one-factor model A (WCBA + intrinsic motivation + surface acting + deep acting + newcomers' organizational socialization);"+" indicates that the factors will be combined.

Table 3. Means, standard deviations, and correlation coefficients of variables.

	M	SD	1	2	3	4	5	6	7	8	9	10
1. Gender	1.55	0.50	1									
2. Age	2.18	1.46	-.232**	1								
3. Education	3.13	0.54	0.031	0.104	1							
4. Job category	3.72	1.93	.185**	-0.032	-0.092	1						
5. Managerial positions	2.16	1.36	-0.063	.273**	0.018	.147*	1					
6. WCBA	3.17	0.76	0.047	0.111	.134*	0.045	0.071	1				
7. Intrinsic motivation	3.53	0.89	0.015	-0.035	.148*	-0.015	-0.059	.596**	1			
8. Surface acting	2.41	0.81	-0.036	-0.05	0.018	-0.042	0.1	-.435**	-.515**	1		
9. Deep acting	3.79	0.66	0.056	.135*	0.056	0	0.045	.582**	.452**	-.604**	1	
10.Newcomers' organizational socialization	3.67	0.68	0.014	0.077	0.033	-0.008	0.021	.491**	.662**	-.449**	.391**	1

Notes：n=296，**P<0.01,*P<0.05,two-tailed test.

Table 4. Results of regression analysis for hypothesis testing.

	Intrinsic motivation		Newcomers' organizational socialization			
	Model 1	Model2	Model3	Model4	Model5	Model6
Gender	-0.003	-0.040	0.034	0.004	0.036	0.028
Age	-0.037	-0.099*	0.081	0.030	0.106*	0.090
Education	0.153**	0.078	0.023	-0.039	-0.082	-0.086
Job category	0.006	-0.019	-0.010	-0.031	-0.014	-0.020
Managerial positions	-0.053	-0.076	0.002	-0.017	0.037	0.028
WCBA		0.605***		0.495***		0.132*
intrinsic motivation					0.679***	0.600***
F	1.602	29.495	0.443	15.537	40.464	36.085
R^2	0.027	0.38	0.008	0.244	0.457	0.467

Notes：***p<0.001, **p<0.01, *p<0.05.

Table 5. Mediated effects test.

	Effect	BootSE	BootLLCI	BootULCI
total effect	0.4421	0.042	0.359	0.523
indirect effect	0.3242	0.0381	0.2523	0.4017
indirect effect	0.1179	0.0442	0.029	0.2037

Table 6. Moderating effects test.

variable	Intrinsic motivation				
	Model 7	Model 8	Model 9	Model 10	Model 11
Gender	-0.040	-0.045	-0.044	-0.050	-0.045
Age	-0.099*	-0.117*	-0.114*	-0.115*	-0.113*
Education	0.078	0.103*	0.098*	0.084	0.083
Job category	-0.019	-0.031	-0.016	-0.013	-0.005
Managerial positions	-0.076	-0.028	-0.013	-0.074	-0.078
WCBA	0.605***	0.460***	0.468***	0.503***	0.516***
Surface acting		-0.322***	-0.343***		
WCBA* Surface acting			-0.100*		
Deep acting				0.176**	0.200**
WCBA* Deep acting					0.112*
F	29.495	35.224	31.81	27.43	25.077
R^2	0.38	0.461	0.47	0.4	0.411

Table 7. Results of the mediation test at different moderating variables.

	conditional indirect effect				Moderated mediation effects			
	Effect	BootSE	BootLLCI	BootULCI	Index	BootSE	BootLLCI	BootULCI
low surface acting	0.3064	0.041	0.2274	0.388	-0.0683	0.0242	-0.1082	-0.0115
moderate surface acting	0.251	0.0322	0.1916	0.3189				
high surface acting	0.1956	0.0342	0.1389	0.2736				
low deep acting	0.2185	0.0372	0.154	0.3003	0.0886	0.0309	0.0264	0.1477
moderate deep acting	0.2765	0.0378	0.2074	0.3563				
high deep acting	0.3345	0.0479	0.2429	0.4335				

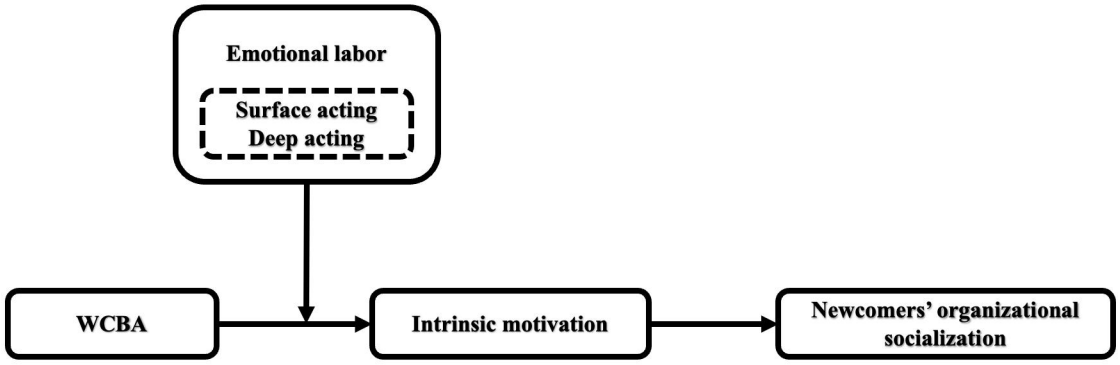

Figure 1. The concept model.

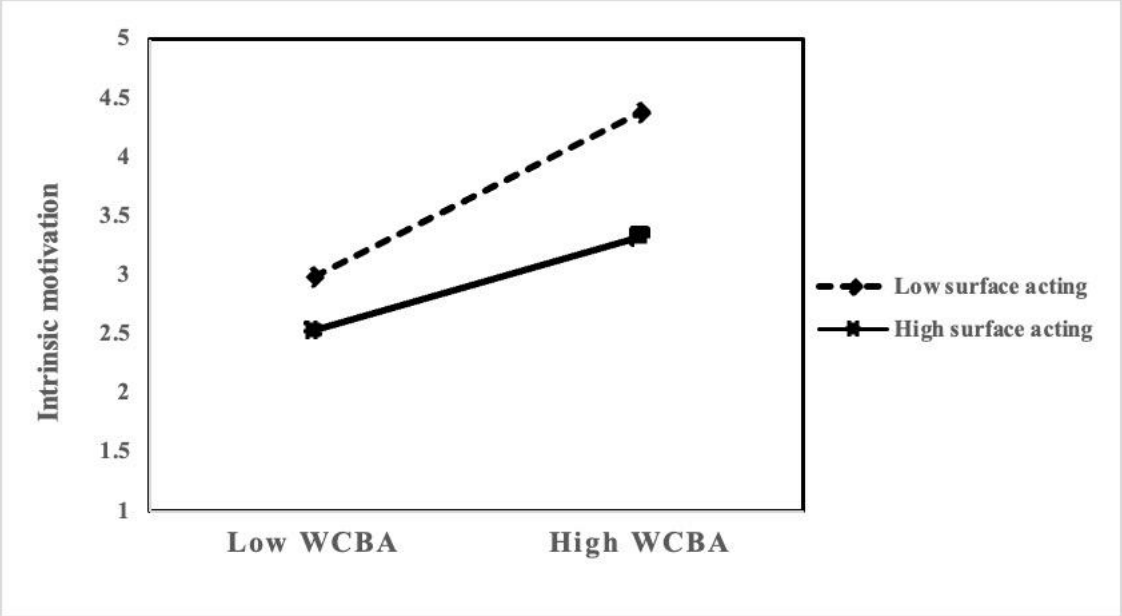

Figure 2. Moderating effects of surface acting on WCBA and intrinsic motivation.

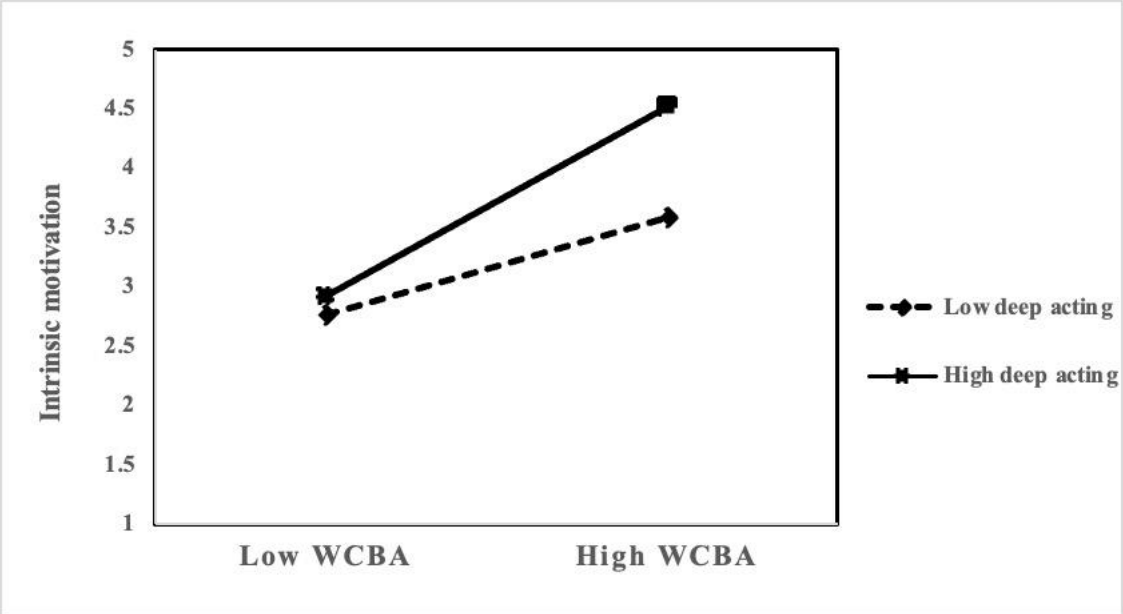

Figure 3. Moderating effects of deep acting on WCBA and intrinsic motivation.

《利用技术进行创业企业的远程劳动力管理》

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摘　要

随着全球化和数字化的快速发展，远程劳动力管理已成为创业企业面临的重要挑战和机遇。本论文旨在探讨如何利用技术来有效管理远程劳动力，提高创业企业的运营效率和员工绩效。首先，论文分析了远程劳动力管理的定义、挑战和优势。其次，通过文献综述和案例分析，探讨了当前技术在远程劳动力管理中的应用情况及效果。接着，论文提出了一些创业企业可以采取的技术工具和策略，包括远程协作平台、沟通工具、项目管理软件等，以提高远程团队的协作效率和管理效果。最后，通过实证研究和调查分析，论文总结了技术在远程劳动力管理中的实际应用效果，并提出了未来研究和发展方向。通过本论文的研究，希望为创业企业提供有益的建议和指导，帮助他们更好地利用技术来管理远程劳动力，实现业务增长和成功发展。

关键词：技术；创业企业；远程劳动力管理；协作效率

Abstract

With the rapid development of globalization and digitalization, remote workforce management has become an important challenge and opportunity for startups. This paper aims to explore how technology can be used to effectively manage remote workforce and improve operational efficiency and employee performance of entrepreneurial enterprises. First, the paper analyzes the definition, challenges and advantages of remote workforce management. Secondly, through literature review and case analysis, the application and effect of current technology in remote labor management are discussed. Then, the paper puts forward some technical tools and strategies that start-ups can adopt, including remote collaboration platform, communication tools, project management software, etc., in order to improve the collaboration efficiency and management effect of remote teams. Finally, through empirical research and investigation and analysis, the paper summarizes the practical application effect of technology in remote labor management, and puts forward the future research and development direction. Through the research of this paper, we hope to provide beneficial suggestions and guidance for entrepreneurial enterprises to help them make better use of technology to manage remote workforce and achieve business growth and successful development.

Key words：technology；Entrepreneurial enterprises；Remote workforce management；Cooperation efficiency

目　录

第 1 章 绪论

1.1 研究背景

随着全球化和数字化的快速推进，工作环境和方式也在不断演变。远程工作已经逐渐成为一种常态，特别是在创业企业中。远程劳动力管理（Remote Workforce Management）不仅可以降低企业的运营成本和招聘成本，还可以吸引更多具有不同技能和背景的人才。然而，远程劳动力管理也带来了一些挑战，如团队协作难度增加、沟通效率下降、绩效监控困难等。因此，探讨如何利用技术来有效管理远程劳动力，显得尤为重要。

为了解决这些挑战，创业企业需要利用技术手段进行远程劳动力管理。各种在线协作工具、项目管理软件、远程会议平台等技术已经成为创业企业管理远程团队的重要工具。通过技术，创业企业可以实现更高效的团队协作、更及时的沟通和更有效的绩效监控，从而提高整体业务的运作效率和质量。

然而，对于许多创业企业来说，选择适合自己团队和项目的远程劳动力管理技术并将其有效应用是一个挑战。因此，深入研究如何利用技术进行创业企业的远程劳动力管理，探讨不同技术工具的优劣和应用场景，对于帮助创业企业解决远程团队管理中的问题，提高团队工作效率具有重要意义。

1.2 研究目的与意义

本论文旨在探讨利用技术手段来优化远程劳动力管理，提升创业企业的运营效率和员工绩效。通过分析远程劳动力管理的定义、挑战和优势，以及技术在这一领域中的应用情况及效果，提供实用的技术工具和策略建议，帮助创业企业更好地应对远程管理挑战，实现业务增长和成功发展。

1.3 研究结构

本论文共分为六个部分：绪论、文献综述、研究方法、结果与讨论、结论和建议。以下将逐一展开讨论。

第 2 章 文献综述

2.1 远程劳动力管理的发展与定义

2.1.1 远程劳动力管理的定义

远程劳动力管理是指利用互联网和数字化技术,通过远程工作的方式管理和组织分散在不同地理位置的员工和团队。远程劳动力管理通过在线协作工具、沟通平台、项目管理软件等技术工具，实现员工的远程办公和协作，确保工作任务的顺利完成和团队的高效协作。

2.1.2 远程劳动力管理的发展

远程劳动力管理作为一种新兴的管理模式，近年来逐渐得到越来越多企业的认可和应用。其发展包括以下几个主要方面：

1、技术的发展推动远程劳动力管理的发展：随着信息技术的不断进步和普及，各种远程劳动力管理工具和平台被广泛运用，使得远程协作变得更加便捷和高效。

2、越来越多的企业接受远程劳动力管理：随着全球化和数字化的发展，越来越多的企业开始意识到远程劳动力管理可以带来的种种好处，如成本降低、人才获取和留存等，因此开始积极尝试和应用远程劳动力管理。

3、新冠疫情的影响：新冠疫情的爆发加速了远程劳动力管理的发展。大量企业不得不采取远程办公的方式来保证业务的正常运转，远程劳动力管理得到了更为广泛的应用和认可。

4、人才流动和灵活工作需求的增加：随着人才流动性的增加和灵活工作需求的逐渐增加，远程劳动力管理提供了一种灵活的工作方式，满足了员工对工作灵活性和工作生活平衡的需求。

2.2 远程劳动力管理的挑战

1、沟通障碍：远程团队成员之间无法面对面交流，容易导致信息传递不及时和理解偏差。电子沟通工具可能会导致信息丢失或误解，从而影响团队合作效率。

2、团队协作难度增加：远程团队成员的时区、文化差异、工作习惯等差异会对团队协作产生影响，导致团队合作难度增加，沟通不畅和项目推进缓慢。

3、绩效监控困难：远程劳动力管理难以监控员工的工作表现和工作进度，导致管理者难以评估团队成员的绩效，也难以及时发现和解决问题。

4、团队凝聚力下降：远程团队缺乏面对面交流和团队活动，难以建立良好的团队凝聚力和团队文化，影响团队成员之间的信任和互动。

5、安全和隐私风险：远程团队对数据和信息安全的要求更高，容易面临信息泄露、数据丢失等安全风险，尤其是在跨国远程团队中。

2.3 远程劳动力管理的优势

1、地域灵活性：远程劳动力管理可以突破地域限制，招聘和利用全球范围内的人才。企业可以雇佣来自不同地区甚至不同国家的优秀人才，让团队更具多元化，为企业带来更广泛的经验和想法。

2、成本节约：远程劳动力管理可以降低企业的运营成本。雇佣远程员工通常不需要为其提供办公空间、设备、工作午餐等额外支出，同时还能节省员工通勤时间和成本。

3、工作灵活性：远程劳动力管理使员工可以更加自由地安排工作时间和工作地点。员工可以更好地平衡工作与生活，提高工作效率和生产力，同时减少因通勤而浪费的时间和精力。

4、员工满意度提升：远程工作让员工能够更加自主地组织工作，提高工作满意度和工作动力。员工可以更加便利地处理个人事务，减少工作压力和疲劳，从而提高员工的忠诚度和幸福感。

5、环保可持续：远程劳动力管理有利于减少车辆排放和交通拥堵，降低企业的碳排放量，有助于环境保护和可持续发展。

6、招聘和留住人才竞争力：采用远程劳动力管理模式可以提高企业在人才市场中的吸引力，吸引更多优秀人才加入企业，同时可以减少员工流失率，留住核心人才。

2.4 技术在远程劳动力管理中的应用情况及效果

通过文献综述，发现以下几类技术在远程劳动力管理中应用广泛并且效果显著：

1、在线协作工具：诸如 Slack、Microsoft Teams、Zoom 等在线协作工具，帮助团队成员实时沟通交流、共享文件和协作，提高工作效率和便捷性。

2、项目管理工具：项目管理工具如 Trello、Asana、Jira 等，帮助团队追踪任务进度、分配工作、管理项目日程，提高团队的协作效率和项目管理能力。

3、远程会议工具：视频会议工具如 Zoom、Skype、Google Meet 等，使团队成员能够远程参与会议、讨论和决策，促进团队协作和沟通。

4、远程监控工具：远程监控工具可以帮助管理者监督团队成员的工作进度和表现，确保工作按时完成并保持高质量。

5、虚拟团队培训工具：针对远程团队的培训工具，如在线培训平台、虚拟现实技术等，可以帮助团队成员获得必要的技能和知识，在远程工作环境中更好地发展和成长。

6、数据分析工具：数据分析工具可以帮助企业分析远程团队的工作绩效、协作效率等数据，为管理者提供数据支持，优化团队管理策略和决策。

第 3 章 研究方法

3.1 研究设计

本研究采用文献综述和案例分析相结合的方法，旨在全面探讨技术在远程劳动力管理中的应用效果和未来发展方向。

3.2 研究方法

1、文献综述：回顾先前有关技术在远程劳动力管理中的研究成果，了解相关理论和现状。

2、问卷调查：设计包括技术应用情况、远程劳动力管理效果、企业绩效指标和员工满意度等内容的问卷，针对创业企业的管理人员和员工进行调查。

3、访谈：选择几家创业企业的管理人员和员工进行深度访谈，探讨他们在远程劳动力管理中利用技术的经验和看法。

4、案例研究：选取几家成功利用技术进行远程劳动力管理的创业企业进行案例研究，分析其技术应用策略、管理模式和效果。

5、数据分析：运用统计分析工具对问卷调查和案例研究数据进行分析，探讨技术在远程劳动力管理中的作用及影响。

3.3 预期结果

通过以上研究方法，预计可以得出创业企业如何利用技术进行远程劳动力管理，以及技术在远程团队协作中的优势和挑战。同时，预计可以深入探讨技术对企业绩效和员工满意度的影响，为创业企业提供更好的远程劳动力管理策略和建议。

第 4 章 结果与讨论

4.1 远程劳动力管理的现状分析

通过文献综述和问卷调查发现，当前大多数创业企业已经意识到远程劳动力管理的重要性，并且开始尝试不同技术工具以提高管理效果。然而，不同企业在技术应用的广泛程度、效果评价等方面存在显著差异，具体原因如下：

1、技术支持的普及：远程劳动力管理得以实现离不开各种协作工具和远程办公软件的支持，比如视频会议、团队协作平台、项目管理工具等。这些技术工具的普及和改进为远程劳动力管理提供了便利条件。

2、全球范围内的人才吸引：通过远程劳动力管理，企业有机会吸引来自全球各地的优秀人才，不再受限于地域和时区，能够更好地满足企业的人才需求。

3、工作灵活性和生活平衡：远程劳动力管理为员工提供了更大的工作灵活性，能够更好地平衡工作和生活，从而提高员工的工作满意度。

4、沟通和协作挑战：远程劳动力管理也面临着沟通协作的挑战，如时区差异、文化差异、沟通效率等问题，需要企业采用适当的策略和工具来解决。

5、安全和隐私问题：远程劳动力管理也带来了安全和隐私方面的考量，需要企业加强信息安全管理和员工隐私保护。

4.2 技术在远程劳动力管理中的局限性和挑战

尽管技术在远程劳动力管理中具有诸多优势，但也存在一定的局限性和挑战。如操作复杂性、成本高昂以及数据安全隐私问题等，这些都是企业在选择和使用技术时需要考虑的重要因素。具体分为以下几个方面：

1、沟通障碍：远程团队成员之间无法面对面交流，容易导致信息传递不及时和理解偏差。电子沟通工具可能会导致信息丢失或误解，从而影响团队合作效率。

2、团队协作难度增加：远程团队成员的时区、文化差异、工作习惯等差异会对团队协作产生影响，导致团队合作难度增加，沟通不畅和项目推进缓慢。

3、绩效监控困难：远程劳动力管理难以监控员工的工作表现和工作进度，导致管理者难以评估团队成员的绩效，也难以及时发现和解决问题。

4、团队凝聚力下降：远程团队缺乏面对面交流和团队活动，难以建立良好的团队凝聚力和团队文化，影响团队成员之间的信任和互动。

5、安全和隐私风险：远程团队对数据和信息安全的要求更高，容易面临信息泄露、数据丢失等安全风险，尤其是在跨国远程团队中。

4.3 预期趋势

随着远程劳动力管理的普及，可以预期未来远程劳动力管理将更加智能化、协同化和定制化。企业将更加注重技创新和数据驱动的远程劳动力管理模式，以提高工作效率，增强员工体验，并解决跨地域、跨时区、跨文化沟通协作的挑战。

第 5 章 结论与建议

5.1 结论

综上所述，随着远程工作的普及，远程劳动力管理已经成为创业企业面临的重要课题。利用技术手段进行远程管理，不仅能够提升企业的运营效率，还能增强员工的工作满意度和绩效。然而，技术的选用和管理仍需慎重，要结合企业的具体需求和现状，选择最适合的工具和策略。

5.2 建议

针对远程劳动力管理中的挑战和需求，本论文提出以下建议：

1、选择合适的远程协作平台：企业应根据团队特点和工作需求，选择合适的远程协作平台，如 Slack、Microsoft Teams 等，以提高沟通效率和团队协作效果。

2、加强项目管理工具的使用:：建议企业充分利用 Trello、Asana 等项目管理工具，进行任务分配和进度跟踪，提高项目的管理和控制能力。

3、规范绩效监控方法：使用 Time Doctor、Hubstaff 等工具，对远程员工进行科学合理的绩效监控和评价，确保员工工作效率和绩效的持续提升。

4、注重数据安全和隐私保护：企业在使用各种技术工具时，要高度重视数据安全和隐私保护，采取相应的技术和措施，保障数据的安全性。

5、持续培训与技术支持:：为员工提供持续的培训和技术支持，帮助他们掌握和适应各种远程工作工具，提升工作效率和满意度。

通过本论文的研究，希望能够为创业企业提供有益的建议和指导，帮助他们更好地利用技术来管理远程劳动力，实现业务增长和成功发展。未来的研究可以进一步探讨不同技术的综合应用效果，以及新兴技术在远程劳动力管理中的潜在应用，为企业的持续创新和发展提供新的思路和方向。

Research on the influence mechanism of knowledge collaboration on innovation performance of formula food for special medical purpose (FSMP) enterprises

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Abstract

When an enterprise lacks innovation resources, it is inevitable that it will quickly flow and share knowledge with external innovation resources through acquisition, integration, alliance, outsourcing and other ways to carry out innovation activities.In the face of open innovation adopted by enterprises, which must be reviewed by regulatory authorities, it becomes particularly important to study these issues: how to generate innovation performance through effective knowledge collaboration, what should be the correct innovation performance of the company, what is the knowledge collaboration's dimension and what factors affect effective knowledge collaboration.According to the theory about knowledge collaboration, knowledge management , innovation theory, Start from the aspect of studying knowledge collaboration between enterprises, external third parties and regulatory review departments. With the relationship between knowledge collaboration and innovation performance as the unit of analysis. Through documents, observation and interview to collect data, the application of grounded theory level 3 stylized coding for data analysis, It is concluded that the dimensions of knowledge collaboration are knowledge sharing, knowledge innovation and knowledge verification. The correct innovation performance should be technological innovation performance represented by new products, and management innovation performance represented by R & D ability, production ability and testing ability. The causal relationship between knowledge collaboration and innovation performance as variables is also obtained, and three influencing factors of effective knowledge collaboration are spirit of contract, implementation of management system and ability to control changing. Four enterprises that adopt open innovation are selected as study cases, and competitive interpretation mode matching group sampling is adopted.The quality function deployment(QFD) method is also used to carry out three-level deployment of customer demand, process realization and regulatory review respectively. To derive results consistent with the conclusions of data coding through 2 methods, and to obtain the support of existing theories through comparative analysis with relevant existing theories, standards and norms.It is more clearly confirmed that only effective knowledge collaboration can produce innovation performance that meets the requirements, namely, the theory of influence mechanism of knowledge collaboration on innovation performance.

Keywords:Formula food for special medical purpose, R&D and registration, Knowledge collaboration, Innovation performance, Influencing factors

1 Introduction

1.1Research background

The regulatory policy of registration, approval and required for marketing of the FSMP has been implemented since 2017 in China. As an emerging industry, all enterprises that want to enter this industry are

faced with how to innovate by generating new knowledge, whether the innovation results can meet the needs of patients, and whether the enterprises have the ability to continuously ensure product quality and safety that can be recognized by the regulatory authorities.According to R&D and registration of FSMP, In the face of open innovation adopted by enterprises, which must be reviewed by regulatory authorities, it becomes particularly important to study these issues: How to generate innovation performance through effective knowledge collaboration? what should be the correct innovation performance of the company? what is the knowledge collaboration's dimension and what factors affect effective knowledge collaboration?

1.2 Research purpose

Based on SECI model of Nonaka&Takeuchi[1][2], this paper scientifically analyzes the knowledge collaborative innovation mechanism of FSMP's R&D and its relationship with innovation performance, and establishes a theoretical model of the relationship between knowledge collaborative innovation, promoting conditions and performance. It is expected to provide new findings for theoretical research on how to use knowledge to produce innovative performance in the process of R&D registration of FSMP, so as to facilitate enterprises to avoid detaches in the future R&D process, save funds and successfully achieve registration.

1.3 Research content and structure

To achieve this research purpose, this study studies how to achieve innovation performance that meets customer and regulatory requirements from the perspective of how to effectively carry out knowledge collaboration among enterprises, external technical service organizations and regulatory authorities.Although the research on knowledge collaboration and innovation performance is not a new content, the causal relationship between variables can be accurately explored from the data collection, observation and interview obtained from case studies in view of the current situation of the industry of this research object. And the causal relationship between variables was verified by case comparison analysis and quality function deployment method (QFD), so as to draw a conclusion with universal regularity.

Describing "what" and "how" knowledge collaboration and innovation performance can effectively carry out collaboration is a descriptive and explanatory study, which is suitable for case study. This paper chooses to adopt exploratory and interpretive case study methods, and follow the rigorous case study of the grounded theory of three-level programmatic coding methodology for data processing to promote the development of research [3] [4].

The structure of this paper is background of the research topic, propose questions, literature review, research methods and design, theory construction, theory testing, theoretical model, conclusion and discussion, research limitations and prospects.

2 Literature Review

This study attempts to study mechanism of influence on innovation performance by knowledge collaboration of FSMP's enterprises. Therefore, this chapter studies previous theories and research results, such as open innovation, knowledge creation, knowledge collaboration and innovation performance, in order to understand the domestic and foreign research history, current situation, problems solved and research limitations of these theories. At the same time, it is also expected that the previous research results can be used to solve the research problem. If the research problem cannot be solved, the research should put forward its own theoretical and practical innovation points through empirical research under specific conditions to solve the practical problems of the research object.

2.1 Open innovation

Chesbrough et al. [5] described the knowledge sharing and interaction between enterprises and external

partners in the innovation process, as well as internal and external knowledge development and knowledge exploration.Acquire knowledge and resources from outside, integrate them into the enterprise, and share, restructure, transform and create within the enterprise to form new knowledge or capabilities[6] [5][7][8].Whether it is defined from the perspectives of company organization, information, resources, intellectual property and stakeholders, it is inseparable from the flow and integration of knowledge. The core means of open innovation that do a good job in knowledge management , intellectual property and make use the flow of knowledge to innovate [9][10][11].

Through the summary of domestic and foreign relevant literature, as well as empirical research, the main knowledge influencing factors of enterprise open innovation are knowledge identification, acquisition, absorption, integration, transformation and risk control ability. There are promoting factors and inhibiting factors for open innovation, among which, the promoting factors include strategy-oriented factors and performance-oriented factors, and the inhibiting factors mainly include the risk of knowledge leakage in cooperation, the difficulty in finding suitable technology partners, the lack of innovation capability within the company, and the difficulty in understanding and absorbing external knowledge. Pay little attention to improvement of enterprise's R&D ability. Innovation path is mainly the traditional way of introducing technology and cooperation between enterprise and university etc. Current research on open innovation has deeply discussed the concept, characteristics, classification and related capabilities of open innovation, as well as the resulting technological innovation performance, which provides a basis for subsequent empirical research [12][13].This study believes that open innovation is only a mode of external cooperation adopted by enterprises to improve innovation performance. From the definitions of open innovation by researchers from different perspectives, it can be seen that the internal mechanism that can really produce innovation performance is not external conditions such as cooperation mode, openness and knowledge heterogeneity. It is how knowledge can flow effectively and smoothly within the enterprise to generate the right new knowledge.

2.2Knowledge collaboration

Definition is elaborated from perspectives of organizational strategy, knowledge management, business process and collaborative work. Karlenzig [14]clearly proposed the definition of knowledge collaboration for the first time, and pointed out from the perspective of organizational strategy that the establishment of dynamic collaborative relationship of internal and external linkage is a strategic method to maximize organizational benefits. Anklam[15] from the perspective of knowledge management, knowledge collaboration is inevitable development of knowledge management, and that knowledge collaboration is third stage.

Knowledge collaboration mechanism on innovation performance has been studied in literature from different perspectives such as knowledge transformation, knowledge creation Ba and transformational leadership, but the mechanism should be different under different environmental conditions. For the problems faced by the object of this study, we should study from the perspective of how to share, transform and verify knowledge, and find out what factors will affect the knowledge creation Ba. In addition to suppliers, customers, partners, etc., the influence of team leaders, participants and interpersonal networks on knowledge collaboration is discussed[16][17], However, there is no research on the participation of government regulators in knowledge collaboration.Different scholars have analyzed and discussed the influencing factors, promoting or hindering conditions of knowledge collaborative innovation from different perspectives. Knowledge heterogeneity, absorptive capacity, trust and contract, strategic consensus, cultural vision, organizational management and environment are all factors that affect knowledge collaborative innovation[18][19][20][21][22][23][24]. Nonaka and Takeuchi[1] consider the 5 promotion conditions for enhancing knowledge creation: organizational intention, autonomous management, volatility and chaos, and necessary diversity as the basis for promoting knowledge collaborative innovation in this study. However, the evaluation of knowledge innovation

performance in this study must pass the review of government regulatory authorities. Regulatory regulations should be an important factor influencing knowledge collaborative innovation. Therefore, this research should be carried out from the aspects of objectives, participants and individuals, process and environment, as well as from the specific policies that must be complied with in order to successfully complete the research project, and from the coping capabilities and program measures that should be available under the uncertainties that should be faced. Therefore, this research should adopt practical case studies. To explore what the factors affect effective knowledge collaboration and produce the right innovation performance.

2.3Innovation performance

Innovation performance of alliance enterprises is an evaluation of the realization of enterprise innovation activities, and its dimensions should include technology innovation performance and management innovation performance [25][26][27].Complementarity degree between management innovation and technological innovation is also vague as to what impact management innovation has on enterprise performance, what performance it will produce and how to measure it under different environmental conditions in literature studies.

This study aims to provide the qualitative needs of "food for patient with specific diseases" through "what to do" and "how to do" into the corresponding food nutrition table, product formula table, process flow and critical control point parameters. At the same time, regulatory requirements should be integrated into the whole process of new product development and production and registration, and investigations and comparative studies between enterprises should reveal the impact of specific factors such as the national institutional environment on management innovation performance.Technological innovation performance includes new products, patents, registration approval, etc[28][26]. In this study, patents are not considered, and registration certificates will naturally be obtained through on-site verification. Therefore, this study only regards new products as technological innovation, and management innovation focuses on the capabilities that enterprises must have in the process of "learning by doing".

2.4 Summary

Through the above literature analysis, it is found that researchers focus on definition and dimension division of knowledge collaboration, regard as a means to realize and complete enterprise innovation. In foreign and domestic research fields, there is no unified, standard and authoritative understanding of the connotation and mechanism of collaboration.

For the emerging industry of FSMP, the object of this study, there are still shortcomings in the research of knowledge collaboration dimension, innovation subject, management innovation performance and micro-mechanism of innovation performance realization after enterprises implement inward oriented open innovation strategy under specific government regulatory environment.From the perspective of knowledge collaboration, innovation background model,the perspective of innovation performance,participants,and the perspective of the process mechanism to ensure the realization of innovation performance,the influencing mechanism of knowledge collaboration on innovation performance should be explored, which is the re-creation of external knowledge flow driven by deep-seated knowledge transformation into internal enterprises, and the process of regulatory review must be passed. The influencing factors of knowledge collaboration should be explored through practice, especially how to effectively share knowledge in the collaborative process. How to promote the smooth transformation of tacit and explicit knowledge, and how to transform passive acceptance of regulatory review into effective use of regulatory review correction opportunities to achieve more effective knowledge collaboration, that is, the environment or influencing factors in each "Ba" of knowledge creation to achieve innovative performance, are also questions to be explored in this study.

3 Research Methods and Design

3.1 Research Methods

Through literature research, it is found that existing theories cannot provide suitable and satisfactory answers to the questions raised in this study. There are many researches on knowledge collaboration and innovation performance. However, there is still no research on knowledge collaboration and innovation performance of FSMP's enterprise, which are emerging industries under the specific regulatory policies of the Chinese government. According to the particularity of the industry, what should be the knowledge collaboration and innovation performance of the research object, how to produce innovation performance through effective knowledge collaboration, and what are the factors affecting knowledge collaboration? For these problems, it is necessary to trace various interrelated factors in chronological order and find out the relationship between these factors. Based on research method of grounded theory, the data collected through multiple channels are encoded at three levels and the results of the research are exactly the answers to the actual questions of "What" and "How" of the research object. Therefore, the case study method in inductive research is suitable for empirical research [29][30].

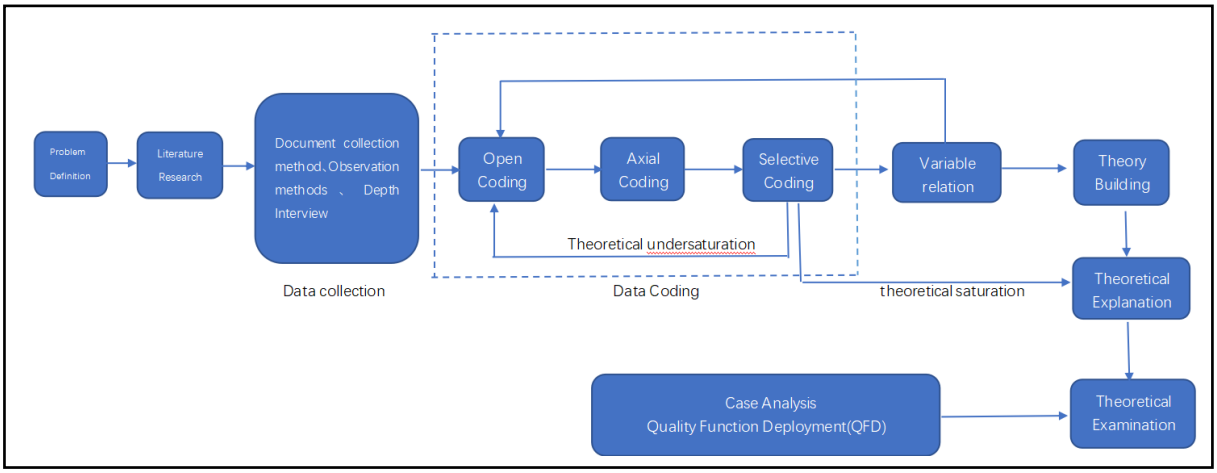
This study adopts multiple case studies, which belong to exploratory case study and explanatory case study. The R & D and registration activity of the research object is action-oriented. In the process of project research, it is necessary to mobilize multiple professional departments for micro-interaction. Grounded theory programmed coding for data processing can be adopted from the bottom up in the concrete analysis stage to summarize and analyze problems and abstract concepts, and through comparative analysis of multiple cases. It is suitable for the qualitative method of exploratory research on the basis of empirical description to establish the theory and realize the abstract interpretation of the concepts in the object of this research.Compared with a single case, multiple cases carry out efficiently conclusion and contrast data across cases , obtain similarity among cases, draw a reasonable and generalized conclusions by mutual confirmation and supplement among cases [29] [31].Multi-case study is adopted as an empirical research method. Through in-depth and comprehensive field investigation of multiple complex processes and specific phenomena in the real R & D and registration work, involving a relatively large number of concepts and complex variable relationships, the collected empirical data is encoded by the grounded theory method, Summarize the experience from the original data, carry out reasonable categorization and abstract conceptualization, and analyze the logical relationship of variables in the event[3][32].This study sorted out facts and observations from practical work, analyzed and summarized the causal relationship between variables, established a primary theoretical model of knowledge collaboration mechanism on innovation performance, finally tested four cases through comparative analysis and QFD method . It proves the theoretical rationality formed by the coding results of multi-channel data collection more effectively.

3.2 Research Design

The design of the overall research scheme after literature research, including data collection, coding and verification of coding results, forms the research conclusion.The research design plans the main research into three stages:theory construction、theoretical examination and conclusion and discussion.In accordance with the principle of case selection, this study first conducted three-level coding based on secondary data such as technical review and correction notices of 14 products of 8 enterprises and data collected by observation method, defined the knowledge collaboration dimension and innovation performance category, summarized the influencing factors that promote knowledge collaboration to produce innovation performance, and verified the coding results and causality through in-depth interviews. Then, these four enterprises are selected as case study objects, and further comparative analysis is carried out according to the sequential nature of the innovation

process, so as to deduce the empirical research of corresponding conclusions. Meanwhile, QFD method also used, which conforms to above principles and can bring clear research conclusions to this research questions.The analysis process is shown in Figure 1:

Figure 1 Theoretical model construction and testing process



3.3 Case analysis design

Whether knowledge collaboration can be carried out smoothly and its effect will influence generate innovation performance. Therefore, analysis unit is relationship between knowledge collaboration and innovation performance, factors affecting knowledge collaboration.

By studying representative and typical cases, Yin [29] mainly gives an accurate description of the general situation of people, events or situations in the selected cases, summarizes and makes comparative analysis of the phenomena or findings in the cases, examines and validates the issues of correlation or causality, draws conclusions, and finally puts forward suggestions and measures. To provide reference, guidance and inspiration for enterprises of the same kind or the same government registration and supervision requirements to study the same kind of problems..The case enterprise information is shown in Table 1:

Table 1 Four cases of enterprise basic situation

Enterprise characteristic	Company A	Company B	Company C	Company D
Founding time	2000 year	2018 year	2017year	1956 year
form of ownership	limited liability	incorporated	incorporated	incorporated
asset size/Ten thousand Yuan	10000	12000	4202.2	14000
numbers of staff	65	50	55	45
Former occupation	Food	pharmaceuticals	Health product	pharmaceuticals、Health product and commodity
Number of declare registered products	6	0	0	1
Number of products approved for registration	0	0	0	1
Adopt open innovation	yes	yes	yes	yes
Knowledge cooperation situation	Knowledge sharing is not good, knowledge innovation is not correct, and knowledge verification is not passed.	The effect of knowledge sharing is not good at the beginning, but timely correction, knowledge innovation is correct, and knowledge has not been verified.	There are some problems in knowledge sharing. Knowledge innovation is difficult and has not been verified.	Knowledge sharing effect is good, some knowledge innovation is not accurate, but timely correction, through the knowledge verification.

3.4 QFD method design

The qualitative patient needs of "food for patients of eating restrictions, or specific diseases" belong to the category of tacit knowledge, and through "what to do" and "how to do ", they are transformed into the

corresponding food nutrition and product formula tables, which belong to explicit knowledge. At the same time, regulatory requirements are integrated into R&D of new products and entire registration process. QFD methods is planning process for design and development of market-oriented products to meet customer needs[33].Technological innovation activity,through quality function of QFD, product innovation can be realized, and enterprises can also have the knowledge management ability in "doing", and successfully pass the product registration review.[34][35] Quality deployment refer to the design of product standard requirements into new products, so that the products meet the minimum requirements of the standards; functional deployment refers to the establishment of multidisciplinary teams to promote effective communication, exchange, cooperation and implementation of team members, and to run regulations and norms through all aspects of the registration of R & D, production and inspection.First, identify and evaluate customer needs, score customer demands importance and technical features difficulty, score correlation between technical features or functional features and customer needs, and establish a correlation matrix according to correlation degree between customer needs and technical features. The technical characteristics auto-correlation matrix is also established a three-level house of quality function. The left and right walls, ceilings, rooms, roofs and basements of the house of quality are clearly expounded.By calculating the technical importance of each technical feature and functional characteristics in the matrix after first-level expansion, items with large importance scores are selected for second-level deployment. Then calculate the technical importance of technical features and functional characteristics in the matrix, also select items with large importance scores, and then carry out three-level deployment. Finally, the result is the innovation result. Respectively the unique characteristics of new product nutritional information, product formula table, process flow and key points of control parameters, as a technology innovation performance, and in accordance with the check points and principles of judgment of three kinds of ability of management innovation performance.

4 Theoretical Construction

4.1 Data Collection

The methods of data collection include document, observation , interview：

The collection of document data comes from the notice of correction files and on-site verification conclusions received by the state review center after enterprise registration application . There are 6 enterprises 12 products of the "state review center for FSMP of correction materials notice".Because the researcher team signed a technical service consulting contract with the enterprise, directly participated in part of the enterprise's R & D and registration work, and also had a certain understanding of the enterprise's R & D work, it could collect data by direct observation.Researcher have visited each enterprise for many times. The technical team of the researcher has a relatively deep understanding of the personnel at all levels of the enterprise, and have enough time to verify the data coding results of this study through in-depth face-to-face interviews,total 21interviewees in 4 cases.

4.2 Data Coding

The core category of this research is to refine and demonstrate around "knowledge collaboration, innovation performance and influencing factors".Record by problem,through open coding、axial coding and selective coding.Through the process :first coding, dialogue with literature,second coding,third coding, analysis causality of coding results, theoretical saturation test,The coding after the dialogue with the literature is shown in Table 2:

Table 2 Three-level coding table (after talking to the literature)

No.	Open initial coding (labeling)	Axial coding(variable)			Selective coding
	Explicit knowledge sharing such as literature, scientific basis, standards, systems and reports a1	Knowledge Sharing A1			
1	Tacit transformed into explicit a2	Knowledge Innovation A2			Knowledge collaboration AA
	Tacit transformed into tacit a3				
	Explicit transformed into implicit a4				
	Verification ,review results a5	Knowledge Verification A3			
	Product formula, product nutrition list, product raw material standard, label description, process parameters, etc. b111	New product b11	Technological performance B1	innovation	
	R&D process proof, related to how R&D is completed etc. b211	R&D ability b21	Management performance B2	innovation	Innovation Performance BB
2	The establishment of raw materials procurement, production control standard measures system and other related to the completion of production b221	Production capacity b22			
	related to how tests are done b231	Testing ability b23			
	Strategic goals, intentions c11	Spirit of contract C1			
	Cooperation Agreement Contract c12				
	Trust and effective communication c13				
	Core member knowledge distance c14				
	Cross-functional project team, group c15				
	Multiple teams working together c16				
3	Disintegrate Comfort c21	Management system implementation C2			
	Breaking convention creates a sense of crisis c22				
	Rethinking in action to solve path dependence c23				Influencing factors CC
	Business activity Management Standard Methodology Responsibility c24				
	Project division and execution c25				
	Penetration into each other's fields absorbs capacity c26				
	Implement industry specification c27				
	Top management philosophy c28				
	Quality first c29				
	Employee training c30				
	Understanding of existing regulations c31	Control "change" ability C3			
	Forecast future trends c32				
	Solution under VUCA conditions c33				

5 Theoretical Examination

The influence mechanism refers to the structural relationship and operation mode of each part of the structural system. The causality between variables generated by encoding the data collected through three channels enables this study to form a preliminary theory on the dimensions of knowledge synergy, innovation performance category, relationship between knowledge collaboration and innovation performance, and factors affecting effective knowledge collaboration. In this chapter, two methods are used to verify separately.

The first is to analyze, explain and verify the structural relationship and operation mode between knowledge collaboration and innovation performance in whole innovation system from the time sequence stage of the whole innovation process by combing the phenomenon of each case and comparative analysis of the four cases.Second, through QFD method , starting from customer demand, process realization and regulatory requirements, the importance of technical characteristics and functional characteristics is scored through three-level deployment and expert scoring is applied to obtain the final innovation result through matrix calculation. In the process of three-level deployment, also further analyze, explain and verify the structural relationship and operation mode between knowledge collaboration and innovation performance in whole innovation system.

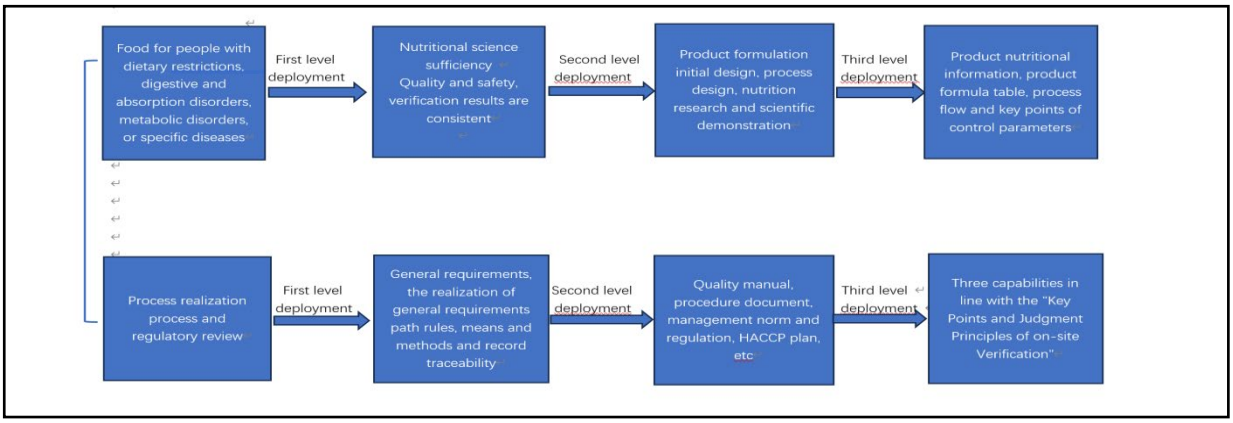
The variables and measurement standards summarized by data coding is shown in Table 3:

Table 3 Variables and measures index

Variable	Measurement index		
Knowledge sharing	inconformity	Basically conformity	Conformity
Knowledge creation	inconformity	Basically conformity	Conformity
Knowledge verification	inconformity	Basically conformity	Conformity
Technological innovation performance	inconformity	Basically conformity	Conformity
Management innovation performance	inconformity	Basically conformity	Conformity
Spirit of contract	poor	medium	strong
Management system implementation	poor	medium	good
Control "change" ability	poor	medium	strong

The whole R & D and registration work is to meet the requirements of patients and supervision, so from the two paths of new product development and management activities, the first stage deployment, second stage deployment and third stage deployment, respectively, to obtain the final technical and functional features that meet the requirements, as shown in Figure 2 of the QFD process:

Figure2 Product registration project QFD flow chart



The conclusion of multi-case analysis is consistent with the conclusion of QFD method, and the difference between groups in different cases is compared in a timely order. For satisfying customers demands and regulators, innovation process is promoted step by step with QFD tool, and the same research conclusion is drawn by using two different methodologies. It shows that the two research methods mutually confirm the authenticity and reliability of the theory of the mechanism of the influence of knowledge collaboration on innovation performance, has popularization significance .

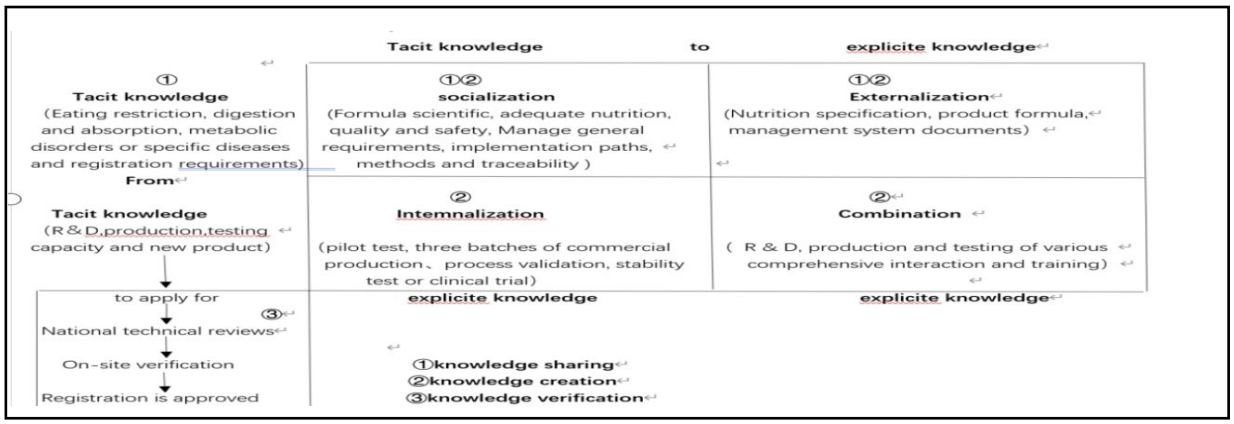
6 Discussion and conclusion

6.1 Discussion

(1) Relationship between knowledge collaboration and innovation performance.

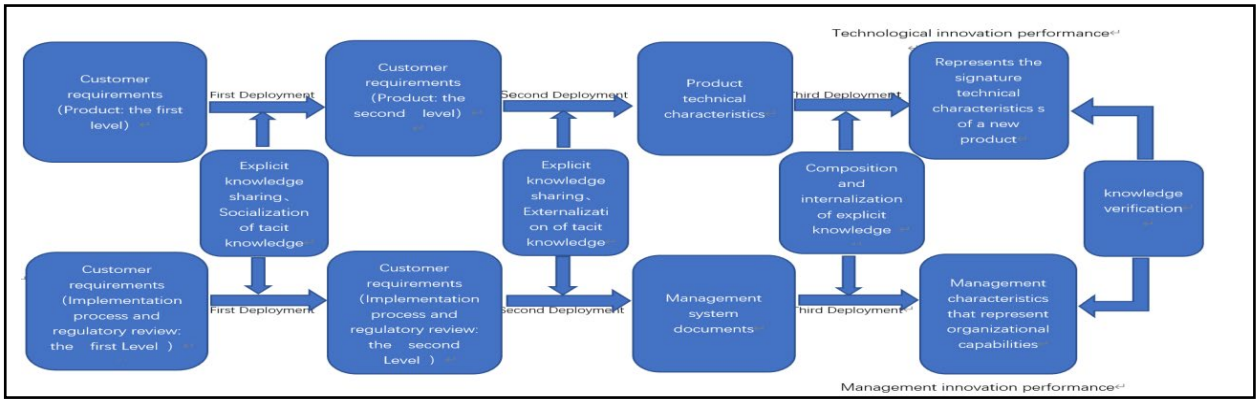
In the process of realization of new products, enterprise management ability, Research and development, production and testing capabilities can also be established in the process of "learning by doing" and pass the regulatory review. The whole process of knowledge collaboration is knowledge sharing, knowledge innovation and knowledge verification, as shown in Figure 3:

Figure3 Knowledge Collaboration Process of FSMP's Company



According to QFD method, knowledge sharing, knowledge innovation and knowledge verification, as vertical flows, also play a positive role in producing innovation performance in gradually developing process and finally satisfying customer demands. Making mistakes at each stage will not produce the final correct innovation results.As for mechanism of knowledge collaboration in achieving innovation performance, as Figure 4.

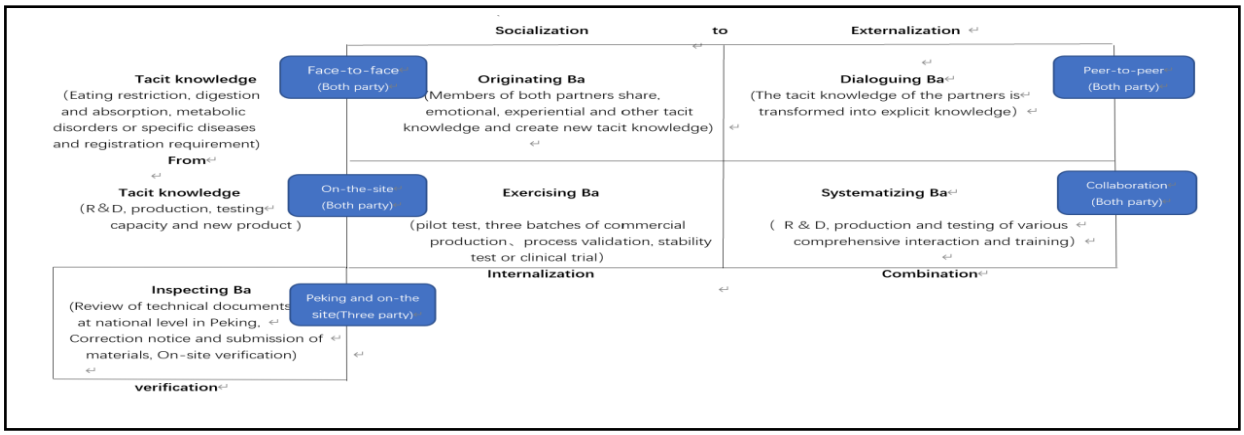
Figure 4 The Mechanism of Knowledge Collaboration in Different Stages of Achieving Innovation Performance



(2)Relationship between knowledge collaboration and influencing factors.

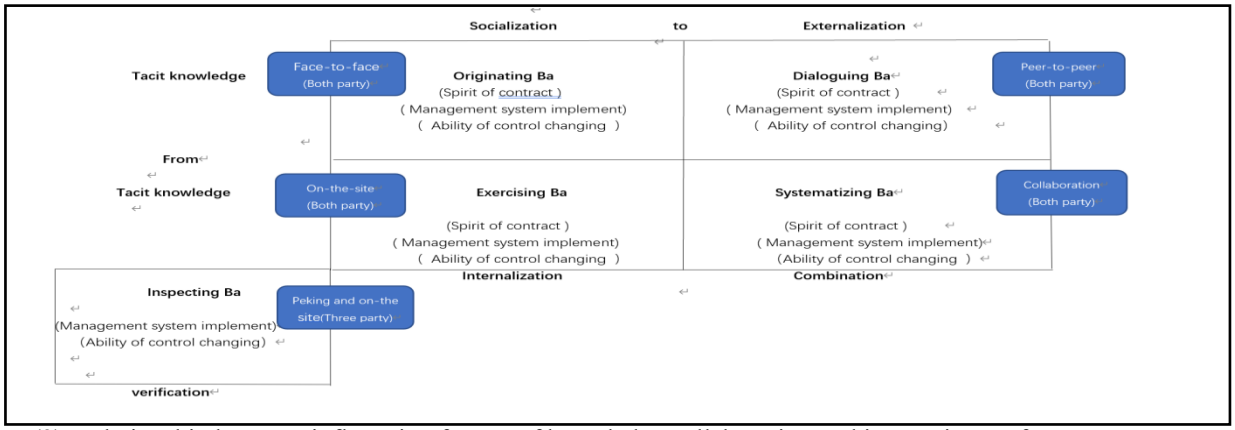
Each stage of knowledge collaboration is in a knowledge creation Ba, that is, a platform for science and technology exchange and ideological collision.This finding in this study is consistent with the theory that Ba is a concept of shared knowledge in innovation that can transcend time, space, and organizational boundaries to create knowledge [36][37], and the entire knowledge collaboration Ba is shown in Figure 5:

Figure 5 Knowledge Collaboration Ba of FSMP's Company



The influencing factors of knowledge synergy this study is also influencing factors of Ba. Due to the different environment and research perspective faced by the research object, the innovation performance of the research object can only be achieved through effective knowledge collaboration. The influencing factors of knowledge collaboration are also different from the five conditions of Nonaka promoting knowledge creation. However, this study is based on multi-channel data collection, coding, multi-case comparative analysis and other empirical research, and conducted strict reliability and validity tests. The conclusions obtained are true and reliable, and can guide practice. The action mechanism of influencing factors in Ba on different dimensions of knowledge collaboration is shown in Figure 6:

Figure6 Influencing Factor of Knowledge Collaboration Ba of FSMP's Company



(2) Relationship between influencing factors of knowledge collaboration and innovation performance.

The spirit of contract, the implementation of management system and the ability of control changing affect innovation performance by directly affecting the transmission effect after knowledge collaboration.

(4)Relationship between knowledge collaboration, influencing factors of knowledge collaboration and innovation performance.

The above analysis shows :

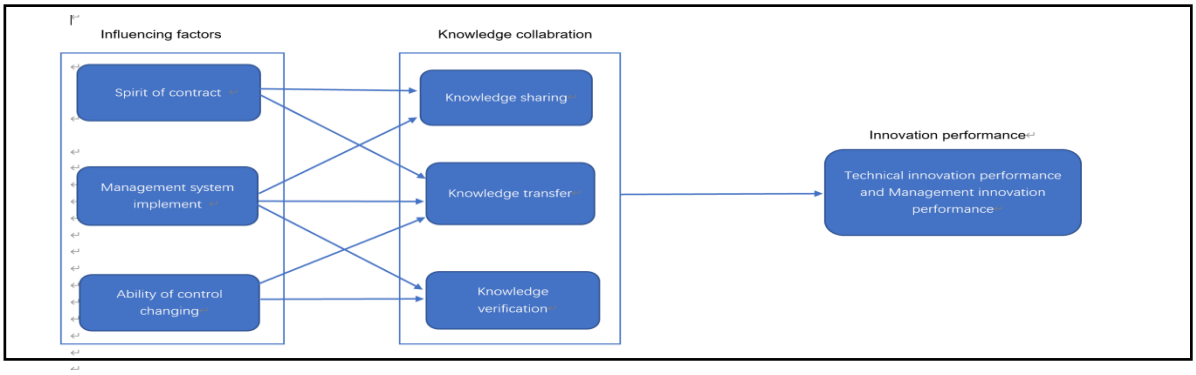
a.There is a observably positive correlation between knowledge collaboration and innovation performance.

b. Knowledge collaboration is also significantly positively correlated with three influential factors, and three influential factors are also significantly positively correlated with innovation performance.

c. According to events time order or data occurrence, influencing factors are in the event to affect innovation performance through knowledge collaboration.

If the above three aspects are all established, it shows that the influencing factors affect the innovation performance through affecting the knowledge collaboration. Therefore, through the above analysis, the theoretical model of knowledge collaboration, influencing factors and innovation performance is proposed, as shown in Figure7:

Figure 7 Theoretical model of influence mechanism of knowledge collaboration on innovation performance



6.2 Conclusions

Knowledge collaboration dimensions are divided into knowledge sharing, knowledge innovation and knowledge verification. The scope of innovation performance includes technology innovation performance and management innovation performance, technology innovation performance is new products, management innovation performance is R&D ability, production capacity and testing ability. The influencing mechanism in the whole innovation system process is:

(1) The spirit of contract plays a positive role in stages of explicit knowledge sharing, tacit knowledge socialization, external transformation of tacit into explicit , combination of explicit and internal transformation of explicit knowledge.

(2) The implementation of the management system has a good promoting influence on knowledge sharing, innovation and verification stage.

(3) The ability of control changing positively promotes the socialization of tacit, the externalization of tacit into explicit, the combination of explicit , the internalization of explicit into tacit and the verification of knowledge.

(4) Each stage of knowledge sharing, knowledge innovation and knowledge verification in knowledge collaboration has a positive effect on the realization of innovation performance.

(5) The spirit of contract, the implementation of management system and the ability of control changing also positively affect innovation performance through knowledge collaboration.

6.3 Research Contributions

The conclusion of this study provides a theoretical explanation that is more in line with China's management situation than the mainstream management theories.

(1) It broadens the application scope of knowledge creation theory under the condition of government regulation entry threshold. In the industry of FSMP, due to strict control of product quality and safety and specific regulatory policy requirements, in the knowledge collaboration, knowledge verification is also introduced. Therefore, the application of SECI model and Ba is expanded.

(2) It is found that government regulation can promote innovation, which is unique in the research of innovation participants and has Chinese characteristics.It has universal theoretical guiding significance for the innovation of infant formula food, health care products and enteral nutrition preparations (pharmaceutical grade) and other products that are also subject to registration regulatory requirements in China.

(3) Also found the importance of management innovation, Previous studies paid too much attention to technological product innovation, but ignored management innovation. Management innovation should complement each other with technological innovation. Management innovation is indispensable throughout innovation.

In practice, it provides a reference of practical value for the enterprises of the food for special medical purpose to innovate by using knowledge creation theory:

(1) In the practice of R & D and registration, enterprises should have management ability, and should pass the assessment of government regulatory departments, then have its own core competitiveness.. When buying technology or cooperating in research and development, enterprises should not "Copy"directly, or "copy templates".

(2) In the open innovation mode, internal and external departments must be involved, and the creation process of new knowledge must be completed inside .

(3) Enterprise should also carry out knowledge collaboration with regulatory departments, and make use of the requirements of regulatory technical review and on-site verification to improve and revise the internal knowledge collaboration results and further upgrade the knowledge collaboration.

(4) It verifies that the management ability of enterprises should be acquired through "learning by doing". In the process of project management balance between quality, time and cost, enterprises should take quality as the first priority, and there should be no speculation.

(5) It has proved that enterprises should develop excellent research and development, quality control and management capabilities, with mature emergency preparedness plans, to deal with the changeable under the VUCA conditions.

6.4 Research limitations and prospects

(1) Due to particularity of industry regulated by the object of this study, the research conclusion may be limited by industry differences; although can be proved knowledge collaboration has a positive effect on generation of innovation performance through multiple case studies, it can only show that the generated innovation performance is in line with the requirements, and it cannot be measured by specific quantitative indicators.

(2) For the collected data, the result of procedure coding based on the grounded theory is not the final result, but the theoretical saturation should be achieved as far as possible within the cognitive scope of the researcher. With the development of the industry or the change of time, there will be new concepts abstracted.

(3) For knowledge collaboration process of case enterprise, although process of knowledge sharing and transformation is constantly repeated, it is not expected that such a cycle is excessive. Multiple cycles mean that the innovation results do not meet the requirements, and more manpower, material resources and time will be wasted, while on-site verification of knowledge verification only has one opportunity. How to achieve the best balance between input and output should be further studied.

(4) Knowledge creation is spiraling. Through knowledge verification in this study, enterprises have accumulated experience, acquired knowledge system and capabilities. How to carry out knowledge re-creation in the future, so as to achieve better innovation performance, should also be further studied in the future.

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"Wu's Three Tendencies for Decision-Making"

---- A Non-Linear Growth Paradigm Based on the Context of "The Changes of Zhou"

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Abstract

Network economy shows a typical nonlinearity and has posed multidimensional challenges to strategic management,for example,the environmental changes are becoming more rapid; the situation is more complicated; and the prospects are more difficult to identify and judge. This high degree of uncertainty is what the static strategic analysis and decision-making based on the Western Schools of Strategic Management,can not effectively handle, which has led to various questioning, doubts and rebellions.

With the rise of China and its deepening integration into the globalization, the digging and presenting of the contemporary value and significance of traditional Chinese culture become more important.

In terms of studies on management thought, as the source of traditional Chinese culture, "The Changes of Zhou" and its management ideas, have been more and more focused and studied in recent years,However, most of the researches elaborated on the general principles of management philosophy, management ethics and management process, and failed to completely and systematically probe the strategic thinking in "The Changes of Zhou" from the perspective of corporate strategy and operation, which provides an opportunity for the research of this subject.

This thesis puts forward the theoretical construction ---"Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou". The purpose of this research is to analyze and interpret the value of the strategic management thinking in "The Changes of Zhou", to construct a corporate strategic decision-making paradigm that both shows local cultural characteristics and fits the world trend, and to enrich the "postmodern" strategic management thinking.

Keywords: Strategic management, Nonlinear growth, Limitations of scientism,Wu's Three Tendencies for Decision-Making,The Changes of Zhou

1. Introduction

In the era of industrial economy, the boundary, content and preconditions of strategic decision are basically controllable; the inter-enterprise competition situation and industrial pattern are predictable; the causality and causal chain among variables are relatively fixed. All the aforesaid factors indicate some kind of "certainty".

In that era, the strategic decision was "procedural" (Simon, 1945), the mission and main tasks of which were to enable enterprises to make optimization in the scene domain of "certainty", that is to say, to achieve the highest output and the optimal profit by using the lowest cost, the shortest time, the highest efficiency and the optimal process under given conditions.

However, since the 1970s, the real world shows more confusing, profound and universal relativity, randomness and uncertainty.

Strategic decision is no longer a predictable, controllable and procedural process, but shows distinct uncertainties. These uncertainties affect the strategic decision of enterprises from five respects, including objective uncertainty, subjective uncertainty, process uncertainty, game uncertainty and mutation uncertainty. In the process of strategic decision, the non-rational elements of "bounded rationality" (Simon, 1945) become more prominent and occupy the dominant position.

The aforesaid situation directly challenged the theoretical hypotheses of the prescriptive strategic management school.

The aforesaid situation directly challenged the theoretical hypotheses of the prescriptive strategic management school. Moreover, since the 1970s, the main standpoints of other schools with "planning" characteristic, such as "Entrepreneur School", "Cognition School", "Power School", "Culture School" and "Environment School", were also under more and more suspicion and criticism as these schools have a common cognition to plan their strategy in advance which occurs before the action.

However, in the current Internet era having surged uncertainties and advocating to win through individuality, innovation and speed, such cognition and the strategies built on it are likely to fall into ossification.

While questioning and criticizing the aforesaid schools, many scholars also began to study the bounded rationality of organizations, and variations in strategy implementation, and put emphasis on the adaptability restricted by unpredictable or unknown internal and external factors, thus, the "Learning School" has gradually been formed, which systematically elaborated how to deal with the challenges brought about by uncertainties.

"Learning school" holds the opinion that the organizational environment is complex and difficult to predict, and therefore the strategy making should be a continuous learning process rather than a rigorous planning process.

During this process, the boundaries between strategy making and strategy execution become vague and inseparable. This learning process shows more collective learning, in which the role of leaders is no longer to make deliberation in advance, but to manage the learning process where new strategies may come up.

The "Learning School" made contribution by firstly putting forward the view of "learning", which supplemented the blank of Strategic Management School and provided effective perspective and path for addressing the complexity and uncertainty of the strategic decision. However, the "Learning School" overly exaggerated the "urgency" of learning. As Mintzberg pointed out, "the Learning School may be at risk to go to another extreme, which would lead to the dispersion, abandoning, or confusion of strategy, or even lead to wrong strategy" (Mintzberg, 1991). In that case, "learning" would lose its significance and purposes. In mid and late 1990s, the turmoil and fast-changing internal and external environment made enterprises feel more and more difficult to keep the sustained competitive advantages, however, the mainstream strategic management school was incapable of taking any action to solve such problem, which significantly shattered enterprises' conviction in strategic decisions and resulted in a groundswell of rebellion against the traditional strategic management theories.

Under this context, the trend of thought of "postmodern" strategic management based on environment uncertainty, future unpredictability, system complexity and evolution dynamism emerged as the time and conditions require.

It's called "postmodern" as this word means the rebellion and deconstruction of reason, inevitability and certainty in philosophy and sociology, while emphasizing instinct, intuition, probability and uncertainty. In the context of "post-modernism", the uncertainty of management will become the key role of entrepreneurs;It would be necessary for entrepreneurs to improve their capability of correctly understanding, resolving, using, and even creating uncertainties in order to make right decisions, which would also be enterprises' core competitiveness in a new "field domain". However, at present, in the trend of thought of "postmodern" strategic management， the systematic theory has not been formed through discussions on decision-making mechanism，which is still in the process of generation and evolution, and in sore need of supporting by a new world outlook and methodology.

However, at present, in the trend of thought of "postmodern" strategic management，the systematic theory has not been formed through discussions on decision-making mechanism，which is still in the process of generation and evolution, and in sore need of supporting by a new world outlook and methodology.

"The Changes of Zhou", as the fountainhead and impetus of Chinese civilization, is a wisdom treasury containing the characteristics of oriental thinking, and also a peak in the development history of human epistemology. The thoughts derived from "The Changes of Zhou" all embody a fundamental characteristic of oriental thinking -- "soft". The so-called "soft" thinking is generally manifested as metaphor, imagination, ambiguity, uncertainty and dynamics, which may offer several options or even several contradictory but respectively tenable answers for one question, showing the "integral" feature. the "soft" thinking attempts to find out similarities and relevance from the inner links between different things. By doing so, the "soft" thinking offers us greater freedom for thinking and larger range of options, which would be more likely to stimulate our subjective initiative. This trait of thinking is what we need to deal with the currently fast-changing strategic decision environment that is full of uncertainties, which is exactly derived from The Changes of Zhou.

2. Theory Construction

What is time? Mr. Yu Shicun pointed out that, in "The Changes of Zhou", time is the sequence of energy levels obtained from the earth's movement around the sun in the effective and also limited solar system, i.e., the sequence of sixty-four "hexagrams". What is space? Space is the structure of each energy level in this sequence, i.e., the structure of "hexagram" (Yu Shicun, 2015).

On this basis, we could carry out deep discussions and studies. I think that this unique view of time and space can also be elaborated as the space and time dimensions of the three levels (which are named as "big tendency, middle tendency, and small tendency" by me) of the subject's life cycle in "The Changes of Zhou".

2.1 Big Tendency

The "tendency" that takes "hexagram" as the evolution unit is called "big tendency", such as Qian, Kun, Tun, Meng, Xu, Song, Shi, ... and Weiji. There are sixty-four hexagrams in total, and the "closed cycle (Figure 1-1)" formed by which shows the sequence of different levels of energy obtained from the sun by all things in the world. The big tendency is the largest "environment" where the subject occurs, develops and disappears, and it consists of two parts: the explicit part and the implicit part (as shown in Figure 2-2), which, in fact, is a reflection of yin and yang thought in "The Changes of Zhou", with "explicit" representing yang and "implicit" representing yin. The energy level ("hexagram") experienced by the subject is the explicit part of the closed cycle, which is indicated by full lines. The energy levels ("hexagrams") not yet experienced by the subject are the implicit parts of the closed cycle, which are indicated by dotted lines, showing the possible tendency for future development of the subject. To what extent could this tendency comes true depends on the following conditions: (1) if the subject is in a single " the sucycle", then its future tendency totally has sixty-four energy levels (hexagrams), and these energy levels have stable quantity and nature with clear boundary or controllable variation tendency; (2) If the subject is located at Intersection Q (as shown in Figure 2-2) of many complex, changeable and uncertain "ultipl cycles"y then, its role, position and the evolution path direction should be in multiple coexistence. For example, the subject at the position of "Qian" Hexagram in one closed cycle is very likely to be concurrently at the position of positiHexagram in another closed cycle, or at the position of "Xu" Hexagram in other closed cycles, i.e., A = A, but meanwhile, A ≠ A, which is a reflection of the "change" principle in "The Changes of Zhou". At this time, the future of the subject will have N×64 energy levels, which accordingly bring about N × 64 kinds of evolution directions. At certain space-time point, its action direction is the result of the combined effect of N kinds of possibilities, which is a multivariate composite function. As for the numerical value of N, It depends on the complexity of the environment.

"Big tendency" has significant reference value for analyzing the current diversified and changeable industrial environment and determining the enterprise's response strategies. Such reference value mainly lies in the fact that, no matter with respect to the tendency of individual status and action evolution, or the development trend of the environment, the 64 "hexagram statements" and 386 "line statements" of "The Changes of Zhou" contain the hints bearing rich wisdom of the east. It not only provides an ontology and methodology, but also provides a way of thinking and humanism.

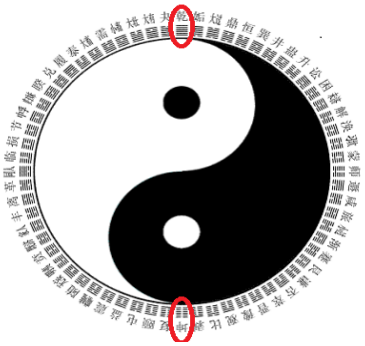

Figure 2-1

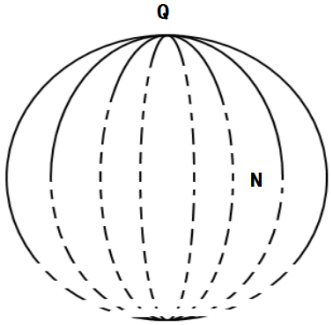

Figure 2-2

2.2 Medium Tendency

The "tendency" taking "line" as the evolution unit is called "medium tendency". As mentioned above, "hexagram" reveals the subject's state and essential features at different energy levels in its lifecycle as well as the process and the main stages (lines) formed by such state and essential features. For example, taking "Qian" Hexagram as an example, the specific explanation is shown in Figure2-3.

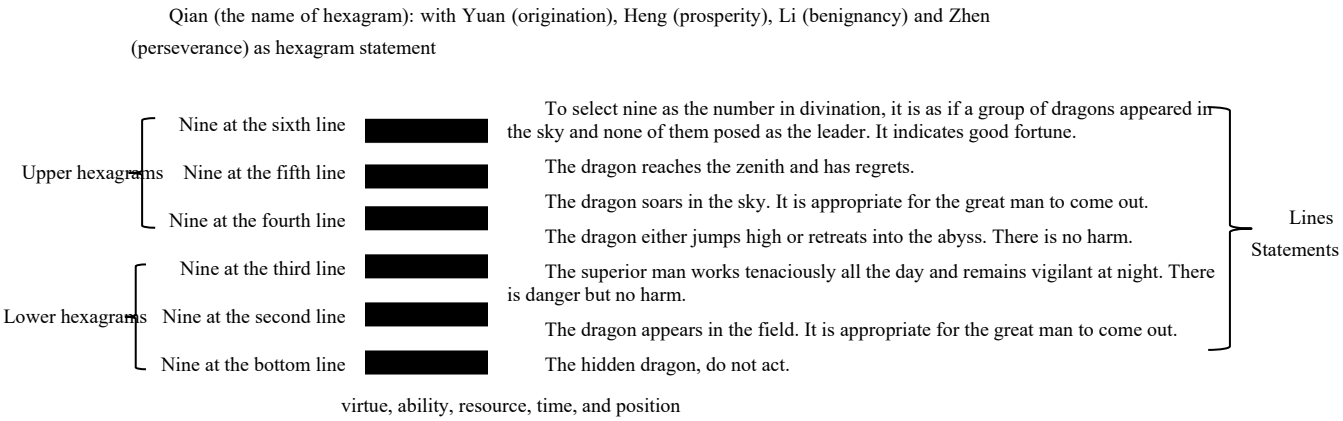

Figure 2-3

The evolution of "lines" drives the formation of the state and essential features of "hexagram". In "The Changes of Zhou", each hexagram consists of six "lines", and the lines indicate six different stages that are necessary for the subject to complete certain energy level. "The Changes of Zhou" has made special settings on the "Qian" and "Kun" Hexagrams, which have a total of seven "lines", meaning there are seven stages.

To describe in detail, time is the sequence of evolution of six "lines" at different energy levels; and space is the structure of each "line", which is not only divided into yin "lines" and yang "lines", but yin "lines" and yang "lines" locating at different positions also have different structures and contents. This kind of space-time integration determines the state, action direction and outcome of the subject on a particular "line", and is also the second manifestation of the space-time view of "The Changes of Zhou", which provides methods and framework for analyzing enterprises' strategy evolutions in different stages of growth.

2.3 Small Tendency

The "tendency" taking "virtue", "ability", "resource", "time", and "position" as evolution units is called "small tendency", as shown in Figure 2-4.

"Lines", including yin lines (—) and yang lines (- -), are the basic symbols in the symbol system of "The Changes of Zhou". But it does not mean that "lines" are indivisible, and if "lines" are indivisible, "lines" will be ossified, as a result, "hexagram" will also be ossified, thus, the life of "The Changes of Zhou" will come to an end. The eternal, inexhaustible, and endless vitality of "The Changes of Zhou" comes from the waning and waxing as well as different combinations of the four elements of "lines", i.e., "time", "position", "virtue" and "ability".The four elements of "lines", namely "virtue", "ability", "time" and "position", are my communication with Professor Deng Xinwen, deputy dean of School of Studies of Chinese Ancient Civilization of Hangzhou Normal University. The root and power of such waning, waxing and different combinations are derived from the differences in energy that the sun gives to these elements. To specify in detail, the four elements -- "time", "position", "virtue" and "ability" coexist in respect of time and vary in spatial energy, which would form different space-time integrations to promote the evolution of "lines", showing the third manifestation of the view of time and space in "The Changes of Zhou". With respect to the four elements, "virtue" refers to personality and morality; "ability" refers to the capacity and resources; "time" refers to providential action opportunity; and "position" refers to the location in the multiple complex relations, and sometimes also refers to geographical location. In order to analyze the environmental elements of strategic decision in a clearer way, this article specifically differentiates "ability" and "resource" by using two different demonstrative pronouns, for which "ability" only refers to capacity; and the concept of "resource" is introduced to refer to resources. Therefore, in

this article, the environmental elements of strategic decision change from four to five, including "time", "position", "virtue", "ability" and "resource", for which combining the initials of each English words will constitute the "TPVAR" (Wu Chong) model.

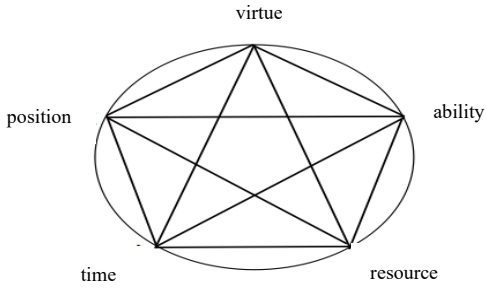

Figure 2-4

3. Values of Research

3.1 A New Perspective for Entrepreneurs

To build the strategic decision paradigms for enterprises that not only bear local cultural characteristics but also conform to the worldwide modernization trends, in order to provide better support for the development of both Chinese and foreign enterprises.

The possibility of revival of these enterprise depends on entrepreneurs' ideological height and depth. The study of "Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou" could undoubtedly provide a new perspective for entrepreneurs to develop their thinking.

3.2 A Comb of Chinese Civilization

To elaborate and explain the contemporary values and significance of the strategic management thought in "The Changes of Zhou".

The values and significance of "The Changes of Zhou" lie in its ancient symbol system, casuistry system, unique way of thinking and life philosophy, which are the cultural blood uninterruptedly maintaining the Chinese civilization for five thousand years. However, since "The Changes of Zhou" has strong Oriental mystical appearance, it's necessary to analyze, comb, develop or discard the content with rational spirit and contemporary humanistic concept, in order to make it adapt to the trend of globalization, which is an important factor for China's enhancement of its national soft power.

3.3 A Enriching the Emerging "Post-Modern" Enterprise Strategic Thought

To enrich the emerging "post-modern" enterprise strategic management thought.

So far, some representative figures have shown up in the trend of "post-modern" strategic management thoughts, such as C. E. Lindblom, J. B. Quinn, H. Mintzberg, J. Waters, A. D. Chandler, Gary Hamel, William Giles et al., they proposed some new ideas on intuition, trial and error, emergency, learning, self-organization, self-adaption, disruptive innovation and other aspects, and made their respective contributions. However, on the whole, these new ideas are still in the one-sided and fragmented state, which have not yet formed a systematic theory.

The study of "Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou" not only help to continue deepening researches on issues of certain aspect in trend of the "post-modern" strategic thought, but also provide unique methodology and thinking tool for integrating the results of the "post-modern" strategy researches in all aspects.

4. Further Researches

4.1 Critical Researches and Inheritance

In my opinion, critical research and inheritance of the strategic thinking of "The Changes of Zhou" involve the following three aspects of work: (1) to deeply tap the strategic decision thoughts in the sixty-four hexagrams of "The Changes of Zhou", and analyze the formation mechanism of "lines" from five analysis dimensions of "TPVAR (Wu Chong) -- time, position, virtue, ability, resource"; to analyze the characteristics of "hexagram" from the evolution course of "lines", and reveal the law of life cycle of all things in the universe from the sequence of "hexagrams", in order to realize the perfect docking of "Wu's Three Tendencies for Decision-Making" and the contemporary enterprises strategic decision. (2) to define the boundaries and preconditions for intuitive thinking of "The Changes of Zhou", so as to minimize the negative impact of arbitrariness of intuitive thinking on strategic decision while giving full play to the overall, organic and flexible positive traits of the intuitive thinking. The key point and difficulty of this study lie in how to realize organic combination with the particularity of individual cases while revealing the general principles of the boundaries and preconditions of intuitive thinking, which is an underlying issue involving "unity of knowing and doing" in the strategic decision process. (3) to figure out how to combine the intuitive thinking of "The Changes of Zhou" with the logical thinking of scientism in the process of strategic decision, in order to maximize the effectiveness of strategic decision.

4.2 Significance of Studying Cross-Cultural Exchange Based on the Strategic Thinking in "The Changes of Zhou"

From my point of view, the significance of studying cross-cultural exchange based on the strategic thinking in "The Changes of Zhou" is mainly reflected in three aspects: (1) With the continuous deepening of China's reform and opening up, more and more Chinese enterprises are going abroad, which brings about a more and more urgent need to understand the traditional Chinese culture under the context of globalization. The precondition for both competing and cooperating with Chinese enterprises is to get to know about China, however, it's not enough to have a comprehensive and profound understanding of China merely by understanding China's technologies, products and strategies. Instead, the comprehensive and profound knowledge of China could only be obtained by grasping the fundamental concepts and the ways of thinking of Chinese people, for which "The Changes of Zhou" is exactly the source of the fundamental concepts and the ways of thinking of Chinese people. (2) Only by comparing and integrating with other cultures could the strategic thinking of "The Changes of Zhou" eliminate the false and retain the true, discard the dross and select the essential, so as to advance with the time and be well-known by the world. Doing so is not only the requirement of the international community, but also necessary for the progress of Chinese culture and enterprises; (3) Lao Tze said, "One is the child of Tao. After one comes two, after two comes three, and after three come all things." In the context of this article, "one" is the entirety of human thinking; "two" is the logical thinking and intuitive thinking in the entirety; "three" means "harmony" which is the result of the unity and opposition of logical thinking and intuitive thinking, being the driving force for the creation of all things in the world. We could derive from the above that, innovation comes from differences. To deal with the uncertain environment of 21st century, the strategic thinking innovation should come from the results of mutual contradiction, unification and integration of the logical thinking and intuitive thinking to a large extent.

4.3 Achieving the in-Depth Integration of the Strategic Thinking of "The Changes of Zhou" with the Practical Situation of Enterprises

Another way for the going abroad of strategic thinking of "The Changes of Zhou" is to integrate its thinking closely with enterprises' strategic decision, in which regard, my specialty has unique advantages, therefore, in the future, I will make more use of "Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou" to provide advisory services for the development of Chinese enterprises. Meanwhile, I will devote greater efforts to collect more cases in respect of enterprises' successful and failed utilization of "Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou", in order to provide empirical supports for the theoretical study on the strategic thinking of "The Changes of Zhou". In addition, I hope to provide consulting services for foreign enterprises by using "Wu's Three Tendencies for Decision-Making" based on "The Changes of Zhou" if I have such kind of opportunities, and I think it would be the best way for publicizing

the strategic thinking of "The Changes of Zhou" to other countries in the world.

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Employing AI to evaluate the predictive accuracy of GMAT scores & undergraduate GPA in MBA admissions

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Abstract

Artificial intelligence (AI) has been increasingly applied in various domains, including education and assessment. We employ both AI and traditional regression models to predict the academic performance of MBA students based on the Graduate Management Admission Test (GMAT) and undergraduate GPA (UGPA). Using a sample of 250 MBA students enrolled in a state university with AACSB accreditation from Fall 2010 to Fall 2017, we examine the validity of GMAT vs. UGPA, individually and jointly, in MBA academic performance prediction through a mix of research tools, including regressions and artificial neural networks (ANNs). We identify that the combination of the GMAT total score and UGPA offers the most reliable prediction, while, individually, the GMAT total score alone offers higher validity than UGPA. Our findings prove that GMAT remains an objective and verifiable predictor of academic performance for MBA students. This study provides meaningful implications for MBA admissions as business schools introduce the GMAT test optional during the COVID-19 pandemic and beyond.

Keywords: AI, GMAT, MBA admissions, MBA academic performance, Artificial Neural Networks (ANNs)

Health-related quality of life and its correlation with autonomous participation among community-dwelling elderly in China: take the eastern region of China as an example

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Abstract

Objective: This study revisits the relationship between autonomous participation and health-related quality of life (HRQoL) in the elderly.Methods: Data used in this study are derived from a cross-sectional study of the community-dwelling elderly in China. The Impact on participation and autonomy questionnaire (IPA) and the three-level EuroQol five-dimensional scale (EQ-5D-3L) assessed autonomous participation and HRQoL. Based on sex and comorbidity stratification, a binary Logit model analysis was used to calculate the risk of adverse health states in different levels of autonomous participation. A flexible simulation of the relationship between autonomous participation scores and health status was performed using a restricted 5-point nodal cubic spline function.**Results:** A total of 1291 elderly people were included in this study for analysis. In the whole population, each 1 percentage point increase in autonomous participation was associated with a 15.2%, 14.5%, and 14.0% increase in the risk of poor health status, respectively. The risk of poor autonomous participation was higher in male elderly [model 2, OR = 107.160,95% CI= (19.596,585.987)] than in female elderly (model 2, OR = 27.649,95% CI= (7.897,96.813)). When autonomous participation status was fair, the elderly without comorbidities were associated with a higher risk of poor health status [model 2, *OR* = 11.929,*95% CI*= (4.289,33.286)] than those with comorbidities [model 2, *OR* = 10.944,*95% CI*= (5.838,20.516)]. When autonomous participation status was poor, the elderly without comorbidities were associated with a lower risk of poor health status [model 2, *OR* = 37.205,*95% CI*= (7.319,189.115)] than the elderly with comorbidities [model 2, *OR* = 63.272,*95% CI*= (16.605,241.088)].**Conclusions:** The status of autonomous participation was strongly correlated with HRQoL in Chinese community-dwelling elderly. In particular, the elderly with fair autonomic participation status without co-morbidities and the elderly with poor autonomic participation status with co-morbidities. We need large prospective studies to demonstrate the findings and to provide more information about the causal inference of this association.

Key words: Health-related quality of life, autonomous participation, community-dwelling elderly

1. Introduction

The world's elderly continues to grow at an unprecedented rate. This has had a significant impact on socio-economic development, disease prevalence, and health patterns. According to China's 7th Census, 18.7% of people (617 million) in China are 60 years and older [1]. In China, the traditional Confucianism and the "9073" policy for the elderly means that we need to focus more on the community-dwelling elderly. Foreign research says the elderly prefer to live in their familiar surroundings for more extended periods than institutions [2][3]. Therefore, special attention should be paid to the health-related quality of life (HRQoL) of the elderly, especially the community-dwelling elderly.In recent years, China has been spending more and more attention promoting healthy ageing. The Health China 2030 Plan has proposed to focus not only on increasing the people's life years but also on improving the quality of life [4][5]. HRQoL is often used to assess the health status of patients, reflecting the patient's physical, psychological, social, and emotional well-being[6]. HRQoL is considered an important indicator of healthy ageing [7]. There are a number of tools for assessing the

quality of life, such as the SF-36[8][9], of which the EQ-5D-3L is a generic tool to evaluate health status and is an appropriate tool for measuring the quality of life values in a population [10][11]. The validity and reliability of EQ-5D-3L have been validated in Chinese populations[12-14], and are continuously used to determine the quality of life in the general population and patients with chronic diseases[15-18].

"Participation" is the personal experience of involvement in a life situation and is a new concept derived from the World Health Organization's classification of health outcomes [19][20]. Autonomy is a prerequisite for effective participation, and autonomy is the ability to make choices [21][22]. The ability to participate autonomously to a sufficient extent can determine the health status of the elderly for some time Cardol[21] et al. developed the Impact on Participation and Autonomy Questionnaire(IPA) to assess rehabilitation interventions and individual perceived impairment. The questionnaire has been translated into multiple languages[23]and is used in stroke patients[24][25], spinal cord injury patients[26], and the elderly population[27]. This study investigated the autonomous participation of the elderly using the revised Chinese version of the Impact on Participation and Autonomy Questionnaire by Li Hong[28] et al. It has been shown that diseases that affect patients' autonomous participation, such as amyotrophic lateral sclerosis[29]and stroke[21] hurt the quality of life and that diseases in the elderly affect their autonomous participation and thus their health-related quality of life[30][31]. The relationship between autonomous participation and health-related quality of life is expressed through the diseases suffered. However, no clear studies explore the relationship between autonomous participation and HRQoL.

Therefore, we assessed baseline characteristics of HRQoL among community-dwelling elderly people, using an example from eastern China. And using cross-sectional data from community-dwelling elderly people in China, we investigated the relationship between HRQoL and autonomous participation, with particular reference to differences in gender and co-morbidity.

2. Methods

2.1 Data collection

Based on the level of economic development and geographical location, China as a whole can be divided into three major economic regions, namely the eastern region, which is the first province to adopt the coastal opening policy and has a high level of economic development, the central region, which is the second most economically developed region, and the western region, which is the less economically developed region. In this study, the eastern region, which has a high level of economic development, is chosen as the target of the study.

A multi-stage stratified sampling method was selected for this study. In the first stage, three provinces were randomly selected from 12 provinces in the eastern region, namely Shandong Province, Jiangsu Province and Guangdong Province. Secondly, one municipality was randomly selected from within each province. Qingdao in Shandong Province, Suzhou in Jiangsu Province and Guangzhou in Guangdong Province.

In the second stage, a county/district was randomly selected within the jurisdiction of each city. Qingdao was chosen as Jimo District, Suzhou was chosen as Kunshan County and Guangzhou was chosen as Yuexiu District. Next, two streets were randomly selected from each city/district. Finally, two communities were randomly selected from each street.

In the third stage, 100 elderly people were randomly selected from each community. Inclusion criteria for elderly people:

(1) age ≥60 years,

(2) receiving community-based home services for six months or more,

(3) being conscious and able to communicate normally,

(4) voluntarily participating in this survey.

Therefore, 1380 questionnaires were collected, missing values of key variables were excluded from the data, and 1291 valid questionnaires were recovered. This study was approved by the Ethics Committee of Zhengzhou University (Approval No. ZZUIRB2022-07). And written informed consent was obtained from all participants.

2.2 Impact on participation and autonomy questionnaire (IPA)

This study used Li Hong et al. to translate and revise the Chinese version of the Impact on participation and autonomy questionnaire (IPA) developed by Dutch scholars Cardo[21] et al. The

Chinese version of the IPA consists of 25 items in 4 dimensions: autonomy indoors (7items), social relations (6 items), family role (7 items), and autonomy outdoors (5 items). Each item was scored from 0 to 4 respectively, from fully conforming to not conforming. According to the scale design, 0-1 score is good for autonomous participation, 2 is fair for autonomous participation, and 3-4 is poor for autonomous participation, with higher scores indicating lower levels of social participation.

2.3 Health-Related Quality of Life (HRQoL)

HRQoL is measured using the three-level EuroQol five-dimensional (EQ-5D-3L) scale. The EQ-5D-3L has five dimensions. Mobility, Self-care, Usual Activities, Pain/Discomfort, and Anxiety/Depression. Each dimension is divided into three levels: no problems, some problems, and extreme problems. The index score quantified the EQ-5D-3L measurements using the time trade-off (TTO) method used by Liu Guon[32] et al. The range of index scores was [-0.149 to 1]. Under the TTO calculation method, a mild status is a health status that is at level 1 (no problems) or level 2 (some/moderate problems). Up to three dimensions were impaired, implying an EQ-5D index ≥ 0.665. therefore, this study defined an EQ-5D index < 0.665 as a state of poor health and an EQ-5D index ≥ 0.665 as normal health. The Visual Analog Scale (VAS) is a self-assessment tool that allows participants to mark their current state of health on a scale, with 0 being the best state in their mind and 0 being the worst state in their mind.

2.4 Independent variable

The characteristics of the assessment subjects mainly include demographic characteristics: gender, age, spouse, education, current living status, monthly income, and financial resources—lifestyle characteristics: smoking, alcohol, and sleep schedule. Participants were also asked to report co-morbidities. Co-morbidity meant that the participant had two co-occurring chronic conditions.

2.5 Statistical Analyses

All continuous variables were assessed by Shapiro–Wilk normality test. Means and standard deviations (SD) were used for normally distributed continuous variables, and medians were used for non-normal continuous variables. Categorical variables are expressed as counts and percentages. The chi-square test compares differences in different variables between normal and poor health states. Logit regression analysis was used to calculate the dominance ratio of poor health status using poor and normal health status as dependent variables and continuous and subtype of autonomous participation as independent variables. Due to the different susceptibility of men and women to autonomous participation and the degree of health impairment, a stratified study of gender and suffering from co-morbidities was performed during the analysis. To avoid the effects of subjectivity and information loss on the number of categories and node positions in the classification, we also used restricted cubic splines with five nodes at 5, 27.5, 50, 72.5, and 95 percentile points to flexibly model the relationship between autonomous participation scores and poor health status and to test the nonlinear relationship between them. In the binary logit regression analysis, model 1 was adjusted for gender, age, spouse, education, current living status, monthly income, and financial resources. Model 2 was adjusted for multiple chronic diseases, smoking, alcohol, and sleep schedule based on model 1.

3. Results

3.1 Baseline Characteristics

Table 1 summarizes the general characteristics of the 1,291participants (567 men and 413 women) by the categories of HRQoL. The average age of the participants was 73.95 years. The mean VAS score was 75.716 ± 17.878. 6.0% of participants had a good level of autonomous participation, 85.8% had a fair level of autonomous participation, and 8.3% had a poor level of autonomous participation. Compared with participants in normal health states, participants in poor health states had a significantly lower VAS and EQ-5D index, and autonomy participation scores increased significantly.

Table 1. General characteristics of 1,291 elderly people according to the HRQoL categories

	Total (n=1291)	Normal HRQoL (n=989)	Poor HRQoL (n=302)	*P*
Autonomous Participation	42.648±12.172	38.730±10.040	55.477±9.410	<0.001
VAS	75.716±17.878	81.019±14.018	58.349±18.160	<0.001
EQ-5D index score	0.813±0.260	0.934±0.971	0.415±0.225	<0.001
Age, year	1.000(0.674,1.000) 73.95±10.679	1.000(0.847,1.000) 71.98±10.038	0.483(0.292,0569) 80.40±10.1180	<0.001
Autonomous Participation				<0.001
good	611(47.3%)	593（60.0%）	18（6.0）	
fair	647(50.1%)	388（39.2%）	259（85.8%）	
poor	33(2.6%)	8（0.8%）	25(8.3%)	
Age(years)				<0.001
60-70	543（42.1%）	491（49.6%）	52（17.2%）	
70-80	327（25.3%）	255（25.8%）	72（23.8%）	
>80	421（32.6%）	243（24.6%）	178（58.9%）	
Gender				0.021
Male	567（43.9%）	417（42.2%）	150（49.7%）	
Female	724（56.1%）	572（57.8%）	152（50.3%）	
Spouse				<0.001
Yes	878（68.0%）	743（75.1%）	135（44.7%）	
No	413（32.0%）	246（24.9%）	167（55.3%）	
Education				<0.001
Illiteracy	365（28.3%）	250（25.3%）	115（38.1%）	
Primary school	376（29.1%）	274（27.7%）	105（33.8%）	
Junior high school	290（20.0%）	239（24.2%）	51（16.9%）	
High school and above		226（22.9%）	34（11.3%）	
Financial resources				<0.001
Pension	642（49.7%）	493（49.8%）	149（49.3%）	
support from family and friends	317（24.6%）	207（20.9%）	110（36.4%）	
Others	332（25.7%）	289（29.2%）	43（14.2%）	
Current living status				<0.001
Live alone	261（20.2%）	182（18.4%）	79（26.2%）	
Live with family	842（65.2）	718（72.6%）	124（41.1%）	

Others	188（14.6%）	89（9.0%）	99（32.8%）	
Monthly income(￥)				<0.001
<1000	470（36.4%）	364（36.8%）	106（35.1%）	
1001-3000	353（27.3%）	291（29.4%）	62（20.5%）	
3001-5000	299（23.2%）	203（20.5%）	96（31.8%）	
>5001	169（13.1%）	131（13.2%）	38（12.6%）	
number of chronic diseases				<0.001
0	225（17.4%）	213(21.5%)	12（4.0%）	
1	355（27.5%）	292(29.5%)	63（20.9%）	
2	306（23.7%）	236（23.9%）	70（23.2%）	
≥3	405（31.4%）	248（25.1%）	157（52.0%）	
Smoking				0.173
Yes	362（28.0%）	268（27.1%）	94（31.1%）	
No	929（72.0%）	721（72.9%）	208（68.9%）	
Alcohol				0.002
Yes	315（24.4）	262（26.5%）	53（17.5%）	
No	976（75.6%）	727（73.5%）	249（82.5%）	
Sleep schedule(h)				0.010
<6	408（31.6%）	309（31.2%）	99（32.8%）	
6-8	590（45.7%）	472（47.7%）	118（39.1%）	
>8	293（22.7%）	208（21.0%）	85（28.1%）	
Co-Morbidities				<0.001
Yes	711（55.1%）	484（48.9%）	227（75.2%）	
No	580（44.9%）	505（51.1%）	75（24.8%）	

3.2Association of Autonomous Participation with the Poor Health States

As shown in Table 2, the continuous and categorical forms of autonomous participation were used as independent variables, and the binary EQ-5D index was used as the dependent variable. Demographic characteristics, lifestyle, and other covariates were gradually adjusted, and binary logistic regression analysis was performed. In the total population, each one percentage point increase in autonomous participation was associated with a 15.2%, 14.5%, and 14.0% increase in the risk of poor health status, respectively. Similar results were found in men and women.

Binary logistic regression analysis revealed a significant correlation between autonomous participation problems and poor health status in the overall population compared to those with good autonomous participation status (model 2: fair, OR = 11.209< 0.001, poor, OR = 51.792, P < 0.001). Male elderly are at higher risk of poor autonomous participation [model 2, OR = 107.160,*95% CI*= (19.596,585.987)] than female elderly (model 2, OR =27.649,*95% CI*= (7.897,96.813)). The risk of poor autonomous participation was 27.649 times higher in female elderly than in good autonomous participation. In comparison, the risk of poor autonomous participation was 107.160 times higher in the male elderly than in good autonomous participation. Health status worsened with increasing autonomous participation in each model (P < 0.05).

In Figure 1, we used restricted cubic splines to flexibly model and visualize the relationship between autonomous participation scores and poor health status. We observed a nonlinear relationship between autonomous participation scores and poor health status for male elderly, female elderly, and all participants (0.039, 0.019, and 0.001, respectively).

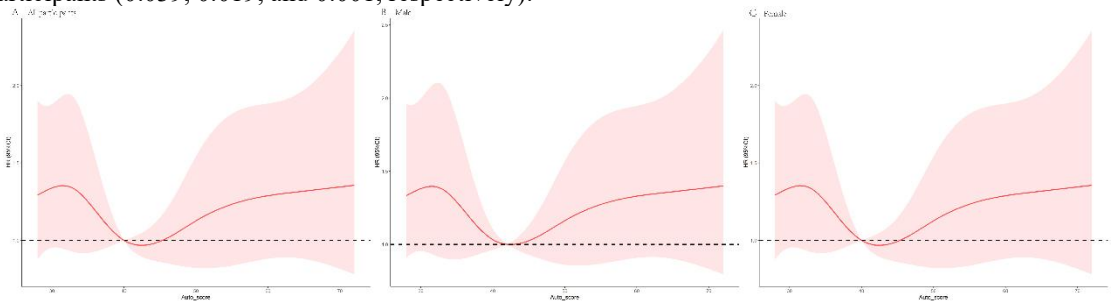

Figure 1. Restricted cubic splines of the relationship between poor health states and autonomous participation score

Note: A, total study population. B, male population. C, female population.
Auto-score is autonomous participation score

3.3 Comorbidity-Stratified Analyses

Table 3 explores the relationship between autonomous participation and poor health status in the elderly with and without co-morbidities. Among the elderly with comorbidities, the risk of poor health was increased 9.944 and 62.272 times in the fully adjusted model for participants with fair and poor autonomous participation, respectively, compared to the normal group. In the full model, when autonomous participation status was fair, elderly people without comorbidities were associated with a higher risk of poor health status [model 2, *OR* = 11.929,*95% CI*= (4.289,33.286)] than elderly people with comorbidities [model 2, *OR* = 10.944,*95% CI*= (5.838,20.516)]. In the full model, elderly people without comorbidities were associated with a lower risk of poor health status [model 2, *OR* = 37.205,*95% CI*= (7.319,189.115)] than elderly people with comorbidities [model 2, *OR* = 63.272,*95% CI*= (16.605,241.088)] when the autonomous participation status was poor.

4. Discussion

This is the first study to focus on the relationship between autonomous participation and HRQoL in a sample of the elderly. The findings found that a decrease in HRQoL was associated with poorer autonomy to participate, and this association was more prominent in the elderly without co-morbidities. Therefore, this study provides evidence for the relationship between autonomous participation and HRQoL in the elderly.

In this study, poor levels of autonomous participation were negatively associated with HRQoL. This is consistent with previous studies of patients with disorders that affect the ability to participate autonomously [33-35] Poor levels of autonomous participation are associated with the illnesses suffered and reduced quality of life. In addition, poor levels of autonomous participation were negatively associated with HRQoL in a cohort of older adults who were visually impaired[36], had cancer[37], and were disabled[38]. This study showed that the poorer the autonomous participation, the poorer the HRQoL. This yielded the same results across genders, while the risk of poor HRQoL was higher for men than for women in poor autonomy participation. The study results by Liang Z[39]et al. showed that HRQoL scores were lower in women with the disease than in men. This is different from the present study results, which may be due to the other study populations. Liang Z et al. targeted adults, and the current study targeted elderly people over 60 years of age. Some studies have indicated that men have a higher prevalence of various diseases than women[40-41]. Men live less than women[42] older women have higher levels of physical activity than men[43] thus contributing to such differences. The susceptibility of physical and psychological aspects between different genders and the influence of environmental factors at macro and micro levels complicate the association. However, even among older adults of different genders, we should pay more attention to those with poor autonomous participation, as they are more likely to be accompanied by low levels of HRQoL.

In the full model, participants with poor autonomous participation had a 62.272-fold increased risk of poor health status, higher than those with fair autonomous participation. This is similar to the general research [36] where the elderly are afflicted by disease and have correspondingly poorer

population health-related lives[44-46]. When autonomous participation was fair, the elderly with no comorbidities were at lower risk of poor health status than those with comorbidities. It is generally believed that multiple morbidities exacerbate the level of autonomous participation in the elderly and reduce HRQoL [47]. A study based on a Chinese population found that participants with chronic diseases had significantly lower EQ-5D indices than those without diseases[48]. The effect of comorbidities on HRQoL varied depending on the combination of diseases[49]. This is consistent with the findings of this study when the autonomous participation status was poor. However, for the results of the present study, when the autonomous participation status was fair, the analysis may be because as the elderly age, they may gradually accept the decline in their physical functions and deterioration of their health caused by biological and psychosocial changes, which may cause them to change their health standards and lower their expectations. So even though their participation status is not as good as the general population, their HRQoL scores may be higher. Survivorship bias should also be considered. In this study, a relatively large proportion of the population aged 60-70 years, a relatively young group of the elderly people and its autonomous participation is not the worst. The elderly with comorbidities are better able to tolerate the adverse effects of the disease, and therefore they may have better HRQoL scores. However, further studies are needed to validate our findings better to address the decline in autonomous participation in the elderly and improve their HRQoL.

There are still some limitations in this study. First, this study is cross-sectional, and no causal conclusions can be drawn. New data will be collected at a later stage, and a longitudinal study can be conducted to elucidate the predictors of HRQoL reduction further. In addition, the level of autonomous participation was obtained from an autonomous participation questionnaire, and there was no clinical diagnosis by a professional clinician. Still, the scale has been commonly used and has some reliability [21][50].

5. Conclusion

This study showed a correlation between autonomous participation and HRQoL in community-dwelling elderly. Autonomous participation is a crucial factor influencing HRQoL in the elderly. This association becomes more pronounced, especially in the elderly without comorbidities. Our study provides additional possibilities for improving HRQoL in the elderly. However, extensive prospective studies are needed to demonstrate our findings and provide more information on the causal inference of this association.

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Table 2. Odds ratios for poor health states among elderly people with different levels of autonomous participation

	Autonomous Participation score		Autonomous participation level						P for trend
			Good	Fair		Poor			
	OR(95%CI)	*P*		*OR(95%CI)*	*P*	*OR(95%CI)*	*P*		
Total									
Crude model	1.152(1.133,1.171)	<0.001	Ref.	21.991(13.411,36.062)	<0.001	102.951(40.865,259.364)	<0.001		<0.001
Model 1	1.145(1.122,1.168)	<0.001	Ref.	11.962(7.123,20.088)	<0.001	54.443(20.251,146.365)	<0.001		<0.001
Model 2	1.140(1.117,1.163)	<0.001	Ref.	11.209(6.623,18.971)	<0.001	51.792(19.275,139.166)	<0.001		<0.001
Male									
Crude model	1.155(1.127,1.184)	<0.001	Ref.	32.702(14.103,75.832)	<0.001	136.664(29.792,626.946)	<0.001		<0.001
Model 1	1.171(1.133,1.210)	<0.001	Ref.	22.167(9.227,53.257)	<0.001	83.626(16.284,429.459)-	<0.001		<0.001
Model 2	1.168(1.129,1.208)	<0.001	Ref.	22.089(9.015,54.123)	<0.001	107.160(19.596,585.987)	<0.001		<0.001
Female									
Crude model	1.148(1.123,1.174)	<0.001	Ref.	16.430(8.874,30.418)	<0.001	86.750(27.078,277.918)	<0.001		<0.001
Model 1	1.132(1.103,1.162)	<0.001	Ref.	7.714(3.972,14.981)	<0.001	33.466(9.470,118.260)	<0.001		<0.001
Model 2	1.127(1.097,1.157)	<0.001	Ref.	6.912(3.524,13.558)	<0.001	27.649(7.897,96.813)	<0.001		<0.001

Model 1: gender, age, spouse, education, current living status, monthly income, and financial resources.

Model 2: gender, age, spouse, education, current living status, monthly income, and financial resources, multiple chronic diseases, smoking, alcohol, and sleep schedule

Table 3. Odds ratios for poor health states among elderly people with different levels of autonomous participation with or without comorbidities

	Autonomous Participation score		Autonomous participation level					P for trend
			Good	Fair		Poor		
	OR(95%CI)	*P*		*OR(95%CI)*	*P*	*OR(95%CI)*	*P*	
With comorbidity								
Crude model	1.135(1.112,1.158)	<0.001	Ref.	14.930(8.285,26.904)	<0.001	68.365(19.859,235.346)	<0.001	<0.001
Model 1	1.143(1.115,1.171)	<0.001	Ref.	10.366(5.578,19.264)	<0.001	64.280(16.849,245.236)	<0.001	<0.001
Model 2	1.142(1.114,1.171)	<0.001	Ref.	10.944(5.838,20.516)	<0.001	63.272(16.605,241.088)	<0.001	<0.001
Without comorbidity								
Crude model	1.170(1.135,1.206)	<0.001	Ref.	29.462(11.595,74.861)	<0.001	178.00(41.452,764.360)	<0.001	<0.001
Model 1	1.146(1.103,1.191)	<0.001	Ref.	12.109(4.426,33.127)	<0.001	41.305(8.267,206.376)	<0.001	<0.001
Model 2	1.143(1.099,1.188)	<0.001	Ref.	11.929(4.289,33.286)	<0.001	37.205(7.319,189.115)	<0.001	<0.001

Model 1: gender, age, spouse, education, current living status, monthly income, and financial resources.

Model 2: gender, age, spouse, education, current living status, monthly income, and financial resources, multiple chronic diseases, smoking, alcohol, and sleep schedule