IMPACT OF ESG RATINGS ON INFORMATION EFFICIENCY IN CAPITAL MARKET FOR CHINESE-LISTED COMPANIES

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DOCTOR OF PHILOSOPHY
IN DIGITAL INNOVATION AND FINANCIAL TECHNOLOGY

GRADUATE SCHOOL
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A THESIS SUBMITTED TO CHIANG MAI UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN DIGITAL INNOVATION AND FINANCIAL TECHNOLOGY

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OF THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY
IN DIGITAL INNOVATION AND FINANCIAL TECHNOLOGY

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10 May 2023

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b

ACKNOWLEDGEMENT

I would like to offer my sincere gratitude to my thesis supervisor, Dr. Ahmad Yahya Dawod Lecturer at the International College of Digital Innovation Chiang Mai University. Throughout the thesis-writing process, his advice, wisdom, and altruistic assistance gave me perspective, motivation, and clarity. "Face everything with a smile" and "No difficulty can stop us" have not only motivated me to complete my thesis, but also serve as a guiding principle for my future life.

I would also like to extend my sincere thanks to Dr. Somsak Chanaim and Dr. Siva Shankar Ramasamy, my co-advisors, who provided additional content integrity to my research. Their expertise and insights have greatly enriched my work. I am also grateful to the teachers and staff who have provided additional support, which I appreciate.

Finally, I would like to express my deep appreciation to my wife and sons. I know that I have been unable to spend as much time with them as I would have liked, and for that, I am truly sorry. Nevertheless, my dear wife, I thank you for quietly taking care of all the family matters, and my dear sons, I hope to make it up to you soon. Once again, I thank you from the bottom of my heart for your invaluable guidance and support.

Guochao Wan

c

หัวข้อดุษฎีนิพนธ์	ผลกระทบของการจัดอันดับสิ่งแวดล้อม สังคมและบรรษัทภิบาลบนประสิทธิภาพของข้อมูลในตลาดทุนสำหรับบริษัทจดทะเบียนในจีน
ผู้เขียน	นายกัวชัว ว่าน
ปริญญา	ปรัชญาดุษฎีบัณฑิต(นวัตกรรมดิจิทัลและเทคโนโลยีการเงิน)
คณะกรรมการที่ปรึกษา	อ.ดร. อาหมัด ยาฮา ดาวูด อาจารย์ที่ปรึกษาหลัก
	อ.ดร. สมศักดิ์ จันทร์เอม อาจารย์ที่ปรึกษาร่วม
	อ.ดร. สิวะ สังคา รามะสามี อาจารย์ที่ปรึกษาร่วม

บทคัดย่อ

ความสัมพันธ์ระหว่างการจัดอันดับสิ่งแวดล้อม สังคม และธรรมาภิบาล (อีเอสจี) และความมีประสิทธิภาพของข้อมูลในตลาดทุนเป็นหัวข้อที่น่าสนใจและควรค่าแก่การนำมาศึกษา โดยเฉพาะอย่างยิ่งเมื่อพูดถึงเป้าหมายการลดคาร์บอนและความเป็นกลางในการลงทุนในตลาดทุนของประเทศจีน หลังจากการกำหนดประสิทธิภาพของข้อมูลในนอร์ทบราวน์แคปปิตอล (เอ็นซีเอสพี) การคำนวณความคลาดเคลื่อนของราคาหุ้น และความเสี่ยงในการตกของราคาหุ้น การศึกษานี้จึงได้ทำการตรวจสอบผลกระทบของการจัดอันดับอีเอสจี ต่อความมีประสิทธิภาพของข้อมูลสำหรับบริษัทจดทะเบียนในจีนโดยกำหนดตัวแปรของความไม่สมมาตรของข้อมูล ดัชนีความสำเร็จทางเทคนิค (ทีเอไอ) และความสามารถเชิงพลวัตเพื่อศึกษาผลกระทบของการระบาดใหญ่ของโควิด-19 การเก็บรักษาบัญชี และสิทธิในทรัพย์สินต่อประสิทธิภาพของข้อมูลและการจัดอันดับอีเอสจี สำหรับบริษัทจดทะเบียนในตลาดหลักทรัพย์ของจีน

งานวิจัยนี้เป็นครั้งแรกที่รวมปัจจัยเหล่านี้เข้าด้วยกันเพื่อวิเคราะห์ว่าการจัดอันดับอีเอสจีส่งผลกระทบต่อประสิทธิภาพของข้อมูลในตลาดหลักทรัพย์ที่จดทะเบียนในประเทศจีนสำคัญอย่างไร การคำนวณทีเอไอ ด้วยวิธีการเอนโทรปีแบบถ่วงน้ำหนัก (อีดับเบิลยูเอ็ม) และการทดสอบความแข็งแกร่งด้วยปัจจัยเบย์ขั้นต่ำ (เอ็มบีเอฟ) โดยใช้ข้อมูลตั้งแต่ปี ค.ศ. 2010 ถึงปีค.ศ. 2021 เป็นตัวอย่างในการศึกษาและสรุปผลที่เหมาะสม ผลการวิจัยแสดงให้เห็นว่า นักลงทุนเลือกลงทุนโดยมองจากจัดอันดับอีเอสจี ที่อยู่ในเกณฑ์ที่ดี โดย 1) การจัดอันดับอีเอสจี ที่สูงขึ้นมีความสัมพันธ์กับเอ็นซีเอสพีที่

d

สูงขึ้น 2) ความสัมพันธ์ระหว่างการให้คะแนน อีเอสจี และความไม่สมดุลของข้อมูลถูกทำให้เชื่อมโยง โดยวัดได้จากค่าทีเอไอ 3) ความสามารถเชิงพลวัตมีบทบาทในการกลั่นกรองความสัมพันธ์ระหว่าง การให้คะแนนอีเอสจี และความไม่สมมาตรของข้อมูล 4) การจัดอันดับอีเอสจี ที่สูงขึ้นนั้นสัมพันธ์กับ ระดับราคาหุ้นที่ผิดพลาดและความเสี่ยงที่ต่ำกว่าที่ราคาหุ้นจะตก และ 5) อิทธิพลของการให้คะแนน อีเอสจี ต่อความเสี่ยงของความพังพินาศของราคาหุ้นถูกควบคุมโดยความไม่สมมาตรของข้อมูล

จากการศึกษาแสดงให้เห็นว่าลักษณะของทรัพย์สินต่างๆ ในช่วงเวลาโควิด-19 และการเก็บ รักษาบัญชี ล้วนแล้วแต่มีผลต่อการจัดอันดับอีเอสจี การวิจัยนี้มีผลกระทบต่อผู้มีส่วนได้ส่วนเสียทุก ฝ่าย รวมถึงบริษัทมหาชน หน่วยงานของรัฐ และนักลงทุน นอกจากนี้ยังระบุแนวโน้มในการวิจัยการ จัดอันดับอีเอสจีรวมถึงการวิจัยเกี่ยวกับแรงจูงใจและผลกระทบทางเศรษฐกิจ การเปิดเผยข้อมูลและ การจัดอันดับอีเอสจีและการมุ่งเน้นทิศทางการวิจัยการจัดอันดับอีเอสจีใหม่ โดยที่แนวโน้มเหล่านี้มี นัยสำคัญต่อการทำความเข้าใจและปรับปรุงการให้คะแนนอีเอสจีซึ่งมีความสำคัญมากขึ้นในการวัด ความยั่งยืนและความรับผิดชอบต่อสังคมขององค์กร

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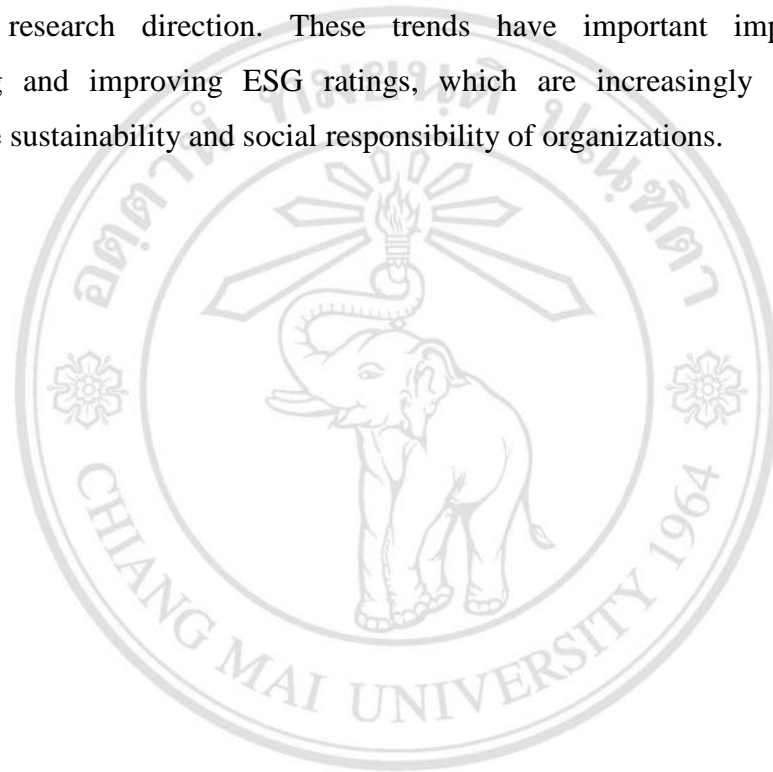|	
Dissertation Title	Impact of ESG Ratings on Information Efficiency in Capital Market for Chinese-Listed Companies
Author	Mr. Guochao Wan
Degree	Doctor of Philosophy (Digital Innovation and Financial Technology)
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ABSTRACT

The relationship between Environmental, Social, and Governance (ESG) ratings and information efficiency in capital markets is a topic of discussion, especially with China's carbon peak and carbon neutrality goals and its capital market opening. After defining information efficiency as Northbound Capital Shareholding Preferences (NCSP), stock mispricing, and stock price crash risk, this study examines the impact of ESG ratings on information efficiency for Chinese listed companies by establishing variables of information asymmetry, Technical Achievement Index (TAI), and dynamic capabilities to investigate the mediating and moderated mediation effects. This study also investigates the impact of the COVID-19 pandemic, accounting conservatism, and property rights on information efficiency and ESG ratings for Chinese publicly traded companies.

The study is the first to combine these factors into a framework to analyze how ESG ratings impact information efficiency in the Chinese capital market for listed companies. Entropy Weight Method (EWM) for calculating TAI, Minimum Bayes Factor (MBF) for robustness testing by using data from 2010 to 2021 as the study sample and drawing the appropriate findings. Results show that investors view ESG ratings favorably: 1) With higher ESG ratings being correlated with higher NCSP 2) The association between ESG ratings and information asymmetry is strengthened by TAI 3) Dynamic capabilities play a moderating role in the relationship between ESG ratings and information asymmetry 4) Higher ESG ratings are associated with lower levels of stock mispricing and a lower risk

of a stock price crash 5) The influence of ESG ratings on the stock crash risk is moderated by information asymmetry.

According to the extensible study, the nature of various property rights, the COVID-19 period, and accounting conservatism all have different implications. This study has implications for stakeholders, including publicly traded companies, governmental agencies, and investors. It also identifies trends in ESG rating research, including research on motivations and economic impact, ESG disclosures and ratings, and a refocusing of ESG rating research direction. These trends have important implications for understanding and improving ESG ratings, which are increasingly important for measuring the sustainability and social responsibility of organizations.

g

CONTENTS

h

i

LIST OF TABLES

l

LIST OF FIGURES

m

LIST OF ABBREVIATIONS

ESG	Environmental, Social, and Governance
TAI	Technical Achievement Index
COVID-19	Coronavirus Disease 2019
EWM	Entropy Weight Method
MBF	Minimum Bayes Factor
NCSP	Northbound Capital Shareholding Preferences
UNPRI	United Nations Responsible Investment Initiative
GSIA	Global Sustainable Investment Alliance
SRI	Socially Responsible Investment
CEO	Chief Executive Officer
UNGC	United Nations Global Compact
PRI	Principles for Responsible Investment
CSR	Corporate Social Responsibility
CSMAR	China Stock Market & Accounting Research
MSCI	Morgan Stanley Capital International
HKSCC	Hong Kong Securities Clearing Company Ltd.
SSE	Shanghai Stock Exchange
R&D	Research and Development
WACC	Weighted Average Cost of Capital
FCPA	Foreign Corrupt Practices Act
REITs	Real Estate Investment Trust Funds
EPA	Environmental Protection Agency
GRI	Global Reporting Initiative
GDP	Gross Domestic Product
DID	Difference-In-Difference
CSP	Corporate Social Performance
CFP	Corporate Financial Performance
ROA	Return On Assets
FP	Financial Performance
IT	Information Technology

S&P	Standard & Poors
OECD	Organization for Economic Co-operation and Development
SPI	Stock Price Information
JSE	Johannesburg Stock Exchange
SR	Socially Responsible
IPO	Initial Public Offerings
CRSP	Center for Research in Security Prices
R/S	Rescaled Range
BRIC	Brazil, Russia, India, China, and South Africa
PLS	Partial Least Squares
SMEs	Small-and Medium-sized Enterprises
CS	Corporate Social
SCSR	Strategic Corporate Social Responsibility
KRX	Korea Exchange
RAEX	Roaming Agreement Exchange
CAPM	Capital Asset Pricing Model
EPA	Ethernet for Plant Automation
DEA	Data Envelopment Analysis
OIC	Organization of the Islamic Conference
HDI	Human Development Index
UNDP	The United Nations Development Program
TFP	Total Factor Productivity
IDI	Information and communication technology Development Index
BoD	Benefit of Doubt
EPS	Economy Prediction System
SOEs	State-Owned Enterprises
CRPPEC	Comprehensive Reform Plan for Promoting Ecological Civilization
SD	Standard Deviation
2SLS	two Stage Least Square

ข้อความแห่งการริเริ่ม

        ผู้วิจัยขอรับรองว่าวิทยานิพนธ์เล่มนี้มิได้ละเมิดลิขสิทธิ์ของผู้ใด รวมถึงมิได้ขัดต่อสิทธิ์ในการเป็นเจ้าของทรัพย์สินใดๆ และขอรับรองด้วยว่าแนวคิด เทคนิค คำกล่าว หรือเนื้อหาอื่นใดจากงานของผู้อื่นที่ได้รวมอยู่ในวิทยานิพนธ์เล่มนี้ ได้รับการยอมรับอย่างครบถ้วนโดยทั่วกันตามหลักมาตรฐานการอ้างอิงแล้ว

        ผู้วิจัยขอแจ้งว่าเอกสารเล่มนี้เป็นสำเนาถูกต้องของวิทยานิพนธ์ของผู้วิจัย ซึ่งรวมไปถึงการแก้ไขปรับปรุงล่าสุดตามที่ถูกรับรองจากคณะกรรมการสอบวิทยานิพนธ์และบัณฑิตวิทยาลัย และขอแจ้งด้วยว่าวิทยานิพนธ์นี้มิเคยถูกนำเสนอเพื่อการสำเร็จการศึกษาจากมหาวิทยาลัยหรือสถาบันใดๆ มาก่อน

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I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate School, and that this thesis has not been submitted for any degree to any other University or Institution.
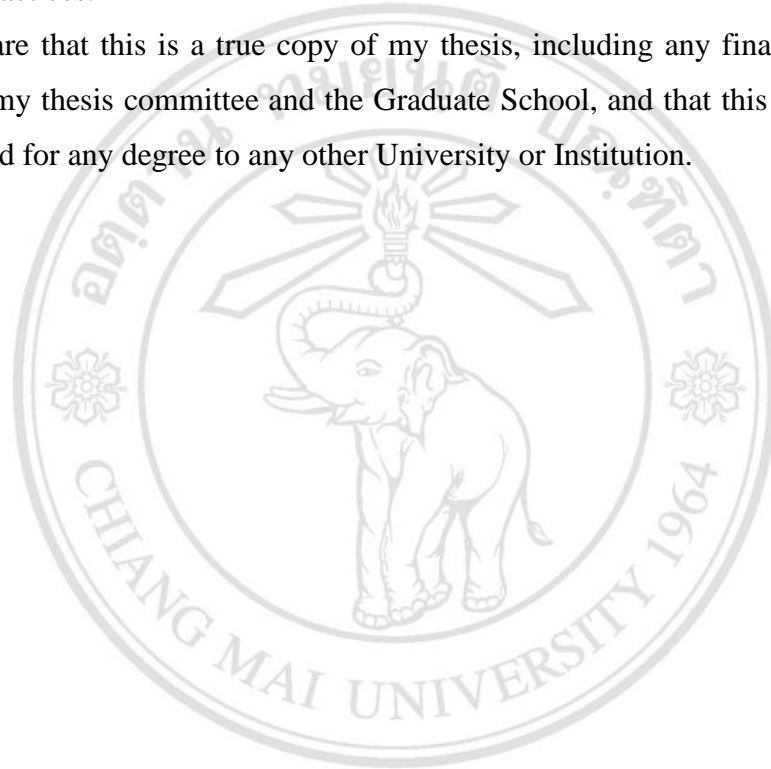
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CHAPTER 1

INTRODUCTION

1.1 Research Background

The information efficiency of the capital market is mainly embodied in the ability of securities prices to reflect information. The more fully the price reflects information, the more efficient the market information. In a market with high information efficiency, the stock price can better transmit the signal to the market and guide the efficient allocation of resources. Despite the importance of information efficiency in the capital market, the prevalence of information asymmetry can lead to opportunistic behavior by companies and managers. This can include manipulating information disclosure, which undermines the ability of stock prices to accurately reflect fundamental information about the company. As a result, the resource allocation function of the capital market can be weakened. Therefore, how to improve the information efficiency of the capital market is a challenging and fundamental problem in both practical and theoretical research within the field of finance. Environmental, Social, and Governance (ESG) is a methodology used to assess a company's capacity for sustainable development and long-term value creation across three key areas: the environment, society, and corporate governance. Its objective is to encourage companies to proactively take on greater social responsibility, foster environmentally conscious corporate development, and promote positive interactions with society (Khan, 2019), and is an important part of the investor relationship management system (Baker et al., 2021). ESG performance is a non-financial about environmental, social and governance evaluation index that conveys the idea that companies should pursue the coordinated development of economic and social impacts, and is helpful in truly achieving sustainable development and high-quality corporate development (Wan and Dawod, 2022). As of 2021 November, 114 exchanges around the world have started to promote ESG disclosure for listed companies, covering 56,783 listed companies and 3,404 members of the UNPRI, total assets under management is close to $100 trillion (Sustainable Stock Exchanges Initiative, 2021) [1]. According to the Global Sustainable Investors Alliance (GSIA), the global sustainable investment incorporated into ESG investment philosophy in 2020 is as high as USD 35.3 trillion, an increase of 54.56% over 2016, with the United States, Japan, the European Union, Canada

1

and Australia accounting for more than 90%. By December 2020, nearly 3,500 institutions around the world had stated the United Nations Principles for Responsible Investment (UNPRI) based on ESG, including 2,532 investment institutions and 575 asset owners. ESG investment has maintained rapid growth for many years. The global development of sustainable investment strategy is shown in Figure 1.1. ESG investment in emerging markets is also growing rapidly, and ESG investment has become a hot spot in China's capital markets. In 2018, China Securities and Futures Commission put forward "Establishing the Basic Framework of ESG Information Disclosure", and in 2021, ESG information will be the key way that listed companies contact with the investors. Since China government states the goal of "peak carbon" and "carbon neutrality", the enthusiasm of listed companies to publish ESG reports has greatly increased. As one of the larger emerging economies globally for China, ESG concepts are gaining attention from investors and government regulators. In 2021, Chinese regulators introduced ESG disclosure requirements for A-share listings companies, establishing an effective channel for investors to access corporate ESG information. As ESG investment concepts have entered the Chinese market for a relatively short period, there are still relatively few relevant studies based on Chinese scenarios. However, as ESG is receiving more and more attention, its research value is also increasing. ESG principle developed from SRI, and as an important evaluation tool for listed companies' sustainability, its impact on the information efficiency of the capital market and its mechanisms have received academic attention and research.

2

	Impact/community investing	Positive/best-in-class-screening	Sustainability-themed investing	Norms-based screening	Corporate engagement and shareholder action	Negative/exclusionary screening	ESG integration
2016	$248	$818	$276	$6,195	$8,385	$15,064	$10,353
2018	$444	$1,842	$1,018	$4,679	$9,835	$19,771	$17,544
2020	$352	$1,384	$1,948	$4,140	$10,504	$15,030	$25,195

■2016　■2018　■2020
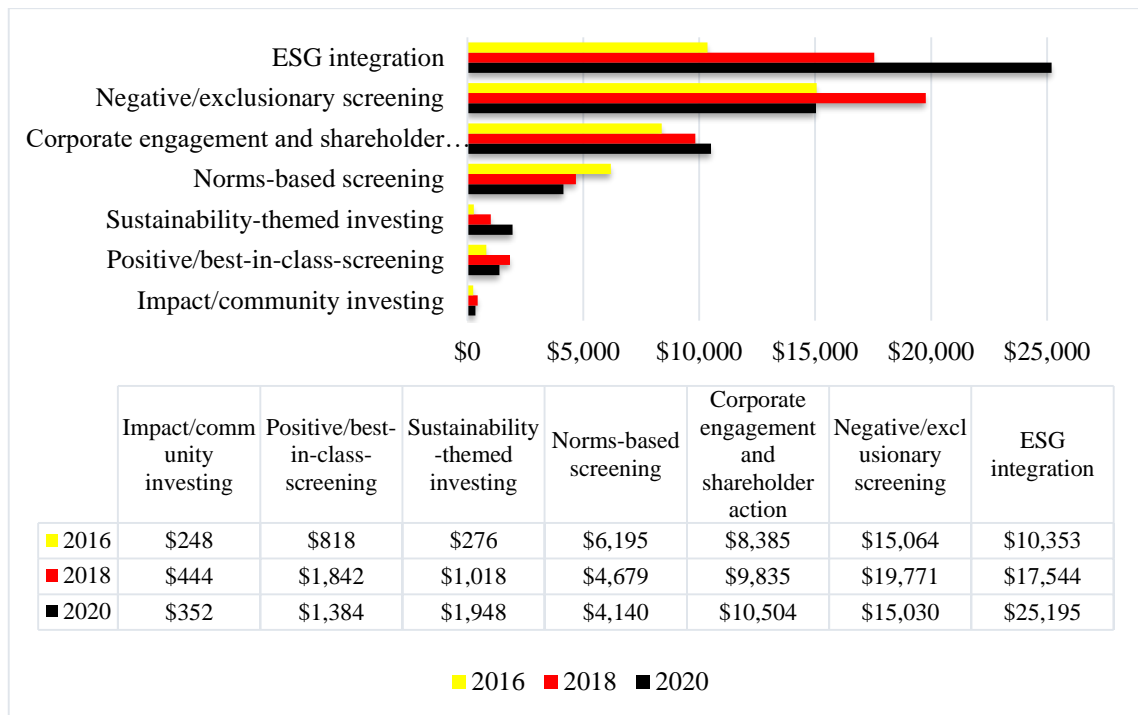
Figure 1.1 Assets in each sustainable investment strategy (billions)

As one of the main information intermediaries, ESG ratings deliver more useful information in promoting the effective dissemination and diffusion of enterprise information and improving the efficiency of stock pricing for capital market. This dissertation will expand the existing research results' understanding of ESG ratings and increase the depth and breadth of ESG research results. In particular, the focus on China is a more appropriate way to study this phenomenon in the emerging markets.

1.2 Problem Statement

The general problem is the information value of ESG ratings to the capital market, that is ESG ratings can effectively provide market participants with information about company characteristics, impact information efficiency in the capital market. The specific problem is a poor knowledge of the extent of ESG ratings on information efficiency expressed by northbound capital shareholding preferences (NCSP), stock mispricing, and stock price crash risk in China. Since the year 2000, numerous studies on ESG have emerged globally. However, prior research on ESG has primarily focused on its impact on corporate financial or organizational performance, with limited exploration of its effect on the information efficiency of capital markets. This gap in the literature has impeded the development of ESG research for Chinese listed companies and has hindered a

comprehensive understanding of the role of ESG in the Chinese capital market. This dissertation aims to contribute to the existing ESG research by examining the impact of ESG on information efficiency in capital markets. Given China's commitment to the "double carbon" goal, it is crucial to guide listed companies towards green investment opportunities, accelerate green and low-carbon transformations, and enhance their sustainable development capabilities. This will promote China's economic transformation and upgrading, increase confidence in the capital market, and foster its stable and healthy development.

Previous literature has primarily focused on the ESG factor and its economic implications. ESG performance has been found to impact the risks faced by companies (Starks, 2009), with a more significant impact observed in companies with higher levels of product differentiation. Better ESG performance is associated with reduced firm risk (Albuquerque et al., 2019), and companies with higher ESG performance levels have demonstrated greater flexibility and better overall performance, indicating that ESG performance can enhance a company's ability to mitigate risks (Lins et al., 2017). Studies have found that higher ESG performance can attract a wider range of investors and result in lower risks of lawsuits, ultimately leading to lower capital costs (Hong & Kacperczyk, 2009). The relationship between ESG performance and corporate bond credit ratings is dependent on the country where the company is located and the level of importance attached to ESG factors (Stellner et al., 2015). Companies with poor performance in the environment generally caused worse credit ratings and lower yields (Seltzer et al., 2020). ESG can reduce the specific legal risks of the company and have a higher market valuation (Hong & Liskovich, 2015). In addition, some studies have found that ESG rating increases the specific risks of enterprises. When enterprises improve their ESG rating, they will lose their flexibility, which will lead to a decrease in the benefits to stakeholders (Becchetti et al., 2015). According to the different influences of ESG components, the capital cost of enterprises with a poor environment is higher (Chava, 2014). Green enterprises have lower capital costs (Pástor et al., 2021). The wealth of unsuspecting investors determines the cost of capital for green stocks (Pedersen et al., 2021). The capital cost of green projects has not decreased (Flammer, 2021).

The results of ESG on enterprise performance is widely researched, and be sought after by researchers. According to different measures of performance or value, existing

4

research conclusions mainly include the positive and negative effect caused from ESG to company performance or value. The choice of rating agencies has an impact on portfolio performance constrained by ESG (Aich et al., 2021). Overall, the actively association from ESG to company financial performance or value is mainstream. The characteristics of the country have some impacts on the ESG, and the legal origin can predict the ESG performance of enterprises better than the political system, social preference, and financial performance of enterprises themselves (Liang & Renneboog, 2017). When the CEO of a company is married, it will increase the diversity of the company and the score of employees, thus improving the ESG score of the company (Hegde & Mishra, 2019). In terms of the influence of ESG on non-financial factors, it not only becomes the evaluation index of financial investment and enterprise management but also displays in the aspects of enterprise innovation, green governance, risk prevention, and control. ESG also promotes the performance of green innovation, which plays an intermediary role (Xu et al., 2020). Previous literature is increasing regarding ESG as a sustainability analysis framework and paying more attention to the connection among its different dimensions. There are gaps in the existing literature regarding ESG ratings versus capital market information efficiency in China. In other words, the effect from ESG ratings to the information efficiency of the Chinese capital market has not been fully demonstrated in the literature. The specific problem is a poor knowledge of the extent of ESG ratings on information efficiency expressed by northbound capital shareholding preferences (NCSP), stock mispricing, and stock price crash risk in China. So far, the existing literature has not adequately explained the mechanism through which ESG ratings account for the differences in information efficiency among Chinese enterprises.

1.3 Research Questions

ESG ratings have the potential to improve the transparency of information exchange between companies and investors and enhance firms' governance framework. This, in turn, can significantly impact the information efficiency of capital markets. Building upon this premise, this dissertation seeks to investigate the effect of ESG ratings on the information efficiency of Chinese capital markets, using a comprehensive review of relevant literature. Given the significant stock reaction phenomenon observed in the Chinese market, this study defines information efficiency in terms of three critical dimensions: NCSP, stock mispricing, and stock price crash risk. Against this backdrop,

this research addresses the following questions: do ESG ratings impact the information efficiency of Chinese capital markets, what are the mechanisms through which ESG ratings influence information efficiency, and what factors affect the transmission effect of ESG ratings on information efficiency? To answer these questions, this dissertation further explores the above issues from three perspectives: NCSP, stock mispricing, and stock price crash risk.

Against this backdrop, this dissertation addresses the following research questions.

1) Can ESG ratings impact information efficiency in emerging markets, specifically for China?

2) How the role can information asymmetry, Technical Achievement Index (TAI), and dynamic capabilities play in the association between ESG ratings and information efficiency in the Chinese capital market?

3) How does COVID-19, the nature of property rights, and accounting conservatism affect the impact of ESG ratings on information efficiency in the Chinese capital market?

4) How does the different effect between ESG ratings and information efficiency work when measuring information efficiency with NCSP, stock mispricing and stock price crash risk?

1.4 Objectives of the Study

The basic function of the capital market is to use the price signal mechanism of stocks to guide resources, and achieve the optimal allocation. However, with the existence of information asymmetry, companies have an absolute information advantage and have the motive to carry out information manipulation to investors, so that stock prices often underreact to information, thus weakening the capital market allocation function. It is an indisputable fact that information efficiency is still poor. The stock price of listed companies often deviates from its intrinsic value, which leads to mispricing, and also influences the preferences of stakeholders. Through the study on the above research questions, this dissertation aims to achieve the following research objectives.

1) To test the relationship between ESG ratings and information efficiency for Chinese capital market.

2) To analyze the mediation effects of information asymmetry and to examine the moderated mediation effects of TAI and dynamic capabilities on the above relation.

3) To investigate the impact of COVID-19, the nature of property rights, and accounting conservatism on the above relation.

4) To explore the different effect between ESG ratings and information efficiency in terms of NCSP, stock mispricing, and stock price crash risk.

1.5 Main Contributions of the Research

The findings of this dissertation contribute to literature in several ways.

First, the first research to discuss the impact of ESG responsibility on the information efficiency of China's capital market from the perspective of ESG ratings, which expands the research scope of effective capital market theory and responsible investment theory. This not only provides the shareholder preferences effect and stock price effect of overall ESG for China, but also expands the existing literature on ESG ratings.

Second, selects a capital trend as an indicator to define the north capital holding preferences, and tests the effect from ESG ratings to northbound capital shareholding, which expands the literature on foreign institutional investors' holding preferences. This dissertation examines the impact of TAI and dynamic capabilities on the relationship between ESG ratings and the shareholding preferences. The findings of this study aim to offer valuable insights and guidance to investors, corporate managers, and regulators in their decision-making processes.

Third, uses the micro-data of listed companies in China, an emerging market, to test the effect of ESG ratings on three dimensions of information efficiency of capital market, namely, northbound capital shareholding preferences (NCSP), stock mispricing, and stock price crash risk, and carries out heterogeneity analysis according to the COVID-19, the nature of property rights and accounting conservatism.

Fourth, introduces the mediation effect model of regulation, explored the mechanical effects of information asymmetry, TAI, and dynamic capabilities, and revealed the specific path of ESG ratings affecting the information efficiency in the capital market for China.

Fifth, the EWM is used as the method to calculate the TAI indicators, and the updated variables and data sets are used to construct the provincial TAI for the period 2010 to 2021. Additionally, the TAI in China province is also analyzed and some characteristics of change are obtained. This is the first time that provincial TAI has been calculated and summarized, to the best of our knowledge. Several policy and management implications for governor and manager to promote the realization of China's "double carbon" goal.

1.6 Research Scope

ESG can be traced back to the environmental protection movement in the middle of the 20th century. In 2005, "Who Cares Wins" written by the UNGC integrated the three dimensions from the views of environmental, social, and governance, and put forward the ESG (Compact, 2004). In 2006, the PRI required that ESG factors should not only be included in investment decisions but also promote the ESG development of invested entities. Since then, ESG has gradually spread to the world. In the last decades, ESG-related regulations and policies have been adopted successively in the United States and Europe. It puts forward higher standards and requirements for the ESG system to be included in investment decision-making. ESG has also been described as "the three pillars of sustainability". ESG differs from CSR. Gillan et al. (2021) concluded that ESG refers to integrating framework in business models for companies.

ESG system includes three key links: ESG disclosure, ESG ratings, and ESG investment. Enterprises disclose the corresponding information according to the contents. Rating agencies evaluate the ESG information disclosed by enterprises by ratings, and ESG investors control risks according to the rating situation, reduce investment fluctuations and improve long-term benefits.

This dissertation conducts empirical analysis on the listed companies in Shanghai and Shenzhen A-shares from 2010 to 2021, using financial data sourced from the WIND and CSMAR databases. The ESG ratings data is obtained from the Huazheng ESG rating in the WIND database, while the remaining variables are sourced from the CSMAR database. The criteria for retaining the sample data were as followed. After excluding firms in financial and insurance industries and excluding samples with ST or *ST, this dissertation excluded firms missing ESG ratings data and firms which were lack data.

1.7 Conceptual Framework

8

This dissertation aims to explore the connection from ESG ratings to information efficiency in the capital market for China. Relying on the supporting theories, this dissertation analyses the extent to which ESG ratings could affect information efficiency for China, and investigate what paths played on the above relation. In this dissertation, the information efficiency is separately treated from the Northbound Capital Shareholding Preferences (NCSP) defined as capital trend perspective, from the stock price crash risk defined as risk perspective, and also from the stock mispricing defined as the price perspective. The other three main variables including TAI, dynamic capabilities, and information asymmetry are used to test the channels through that ESG ratings affect information efficiency in the capital market. Additionally, dissertation considers the external social environment and the internal corporate environment factors which would be introduced in the variable definitions. The concept map is shown in Figure 1.2 which was adopted to guide this thesis.
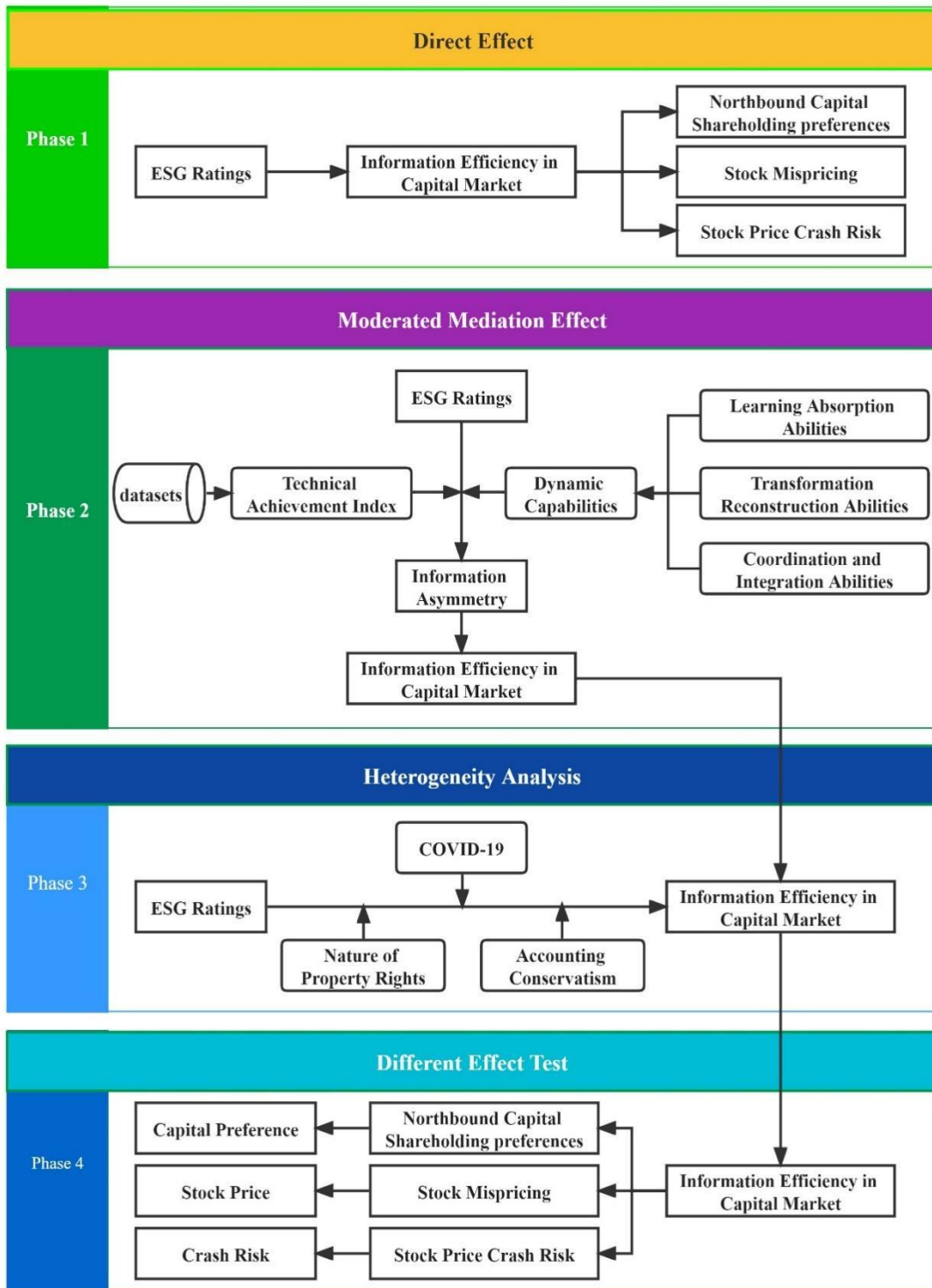
Figure 1.2 Conceptual framework for ESG ratings and information efficiency in capital market.

1.7.1 ESG Ratings

ESG rating is an objective reflection of company ESG practice, and the result of ESG ratings becomes one of the criteria to judge whether an enterprise is worth investing in. At present, many international organizations put forward the ESG rating system and regularly publish related indexes, and representative systems include MSCI, KLD, Dow Jones, FTSE Russell, Townsend Reuters, Refinitiv, and so on. Under the background of the new economic development, some enterprises in China have also put forward ESG rating systems, such as Huazheng, SynTao Green Finance, and Business and Road Integration. These rating systems focus on building standardized indicators that can reflect the ESG practice of Chinese enterprises, thus providing an orderly and feasible organizational framework for ESG evaluation.

Although different rating systems have differences in many aspects, the connotations of the major systems are basically the same. Take China Business Road Green ESG Rating System as an example, which was launched in 2015 and established based on international ESG standards and Chinese local characteristics. For example, according to the standards of the international mainstream rating system, combined with the development of enterprises in China, China Huazheng Index has formulated a three-tier ESG index rating system with local characteristics in China. Compared with other ESG rating systems of listed companies in China, Huazheng ESG rating system is deeper and more comprehensive.

ESG rating is a ranking system based on the ESG comprehensive scores covering all listed companies and cluster analysis. The ESG ratings refer to the most widely used ESG rating framework in the world, which takes into account the realities of the capital markets. Normally, ESG rating data contains 9 levels which range from 'C,' 'CC,' and 'CCC' to 'A,' 'AA,' and 'AAA'. Through the assignment, in turn, this dissertation assigns C to 1, CC to 2, CCC to 3, B to 4, BB to 5, BBB to 6, A to 7, AA to 8, and AAA to 9. A Higher ESG rating value represents better corporate ESG performance.

1.7.2 Northbound Capital Shareholding Preferences

In 2014, China launched the "Shanghai-Hong Kong Stock Connect" and in 2016, the "Shenzhen-Hong Kong Stock Connect". Together, they are commonly known as the "Land-Hong Kong Stock Connect". These initiatives marked a significant milestone in

11

the opening up of China's stock market. With the increase in the number of shares on the Land-Hong Kong Stock Connect and the passage of time, the transaction of funds on the Land-Hong Kong Stock Connect has become increasingly active. By the end of December 2019, the net inflow of funds from Lu Gang Tong northbound was RMB 9790.64 billion, by 2021, the total turnover of northbound capital surpassed RMB25 trillion, with net purchases of RMB432.1 billion, which has become an important force influencing the operation of A shares in the Shanghai and Shenzhen stock markets. Northbound capital has become more important (Kim et al., 2015), more information advantages (Sohn and Jiang, 2016), and good capital structures. At present, China's stock market is still dominated by retail investors. Compared with professional investment institutions, the majority of retail investors are weak in knowledge reserve and investment experience, and investors' emotions are more prone to irrational fluctuations due to the influence of political information or short-term market trends, and often show obvious "herd effect" (Chou and Zhang, 2014). Northbound capital can help to improve the performance of invested companies (Liu et al., 2020). With the continuous internationalization of China's financial market, the trend of northbound capital has increasingly become an important indicator for domestic investors. The daily net inflow of northbound capital has been closely watched by more and more investors, which has influenced investor behavior and thus the operating trend of the mainland stock market. Northbound funds have always been known as "smart funds". In the past two years, when the mainstream media in China reported on the stock market, they often mentioned the inflow and outflow of funds from the north. There has been more and more research and articles on funds from institutions and the media, and funds from the north have become one of the mainstreams "weather vanes" of investment in China's stock market. In fact, it is not clear whether the actual controller of the funds going north is a Chinese trader in Hong Kong or a Chinese trader on the mainland. It may only be an account opened in Hong Kong, and there is a phenomenon that the mainland capital is wearing the vest of "northbound capital" to speculate in junk stocks. In 2022, the volatility of the Chinese A-share market increased, and northbound capital once flowed out sharply. However, with the net purchase of RMB95.1 billion in November and December, the net purchase for the whole year reached RMB90.02 billion, which was the ninth consecutive year. In terms of months, the net purchase in June and November was the highest at RMB72.96 billion and

12

RMB60.095 billion respectively; the net sale in October was the highest at RMB57.3 billion. In terms of months, the net purchase amount in June and November of 2022 was the highest, with RMB72.96 billion and RMB60.095 billion respectively; the net sales amount in October was the highest, reaching RMB57.3 billion. In 2022, the five major industries received more than RMB10 billions of northbound capital, namely photovoltaic equipment, banks, medical equipment, energy metals and power grid equipment, with the amount of storage of RMB21.818 billion, RMB19. 676 billion, RMB15.318 billion, RMB13.646 billion and RMB12.056 billion; the total stock market value of the industry is RMB108.245 billion, RMB177.865 billion, RMB68.097 billion, RMB23.644 billion and RMB47.891 billion. In addition, the coal industry, logistics industry, non-ferrous metal industry, food and beverage industry and other industries have gained more than RMB7 billion in market value from northbound capital. In 2022, the industry with the largest capital reduction in the northbound direction was batteries, with the amount of capital reduction as high as RMB14.202 billion, and the total market value of positions fell to RMB128.924 billion, accounting for 7.39% of the northbound capital ratio. In addition, the reduction of medical services, chemicals and pharmaceuticals, steel and consumer electronics exceeded RMB6 billion. At the end of 2022, Guizhou Moutai was still the largest heavyweight stock in northbound capital, with a total of 85 million shares and a market value of RMB146.447 billion, a decrease of 4,883,200 shares compared with the end of 2021. The second and third largest positions are Midea Group and Contemporary Amperex Technology Co., Limited, with a market value of RMB74.215 billion and RMB67.473 billion respectively. Among the top 20 Awkwardness stocks, Northbound Capital reduced its holdings of 7 stocks, with Guizhou Moutai, Contemporary Amperex Technology Co., Limited and Luxshare holding a large proportion; at the same time, it increased its holdings of 13 stocks, with Midea Group, Longji Green Energy, Guodian Nanrui and Zijin Mining holding more shares. In terms of individual stocks, Northbound Capital increased its holdings by 869 stocks in 2022, and 47 stocks increased their holdings by more than 100 million shares. Agricultural Bank of China increased its holdings by 734 million shares, with a total holding of 2.47 billion shares and a market value of RMB7.187 billion. China Construction, Zijin Mining, Focus Media and China Unicom ranked second to fifth in terms of number of holdings; among them, after China Construction and Zijin Mining Focus Media increased their holdings,

the market value of their positions exceeded RMB10 billion. From the above data analysis, it can be seen that northbound capital has become an important factor influencing China's capital market, an important participant in the stock market, and represents investors' preferences.

1.7.3 Stock Mispricing

There are some shortcomings in the size, function and rules of China's capital market, which is reflected at the micro level that there is widespread valuation bias among the most active listed companies in the capital market, which ultimately forms the problem of wrong pricing. Therefore, stock mispricing refers to the long-term financial anomaly that causes the stock price to deviate from its intrinsic value due in an inefficient capital market, this anomaly in capital markets is known as stock mispricing. Some scholars have pointed out that wrong pricing causes the failure of the resource allocation function, which will not only cause great damage to listed companies and financial investors, but also have a serious impact on the stability of the financial system and even the whole economic operation. Faced with the problem of mispricing in China's capital market, it is of great practical significance to intervene as a driving factor to correct the valuation, which will improve the efficiency of resource allocation in the capital market and ensure the high-quality operation of the economy. Limited by the problem of information asymmetry, it is difficult for the stock price information covered by enterprises to theoretically achieve strong efficiency, and it is often difficult to avoid mispricing, especially under the influence of the superposition of irrational emotions in the market, the frequent and violent fluctuations of stock prices further deepen the degree of mispricing. Solving the problems of information asymmetry and irrational emotions has become one of the major breakthroughs in correcting mispricing. How to improve the degree of stock mispricing is not only a realistic problem that urgently needs to be solved in the high-quality development stage of China's capital market, but also a hot topic that has been studied by theoretical circles. Information asymmetry theory hold that information asymmetry and irrational behavior in the capital market will cause stock prices to deviate from their true values, leading to mispricing problems, which will hinder the effective allocation of capital and damage the efficiency of financial resource allocation. Scholars have explored the solutions to the problem of stock mispricing. Francis et. al. (2005) found that the quality of accounting information can affect investors'

14

judgment of stock price, low-quality accounting information leads to an increase in the cost of equity. High-quality accounting information can alleviate stock mispricing by improving investors' irrational behavior. Judging from the existing literature, the current mispricing hypothesis is mainly based on the theoretical framework of information asymmetry, which emphasizes the role of irrational behavior of market investors and managers in reflecting stock price information caused by information asymmetry. Investors' bounded rationality and information asymmetry are the main reasons that lead to stock mispricing. First, from the perspective of information asymmetry, it is found that the higher quality of accounting information and better internal control of enterprises will improve the efficiency of capital allocation, and information disclosure by enterprises will improve investors' understanding of listed companies, thus alleviating the overvaluation of stock prices, so improving the quality of information disclosure will reduce the degree of stock mispricing. Some scholars also found that analysts can collect enterprise information, analyze and publish the information, and effectively reduce the information asymmetry inside and outside the enterprise. Investors have the ability to gather information on enterprises, monitor and manage them, enhance their transparency, and in turn, diminish stock mispricing. Therefore, information plays a crucial role in boosting the pricing efficiency of the capital market. Investors have bounded rationality, and their ability to collect and process information is limited, which means that investors' decision-making behavior will be biased due to the influence of the surrounding environment, which will lead to errors in market information. Information with informational value can convey the real information inside the company to the market, thus guiding investors to rationally adjust their investment decisions, promoting the stock price to return to its fundamental value, and reducing the degree of stock mispricing.

1.7.4 Stock Price Crash Risk

The stock price crash risk refers to the possibility that the stock price of individual stocks will be greatly reduced, and the return of individual stocks will be extremely negative. The sharp decline in stock prices led to huge property losses faced by investors and even hit market participants' confidence in the investment. As an anomaly in the capital market, the stock price crash is characterized by strong concealment, rapid contagion and great destruction. The risk of a stock price crash has become a crucial issue in recent years, not only because it directly impacts market investors' confidence and enterprises'

15

interests but also because it can destabilize the capital market, trigger systemic financial risks, and even affect the real economy's development. Thus, this issue has gained significant attention in the macroeconomic and micro-financial fields in recent times (Anastasiou et al., 2021).

The stock price crash refers to a sudden and significant decline in the stock price over a short period of time without any prior warning. According to the theory of information economics, the controller or management of listed companies may hide bad news for selfish reasons. Once the accumulated bad news exceeds the threshold, it will be released to the stock market in a concentrated manner, causing the stock price to fall sharply in a short period of time, resulting in a crash. For investors, the crash means a large loss of wealth, which aggravates the production and operation crisis for listed companies and regulators. There are two main ideas about the formation mechanism of the risk of stock price crash: One is to mainly consider the strategic concealment of bad news by the company's management. When the bad news accumulates to the critical value that the company can bear and breaks out, it will quickly be reflected in the stock price and cause the stock price to collapse. The motivation for the management to hide bad news is mainly the attempt to avoid taxes (Kim et al., 2011) and so on. On the other hand, the risk of stock price collapse is mainly explained by the information asymmetry among investors in the market, believing that when the stock price falls, the selling behavior of informed investors will cause panic among uninformed investors. In order to compensate for this risk caused by uncertainty, uninformed investors will follow the trend and drive down the stock price in order to earn a return, which will increase the risk of a stock price collapse. When insiders of listed companies sell stocks, outside investors will not judge the reasons for their selling, but subjectively believe the existence of bad news according to their selling behavior, and follow the trend to sell, causing the stock price to crash (Flammer, 2015).

Based on the understanding of the risk mechanism of stock price crash, scholars explain the causes of stock price crash risk from different angles (Jin and Myers, 2006). For example, in terms of information disclosure, scholars find that a company's information disclosure environment is inversely related to its stock price crash risk, and the better the information environment, the lower the stock price crash risk. In terms of management mechanism, it is found that both option incentives are positively related to stock price

16

crash risk. Theoretically, a company's ESG rating provides new information to the public, which will affect the company's disclosure of its own information, the asymmetric relationship with market investors, and thus affect risk taking, risk management, risk prevention, and the ability to withstand external uncertainties, and then affect the risk of stock price collapse. The existing literature has not investigated the economic consequences of ESG rating from the perspective of stock price crash risk, so this would have significance to some extent.

1.7.5 Technical Achievement Index

Actually, there is no consistent conclusion on how to measure the gap between countries' technological performance. On the one hand, there is a lack of uniform standards for indicators to measure the level of technological achievement, and on the other hand, the method of selecting indicators is arbitrary. The TAI proposed by the United Nations Development Program (UNDP, 2001) comprehensively measured the level of technological achievement of countries from four dimensions, but UNDP only calculated the TAI of countries in 2000. According to the TAI assessment system and data on the world's major countries published for the first time by the UNDP in 2001, the average TAI of the 72 countries (regions) participating in the assessment is 0.374. The TAI consists of four aspects: technological innovation, diffusion of new technologies, diffusion of traditional technologies and human capabilities. In order to meet the needs of the world's development in the information age, the UNDP took TAI as a comprehensive measure of the technological revolution and innovation capability of countries (regions) to evaluate the achievements of a country (region) in creating and disseminating technology and cultivating human skills. According to the TAI data published in 2001, Finland has the highest technological performance index in the world, with an index of 0.744. The United States and Sweden ranked second and third in the world with TAIs of 0.733 and 0.703 respectively. The top ten countries are Japan, South Korea, the Netherlands, the United Kingdom, Canada, Australia and Singapore. The 72 countries (regions) participating in the evaluation are divided into four types according to the level of their TAI: Leaders, Potential leaders, Active adopters and Marginalized. China's technological achievement index is 0.299, ranking 45th, which is below the world average. Compared with Brazil and India in the same category, China's overall level of technological achievement is low, while China's share of exports of medium and high-

17

tech products and average years of education are slightly higher than Brazil, and other aspects are lower than Brazil; compared with India, China is superior to India in all indicators. However, there is a huge gap between China and the top performers, especially in technological innovation, and there is also an obvious shortfall in the diffusion of new technologies. The gap in human skills training restricts the improvement of the overall level of technological performance. The TAI reflects the basic platform capability of a country's technological innovation in the network era. The index reflects existing technological achievements, not future efforts; it reflects the basic capability of a country's overall innovation and the degree of participation in innovation, rather than the degree of a country's leadership in global technological development.

Technological development has become the fundamental condition for sustainable innovation and development (Incekara et al., 2017). In the context of increasingly fierce global economic and trade frictions, the level of technological achievement has become the core force to break the bottleneck. Regions with technological advantages not only facilitate their own development but also promote the overall technological development of the country. To achieve this, various measures have been taken by countries to enhance their technological achievements. The development of innovative provinces within a country has also been shown to foster regional economic development and social progress (Wan et al., 2022), and then promoted the whole country to a leading position in global competition. In the existing literature, TAI is mostly used to compare the technological performance of different countries, and few documents use TAI to calculate the technological performance of provinces within a country. Innovation and development are one of the important measures for high-quality development in China. How to measure and compare the technological achievement indexes of provinces still needs to be studied and solved. Based on UNDP TAI index and the reality of China, this dissertation will explore Entropy Weight Method (EWM) to calculate the indicator weighting, and finally calculate the TAI of China province. TAI will be an important regulating variable in this thesis to measure the level of regional technological development.

18

1.7.6 Dynamic Capabilities

Dynamic capabilities are beneficial for building, incorporating and reconstructing resources as the environment changes (Makadok, 2001). It has an important effect on enterprises to establish, maintain and enhance their competitive advantages and improve their performance (Felin and Powell, 2016). Dynamic capabilities are a kind of flexible capabilities that enterprises set up, integrate, and reconfigure their inside and outside resources to gain the advantage they need to compete in a rapidly changing marketplace. Dynamic capabilities clarify the importance of reallocating resources in response to environmental changes and emphasizes that resource reconfiguration can realize different capabilities within firms, which is also the difference in competitive advantage between firms (Liang et al., 2022). Dynamic capabilities focus on searching for and grasping new opportunities so that enterprises can reallocate resources promptly, improve knowledge absorption, promote knowledge transformation, and enhance the ability to respond to changes in the internal and external environment. Dynamic capabilities are the resiliency capabilities that explains why a business can sustain a competitive advantage in a changing environment (Katkalo et al., 2010). Moreover, dynamic capabilities have the power to persuade businesses to recognize risks and mitigate their negative effects. Companies can gain new competitive advantage through strong dynamic capabilities. When the enterprise ESG risk is high, strong dynamic capabilities can help enterprises integrate internal and external resources, use opportunities to create value, and reduce the negative effects of risk. According to resource-based theory, it is the basis for a company to acquire valuable resource heterogeneity. Corporate social responsibility helps to obtain strategic resources, but it is not enough to obtain resources. Enterprises also need to make rational use of resources through integration and reorganization to create value. This process is related to the formation of dynamic capabilities of enterprises, and then affects the overall strategic performance. Therefore, it is necessary to introduce the concept of dynamic capabilities when studying the link of corporate social responsibility performance and information efficiency.

1.8 Thesis Outline

This dissertation is made up of six chapters, each of which describes how to carry out the research methodically. The first chapter briefly introduces ESG as the research

19

background, its framework and overall design, problem statement, research questions, objectives, motivation, research scope, basic concepts description and contributions.

The second chapter includes an extensive literature review. Based on the introduction of related theories, this review covers ESG, ESG rating, information asymmetry, TAI, dynamic capabilities, probit regression, information efficiency measured by NCSP, stock mispricing, and stock price crash risk. Notably, NCSP stands for investors; stock mispricing represents price of stock; stock price crash risk acts for risk in stock market. This dissertation includes stakeholders in the capital market who tend to respond more positively to companies with higher ESG ratings. This dissertation seeks to understand the explanatory links from ESG ratings to information efficiency of the capital market for China defined as NCSP, stock mispricing, and stock price crash risk.

The third Chapter of this dissertation explains the research design, including data and methodology. This dissertation is a quantitative correlational design for empirical testing. The research presents both a current view and a potential trend emerging over time. This dissertation employs the data of A-share listed companies in the Chinese stock market during the 2010-2021 period. This chapter includes the hypothesis proposed, the data collection process, the definition of variables, and the research models. This study employs TAI to measure the provincial technical performances for China. This dissertation also investigates the calculation of TAI.

A summary of the results of the research is presented in Chapter 4 of this dissertation. In addition, chapter four includes a descriptive analysis, an analysis of the hypothesis, robustness tests, a mechanism analysis, and moderated mediation analysis. This chapter measures the dependent variable defined as NCSP, stock mispricing, and stock price crash risk respectively tests the impact of ESG ratings on the three dimensions, and conducts the above analysis. Additionally, the fourth chapter also conducts a heterogeneity analysis, and examines the differences in the impact of ESG ratings on information efficiency in different environments. The external social environment includes the COVID-19 epidemic, and the internal corporate environment includes the nature of property rights and accounting conservatism.

Chapter 5 of this dissertation shows the evaluation of the findings, and then follows discussion. This chapter will compare the findings of this dissertation with other'

research. The importance of the research in this dissertation is further illustrated by the different evaluation results.

Chapter 6 summarizes this dissertation. This chapter will summarize the main research conclusions, then put forward implications, and finally propose future research directions. Additionally, this chapter also highlight the shortcoming of this dissertation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Since China proposed "Carbon peak", "Carbon neutrality" targets, listed companies to release ESG reports has increased significantly. There is a total of 1,092 Chinese A-listed in 2021, with listed companies issuing the 2020 ESG report, accounting for 25.5% of the total number of A-listed companies [2]. Although policy encouragement is important at this stage of the company's development, it is even more crucial to see if it can become the endogenous driving force behind the company's ability to sustain itself and generate higher-quality earnings from strong ESG performance. There is an opportunity to determine whether the adoption of ESG strategy by Chinese listed companies enhances information efficiency in the capital market. This exploratory quantitative study aimed to analyze whether and how ESG ratings is efficient in the capital market for Chinese listed companies. The goal of this literature review is to examine the existing literature and provides a basis for investigating the problem statement.

Chapter 2 reviews theories, key literature, themes regarding ESG and ESG ratings, and also includes literature about key variables. Chapter 2 covers an overview of theoretical, seminal, and core research. Chapter 2 includes a discussion of theories, involving information asymmetry theory, signal transmission theory, stakeholder theory, effective capital market theory, and regional technological innovation theory, which are the backbone of the theoretical framework. This review is based on the current literature. The search strategy included a review of peer-reviewed journal articles obtained from the SCOPUS and Web of Science Collection databases. The search themes used to locate the literature included: ESG, ESG ratings, ESG and capital market, ESG and dynamic capabilities. Additional search terms included information asymmetry theory, effective capital market theory, technical achievement index, and probit regression. And finally, this thesis also gave a bibliometric and visual analysis in the field of ESG research. This review of the literature sets out a number of theories that underpin the link between ESG ratings and the efficiency of information in the capital markets. Additionally, the information asymmetry theory, technological innovation theory, and dynamic capabilities theory are applied to the mechanical test of the relationship between ESG ratings and

22

information efficiency, which forms the basic research framework of this dissertation. The literature review also points out and strengthens the dissertation's study direction. In short, it is more and more urgent to extend ESG study to information efficiency of the capital market, especially in the emerging market of China. This will lead to long-term high-quality development of the capital market while creating shared value for all stakeholders.

2.2 Theoretical Framework

2.2.1 Information Asymmetry Theory

According to information asymmetry theory, investors are often at a disadvantage with insufficient way to true information due to the different availability information among different market players. Therefore, the investment decisions made by investors based on limited information often deviate from the fundamentals of enterprises and are easily disturbed by market sentiment, policy news, and other factors, resulting in irrational investment behavior, which in turn leads to large fluctuations in stock prices.

Disclosing ESG information can help address information asymmetries and improve information efficiency in the capital market. Under the framework of ESG information disclosure, investors can understand the enterprise more comprehensively. The enterprise management's strategy can also be effectively communicated to the investor thanks to the ESG information disclosure, which will help investors with more information and form a more truly decision to the company.

ESG ratings given by recognized third-party organizations cover a large amount of public information and can accurately capture information on environmental protection, staff management, social welfare, business ethics, corporate governance, and other aspects of the enterprise. Corporate ESG ratings and their changes provide the market with objective indicators of risk and provide an easy-to-understand presentation of the ESG performance, it's a huge relief for the information asymmetry.

2.2.2 Signal Transmission Theory

Signal transmission theory shows that information asymmetry is widespread in the capital market. Companies reduce the degree of information asymmetry by "signaling". Good ESG evaluation is an effective means of "signaling" which can improve the company's

reputation and social recognition, reduce potential risks and alleviate investors' underestimation of the company's value. On the other hand, a good reputation and social recognition can effectively help enterprises reduce risks in times of economic fluctuations, competitors' geology, and other crises.

Generally speaking, enterprise management outside of the signal includes financial statements, dividend policy, and capital structure. ESG performance, as non-financial information, is also an important signal to society. For example, corporate environmental responsibility could be used as a signaling mechanism to reflect that companies are not neglecting environmental protection in their development, which means that they will face fewer penalties for environmental damage and, at the same time, also is the enterprise own financial strength proof, releases the positive public signal to each stakeholder.

According to the theory of signal transmission, the good performance of ESG is the embodiment of sustainable development ability, and the active information disclosure of ESG is a kind of powerful signal transmission. ESG ratings from rating agencies also send important signals to the market about investment risk. This process decreases the information asymmetry and reduces transaction costs, thus increasing the efficiency of cooperation.

2.2.3 Stakeholder Theory

Stakeholder theory indicates that the main stakeholders are its shareholders, creditors, suppliers, employees, consumers, government agencies and so on. Although shareholders and creditors are the main stakeholders of the enterprise, however, it is impossible to ignore other stakeholders like the manager, tax department, employees, banker, customers, and so on, who play an extremely important role in the development of the enterprise. Stakeholders provide the necessary resources for the development of the enterprise. Therefore, in the process of development and operation, the company needs to consider the interests of shareholders and other investors. Meantime, companies need to meet the requirements of other stakeholders, so that the enterprise can better develop.

With the increasing emphasis on sustainable development, stakeholders pay more attention to environmental information and social responsibility reporting. Stakeholders also expect companies to regularly disclose environmental information and accountability. For the stakeholders, the enterprises should take social responsibility, and

24

strengthen environmental protection and corporate governance, so that the enterprises can achieve sustainable development and to better meet the demands of the stakeholders. These actions not only help businesses build a strong brand identity that will garner more social attention for them, but they can also entice more social capital to invest in them. For the government, according to the relevant information disclosed by enterprises, the government departments are more targeted to formulate sustainable development policies, while promoting the transformation of enterprises while protecting the enthusiasm for enterprise production.

At present, in the context of the Chinese government's active promotion of sustainable development policies and green finance, investors are more likely to favor companies that actively disclose ESG information and perform better in ESG. This is a good incentive for enterprises to actively disclose ESG information, thus further promoting enterprise information disclosure. Enterprises invest in ESG, which is helpful to maintain good relations among them. For example, relationship maintenance with employees can strengthen employees' sense of belonging to the company, enhance enterprise cohesion and improve work efficiency. Establishing a good relationship with suppliers will help to reduce the upstream purchase cost and ensure the stability of supply. Good ESG evaluation can promote consumers' purchases and reduce advertising expenditure. Good ESG evaluation can be recognized by the local government which gives the business support. Good ESG evaluation can effectively reduce financing costs.

2.2.4 Effective Capital Market Theory

The effective capital market theory holds that stock price is related to information disclosure and other factors in the capital market. Fama (1970) proposed a classification of the market into three categories, namely weakly efficient, semi-strongly efficient, and strongly efficient. In a weakly efficient market, market prices can reflect historical information about securities, but not public and internal information. In a semi-strong efficient market, the stock price can reflect the company's information that has been made public, including the company's development prospects and other predictive information. Investors can't obtain excessive returns by making their investments public, but part of some investors can be based thereon inside information to invest in order to obtain excess

profits. The theory of effective capital market brings forward the discussion of mandatory information disclosure systems.

China's securities market was only established recently and is still undergoing constant development. For the less efficient Chinese capital market, if the ESG rating information is widely concerned by investors, when the ESG rating of the enterprise is made public as information, investors will make corresponding adjustments according to the changes in ratings, so that the stock price changes will reflect the investor's response to the changes in corporate ESG ratings. Specifically, when an ESG rating is raised, a large number of investors who pay attention to this information and apply the ESG investment philosophy to their investment activities are more likely to buy their shares, thereby driving up the stock price, companies with downgrades are more likely to sell their holdings, causing share prices to fall. Conversely, if the ESG rating information is not valued by investors, when the ESG rating changes, the company's stock price may not change significantly. Therefore, whether the change of ESG rating will affect the information efficiency depends on the investors' attention to the ESG rating information and whether the ESG investment concept is widely practiced.

2.2.5 Regional Technological Innovation Theory

The core competitiveness of a region's development is its capacity for technological innovation. This theory states that regions need to satisfy the technical requirements of companies to form a better development trend to find the space to increase profits. The business must use technology to influence the product if it wants to maximize enterprise value in the market. Technological innovation is regarded as an efficient way to meet consumer demand and determine the true worth of an enterprise. Therefore, if companies want to gain an edge value, they need to constantly research customer demands, according to the needs of customers for targeted technical improvement. In the process of innovation, constantly looking for vacancies in the market, through innovation and development of new technology to enter the market, creating new enterprise value promotion point. Regional technological innovation refers to the R&D innovation by the subject of technical innovation in a specific region, which makes use of the existing resources endowment, through ideas and expectations, and introduces the new technology developed into the production system, the transformation of new knowledge into new

products, processes, and services, as well as the realization of a series of market-oriented activities, will lead to the establishment of more efficient production systems throughout the region. Regional technological innovation is the contribution to the regional economy and society, including the whole process of R&D, production, and market application of new products, processes, or services.

Increasing ESG investment helps management to establish a better image of entrepreneurs. However, the information asymmetry between owner and management gives management an incentive to engage in corporate ESG "Greenwashing" to deceive shareholders. Better regional technological innovation environment can alleviate information asymmetry, and also is conducive for corporate sustainability. Therefore, the standard enterprise ESG information disclosure requirements and the corresponding corporate governance mechanism construction appear to be particularly important. Compared with CSR, ESG is based on the theory of sustainable development, which merges environmental factors with the long-term better development.

2.3 Related Work about ESG

ESG is a new path toward sustainable economic and social development and a fresh way to view the opportunities and risks that businesses must deal with. Growing evidence suggests that ESG procedures are both socially responsible and a way to enhance a company's reputation for excellence as ESG enters the public eye. It has been amply proven that there is a connection between ESG and business operations, corporate governance, risk, and cost of capital. How ESG affect corporate performance has been paid close attention and widely lighted by the government, academia, and industry. Much research has been done to investigate the impact of ESG on corporate performance. The most controversial issue in the literature is whether and how ESG affects firm performance and firm value.

2.3.1 ESG and Non-financial Factors

Kölbel et al. (2017) discussed the relationship between negative reports of ESG issues and financial risks by analyzing the international panel data of 539 companies from 2008 to 2013. The study found that negative ESG news would increase the credit risk of the company. Additionally, the study put forward three strategies for the company executives to avoid the company's exposure to this risk.

Syed (2017) collected data from questionnaires completed by fund administrators in the UK and France, and discussed the incorporation of ESG-relevant issues by fund managers. The study found that, due to differences in beliefs, fund managers' incorporation of ESG standards into the management making process was uneven. What was common in both countries was that corporate environmental and social responsibility can better mitigate investment risk, while governance can enhance long-term value.

Cucari et al. (2018) used ESG data from more than 54 Italian companies from 2011 to 2014 to investigate the relationship between ESG disclosure of Italian-listed companies and board diversification. The study found that ESG information disclosure was linked to the social responsibility of independent directors, and shareholders and decision makers will have a deeper insight into the important role of board diversification as a critical driver of ESG disclosure.

Landi and Sciarelli (2018) employed a fixed effect model, and used Italian firms listed companies' data from 2007 to 2015 on the FTSE MIB Index to empirically find that ESG has an improving quality because of the reliable corporate disclosure. The study also found that ethics was still not a reliable financing tool for Italian companies. Investors didn't seem to have priced corporate social responsibility in the stock market.

Miyai and Sugiura (2018) used an empirical study to find a negative correlation between higher ESG scores and the WACC. The study also found that there was a significantly effect from environmental score to WACC, and there will be significantly negatively effect from ESG score to WACC in companies with high enterprise-specific information.

Nofsinger et al. (2019) proved that environmentally conscious companies had a positive impact on productivity, while companies with poor environmental performance were more likely to end up in bankruptcy or delisting. In addition, the level of carbon emissions of the acquirer would affect its acquisition decision. This study also found that this model may be driven by economic incentives because the existence of negative environmental and social indicators reflected the downside risks.

Hong et al. (2019) used the Foreign Corrupt Practices Act (FCPA) to find that companies with ESG policies significantly reduced the level of bribery and received $14.3 million less in sanctions. Therefore, the practice of ESG can form a supervision mechanism, regulate the behavior of enterprises, and effectively reduce litigation risk. The study found

that ESG received a low sanction of 65%, and state law had nothing to do with bribery income.

Nofsinger et al. (2019) noted that rising environmental scores can significantly reduce a company's downside risk, and that the extent to which downside risk was reduced depended on whether and where ESG issues were addressed. It can be seen that the changing market environment may lead to lower-than-expected future trends for enterprises, and this kind of downside risk often occurs in the case of enterprises with large negative uncertainty.

Eichholtz et al. (2019) studied the debt spreads of real estate companies to find that the loan spreads of environmentally certified real estate companies were lower than those of traditional real estate companies, and when there was more environmentally certified real estate in Real Estate Investment Trust Funds (REITs), the bond spreads were lower. Additionally, at the company level, the real estate investment trust fund with a high proportion.

Nguyen and Phan (2020) tested the causal relationship between carbon risk and corporate capital structure decisions using the Australian-approved Kyoto Protocol as a natural experiment. The study found that the ratification of Kyoto Protocol reduced the financial leverage of carbon-emitting enterprises, especially those with financial constraints. The increased carbon risk led to higher risk of financial distress, which urged enterprises to reduce financial leverage.

Asante-Appiah (2020) found that ESG also affects audit quality. When a customer's ESG reputation was damaged, the auditor would make more efforts to improve audit quality in order to reduce business risk, so the possibility of the financial restatement was reduced. On average, when ESG's reputation was damaged, financial restatements were 13.47% less likely and core business-related restatements were 25.63% less likely.

Shive and Forster (2020) paid more attention to the effect occurred by ESG to family and private companies. The study found that family businesses and private companies were subject to fewer institutional constraints and external oversight, and that independent private companies were less likely to be penalized by the EPA for polluting the Environment Than Public United States Environmental Protection Agency. As a result,

29

private and family businesses may focus more on short-term goals and abandon ESG practices.

Zhang et al. (2020) used hierarchical regression method to analyze the data of A-listed companies in Chinese stock market and found that E, S and G would promote enterprise innovation. The governance of a company can regulate the relationship between the environment, society and enterprise innovation, which is influenced by the level of system development.

Fedorova et al. (2020) used the annual reports, sustainable development reports, ESG reports, and Global Initiative (GRI) reports of Russian-listed companies from 2010 to 2018 to explore the relationship between non-financial information and stock returns and the WACC based on latent semantic text analysis techniques. The study found that the subject of the report or information disclosure was important to stakeholders and independent market agents.

Asimakopoulos et al. (2021) research showed that when companies get an ESG rating, they reduced the leverage on their books and reallocated their funding from bond debt to bank loans, and this kind of change in the financial pressure was big, the growth opportunity was few, the asset specialization enterprise was more remarkable.

Bose et al. (2021) demonstrated higher carbon emissions would look for acquisitions in other countries with low GDP or weak environmental regulations, and were less likely to buy domestic firms. The study found that the return on cross-border takeover announcements was higher when acquirers with high carbon emissions targeted countries with less regulation or weak environmental standards. Additionally, investors would blame buyers who promote CSR but also had high carbon emissions, leading to worse abnormal returns.

Pedersen et al. (2021) indicated that institutional investors were more socially responsible and would actively participate in the corporate governance of invested enterprises as shareholders through "Hand-voting", direct intervention or threat of withdrawal were two ways to supervise and restrain the behavior of enterprises.

Azar et al. (2021) analyzed the impact of ownership of three major investment institutions on actual carbon emissions and found a significant and robust negative correlation

30

between the two, suggesting that higher environmental scores may be a kind of 'green cleaning' that does not represent actual environmental improvement.

Gu et al. (2021) found that public environmental issues have affected the career of corporate executives, who may be making environmental investments in order to maintain their positions. It also showed that if enterprises wanted to carry out ESG practices and took the road of sustainable development, they should set reasonable long-term CEO compensation incentives and make the CEO focus on long-term goals.

Demers et al. (2021) based on the agency cost theory, and found that investing in ESG could not prevent the decline of stock prices, and only investing in innovative assets could protect against crisis and downside risks. This showed that the proxy problem between shareholders and managers affected the implementation of ESG, ESG funds with a longer horizon were more able to resist the downside risk.

Pástor et al. (2021) validated the negative impact of ESG practices to the cost of equity capital, with agents with ESG preferences preferring to invest in green assets, deriving utility from green assets, and thus demanding lower rates of return and reducing the cost of equity capital for green enterprises.

Díaz and Escribano (2021) found a positive correlation between the environmental problems of U.S. energy companies and the cost of debt capital. The cost of capital for corporate debt increased because environmental problems created more risk for businesses and lenders charge higher interest rates on loans to environmentally troubled businesses.

Wong et al. (2021) examined and found that capital cost was reduced by ESG certification, while Tobin's Q value increased significantly, showing that the value-add emerging-country firms derive from corporate social responsibility disclosure. The study confirmed that stakeholders have benefited from companies pursuing ESG agenda.

Pedersen et al. (2021) developed a theory that the ESG score serves two functions: providing information about company fundamentals and influencing investor preferences. The study calculated the empirical ESG frontier and showed the costs and benefits of responsible investing. Finally, the study tested the theoretical prediction by using the agents of E, S, G and the whole ESG.

31

Martins (2022) used the DID method to study the 6,906 firm-year observations of Brazil from 2011 to 2019, and found that emerging market firms will make negative adjustments to their ESG behavior after being impacted by competition. This conclusion was in sharp contrast to past research on advanced economies.

Barth et al. (2022) took American and European companies as samples, and employed a fixed effect model to discuss the extent to which ESG reduces credit risk. The study found that higher ESG ratings not only reduced credit risk, but also showed a U-shaped risk mitigation effect, which was consistent with the opposite effect of increasing stakeholder influence and decreasing marginal return of ESG investment.

Bofinger et al. (2022) collected a sample of 1,817 US companies from 2004 to 2017 and empirically found that ESG amplifies the existence of overpricing, while decreasing the deviation of underpriced companies from their real values. Both of the valuation effects were attributed to the global trend towards socially responsible investing. Further analysis showed that market sentiment played a moderating role in the relationship between ESG and undervaluation.

Boros et al. (2022) used the data from 16 Hungarian and Further 27 International Sustainability Reports from 2018 to 2020 to explore the characteristics of ESG reports and the compliance of ESG standards with non-financial information disclosure rules. The study found that ESG reports of companies only covered ESG issues in principle, and only a small number of companies reported actions and results. Additionally, the study suggested building a reporting system based on ESG indicators to enhance the comparability of the company's sustainable development activities.

Neitzert and Petras (2022) used the data of 582 banks in the world from 2002 to 2018 to empirically analyze the impact of corporate social responsibility activities on bank risks. The study found that the ESG activities of enterprises generally reduced the risk of banks, and the environmental dimension determined the degree of risk mitigation. Otherwise, the social dimension and governance dimension had no obvious reduction effect. The study also highlighted the importance of environmental factors in ESG activities.

2.3.2 ESG and Corporate Performance

Odriozola and Baraibar-Diez (2017) used logistic regression to analyze Ibex35 companies from 2006 to 2011 for Spain, and explored the impact of the quality of sustainable reports on company reputation. The study found that high-quality ESG information disclosure improved the company's reputation. The study regarded the quality information level as the proxy of reputation, rather than the result of some company variables.

Isaksson and Woodside (2017) used the survey of senior managers and independent CSP company evaluation of ESG factors to conduct a mixed-method research design, and studied the relationship between CSP and CFP. Based on the complexity theory, the study tested and supported the viewpoint that "good management" occurred in configurations with high CSP to indicate high CFP. The findings of the study supported the core principles of complexity theory.

Miralles-Quirós et al. (2018) used listed companies' data on the São Paulo Stock Exchange during the 2010-2015 period to find that socially responsible activities can lead to differentiated strategies among companies and contribute to increased corporate value. The overall result supported the value enhancement theory rather than the shareholder expense theory. At the same time, the research results also showed that the market valuation of the three pillars of ESG was not obvious.

Li et al. (2018) used data from 350 FTSE listed companies to find that ESG disclosure level was positively related to enterprise value, indicating that corporate information transparency can enhance investor information and increase enterprise value. CEO power played a moderating role between the above link, suggesting that the higher the CEO power, the more ESG disclosure can become a practice that was more conducive to firm value.

Yoon et al. (2018) employed ESG scores to measure CSR performance based on Korean market data and explored their impact on corporate value. The empirical study showed that ESG score had a significantly positively connection with firm value, which was coincident with the sample results of developed countries. However, the connection of ESG on stock price differed depending on the characteristics of the company. Environmentally sensitive industries are heterogeneity variables in the above relationships.

Brogi and Lagasio (2019) used Return on Assets (ROA) to measure financial performance. An empirical study of 358 companies in the United States found that ESG significantly improved financial performance. The study found that ESG was closely related to banks' environmental awareness and profitability, which provided enlightenment for policy makers and policy implementers.

Hartzmark and Sussman (2019) studied the sustainability of the US mutual fund market and presented causal evidence that market-wide investors value sustainability, suggesting that sustainability was seen as a positive predictor of future performance. However, the study found that there was no evidence that the high sustainability fund was superior to the low sustainability fund. The evidence was consistent with the positive emotion that influences the performance expectation of sustainable funds and the non-monetary motivation that influenced the investment decision.

Ortas et al. (2019) used a multi-level model to explore the impact of different national systems on enterprise ESG performance by using the data of 4,751 companies in 52 countries. Based on the background of national systems, the study determined which national systems improve or limit the company's ESG performance. As the study considered companies in other economies, it had a richer institutional system.

Garcia and Orsato (2020) used a panel data to conduct regression analysis of 2165 companies in developed and emerging markets. The findings showed that there was a general relationship between the institutional environment and ESG performance.

Li and Wu (2020) provided evidence that private firms had significantly reduced their negative ESG events after participating in the United Nations compact (UNGC). The study suggested that while private companies ignored ESG practices, they actively improved ESG performance when they faced strong external constraints.

Broadstock et al. (2020) employed a nonparametric frontier analysis framework by using the data of 320 Japanese enterprises from 2008 to 2016, and explored the influence of ESG policy on the innovation capability of enterprises. The study found that there was a nonlinear relationship between ESG policy and enterprise innovation capability. Additionally, ESG policy initially enhanced the innovation ability of enterprises, and ultimately positively affected the financial and operational performance of enterprises.

34

Qureshi et al. (2020) used panel data of 812 European listed companies to empirically analyzed and found that ESG disclosure and board diversity significantly affected firm value. In addition, companies in sensitive industries had better social and governance performance. Companies with a high proportion of women on the board had better ESG performance.

Peng and Isa (2020) empirically analyzed the impact of ESG practices on financial performance using a sample of 461 Shariah-compliant companies in 20 countries and MSCI index data. The study found that ESG and its dimensions are positively related to company financial performance, which also confirms stakeholder theory. Combined, ESG and Shariah screening can enhance shareholder value.

Shin (2021) provided evidence that high ESG-rated banks do not lend to businesses that violate ESG principles, despite the high profits and liquidity of their clients. Second, banks have a reputation motive to focus on the ESG performance of borrowers. To improve their ESG image, banks with poor ESG performance are more likely to select higher ESG-rated borrowers and lend to them at lower interest rates, in order to repair the reputation of society.

Lee et al. (2021) used Thomson Reuters Asset4 ESG rating data to study the relationship between corporate ESG ratings and financial returns and risk and constructed a variety of investment portfolios to determine the range of risk preferences of investors and their overall confidence in the financial opportunities and risks faced by the enterprise.

Eliwa et al. (2021) studied the data of non-financial enterprises in 15 EU countries to find that the improvement of ESG performance and the level of information disclosure can reduce the debt cost of enterprises. The impact is more pronounced in stakeholder-oriented countries than in other countries. The study also found that ESG performance has a more significant impact on debt cost in stakeholder-oriented countries.

Duque-Grisales and Aguilera-Caracuel (2021) used linear regression method to explore Latin American companies. they found that ESG score had a significantly connection with company performance. Financial leverage and international geographic diversification have moderating effects on the relationship between ESG dimensions and corporate FP.

35

Egorova et al. (2021) examined the impact of ESG factors on the performance of IT companies. The analysis showed that IT companies are not currently in a leading position in ESG ratings, and the author suggests that a company's market value is the most appropriate index to assess the impact of ESG factors on the company.

Kuo et al. (2021) examined the impact of ESG disclosure on performance indicators for 30 airlines around the world over five years. The study argued that excessive investment in ESG can weaken the main business capabilities and affect the short-term performance of the company. However, after a period of implementation, ESG would gradually increase corporate performance.

Xu and Kim (2022) discovered that the state of the economy has an impact on ESG performance. Financial limitations lead to an increase in toxic emissions from businesses, and their effects are exacerbated when regulatory enforcement is weakened and managers place a premium on short-term gains. The finding implied makers consider regulation when government enhances policies.

Houston and Shan (2022) found that banks may lend to borrowers who share similar ESG characteristics, and as a unique and novel source of influence, banks can have a significant positive impact on borrowers' subsequent ESG performance. ESG practices can often enhance the operational efficiency of enterprises, and effective production and management are helpful in improving ESG performance.

Dasgupta (2022) used cross-border data from 24,390 firm-year observations of 27 countries to explore the links for ESG and financial performance. The results showed that corporate would like to improve their worse financial performance by promoting ESG practice, and ESG controversies played a significantly mediating role in this link. The study also indicated managers whom eager to get better corporate performance should focus on ESG controversies.

Khoury et al. (2022) used the cross-sectional data of G20 countries and four new indicators to explore whether ESG directly affected the financial performance of enterprises. The study found that ESG was beneficial to corporate financial performance during COVID-19, and the results were related to specific aspects of ESG, income level and company-specific variables.

Atif et al. (2022) empirically explored the impact of ESG information disclosure on cash holdings by using the annual sample data of 9,811 companies from 2006 to 2015. The study found that there was a significantly negatively link between ESG information disclosure and cash holdings. The results were also applicable to every stage of the life cycle of S&P 1500 index companies.

Saygili et al. (2022) investigated whether ESG practices affect the FP of listed companies in Turkey, using data of companies listed in the XKURY from 2007 to 2017. In addition, the study discussed the links of 20 ESG variables on CFP. The study confirmed the negative impact of environmental disclosure on CFP, and stakeholder participation in management was beneficial for operational effectiveness.

Chang et al. (2023) used the DEA method to analyze the panel data of XKURY from 2007 to 2017 and found that ESG performance improved the efficiency of corporate financing, in which digital finance played a regulatory role. This research takes digital finance as a mechanism and expands the research field of ESG.

2.3.3 ESG and Capital Markets

In the context of sustainable development, both the world's mature capital markets and China's emerging capital markets are taking ESG factors into account in their investments. Investors are beginning to look at low-carbon assets as attractive investment targets. At the same time, investors see a company's ESG focus as a sign of being competitive in the market. ESG-related risks have begun to influence the pricing of assets in capital markets. Both ESG ratings and ESG disclosure can influence stock prices and trading by providing capital market participants with a basis for decision analysis through increased information transparency. ESG funds refer to mutual funds that invest in companies with ESG characteristics, which can help investors screen companies with good long-term performance, effectively avoiding risks such as flash crashes and maintaining solid performance. Typically, companies that engage in ESG practices have the potential for sustained growth and will earn higher stock returns. More notably, it is not the case that having ESG practices in place will lead to higher stock returns.

Escrig-Olmedo et al. (2017) developed the integration of ESG investor preferences based on the application of the fuzzy multi-criteria decision-making method, and tested the usefulness of this scheme by using the data of the clothing industry. The study confirmed

that this commercial solution can integrate various investors' preferences, and can integrate ESG standards into asset appraisal procedures.

Tamimi and Sebastianelli (2017) found that governance factors affect ESG disclosure, with S & P 500 companies scoring high on ESG disclosure. At the same time, these companies had larger boards and more diverse board gender ratios, allowed CEO to double as chairmen, and linked executive pay to ESG scores.

Gerard (2018) found that the higher returns from ESG practices halved in the early 21st century and disappeared after the financial crisis. Today, bonds of issuers tend to have lower returns than those of issuers with moderate ESG performance. The "Green-Washing" of bonds explains this phenomenon. Companies and funds pretend to take ESG into account, but in reality, it is just a marketing strategy. When investors become aware of this 'superficiality', the returns on so-called green bonds will be reduced.

Joliet and Titova (2018) used U.S. equity SRI funds data to investigate whether funds with ESG information affect investment decisions. The study found that while both SRI and traditional funds integrate ESG information in their investment decisions, SRI adjusts portfolio weights by considering the relative ESG performance of different companies as a way to increase value.

Shaydurova et al. (2018) showed that the concept of sustainable development can create new investment attraction factors and avoid speculation. "Green" financial instruments can help to pool resources for adapting to the climate and for building infrastructures. The study explored the defensive nature of "green" tools and their sustainability effect on the economic market.

Capelle-Blancard et al. (2019) explored the relationship between ESG performance and sovereign borrowing costs in the international capital market by using samples from 20 OECD countries during 1996-2012. The study found that the better ESG performance, the lower the default risk and sovereign bond yield spread. Additionally, among the three dimensions of E, S, and G, the S and G dimensions are negatively correlated with sovereign bonds.

Grewal et al. (2019) examined the stock market response to events related to the passage of a directive in the EU. For companies with poor ESG performance, the average return

38

was -1.54%. In contrast, companies with good ESG performance earned an average positive return of 0.52%.

Fyodorova et al. (2019) analyzed the annual conference calls of listed companies in Moscow (MOEX) and the London Stock Exchange (LSE) from 2015 to 2019 by using the semantic analysis method, and explored the influence of ESG thematic features on stock recommendation by analysts. The study found that the text features of teleconference had a significant impact on abnormal stock returns, but the theme features of teleconference have a different impact, which is related to the mandatory disclosure of ESG reports.

Khan (2019) developed a new corporate governance and ESG index using MSCI ESG ratings data from companies in 23 developed and 24 emerging markets. The study utilized novel indicators to forecast stock returns in global investable sectors and evaluated the potential investment value of ESG signals.

Capelle-Blancard and Petit (2019) used 33,000 pieces of ESG news from 100 listed companies from 2002 to 2010 to study the stock market's response to ESG factors. The study found that ESG negative events led to an average decline of 0.1% in the company's market value, but ESG positive events did not lead to changes in the market value on average. Additionally, the study also found that market participants would respond to media news.

Ng and Rezaee (2020) used the Fama-French three-factor model and found that ESG is positively correlated with stock price information (SPI). When companies have higher levels of disclosure and weaker profitability and growth, investors are more concerned about a company's ESG performance and the correlation between ESG and SPI is stronger.

Huang et al. (2020) used unique data on stock trades by 87,504 individuals from 34 cities for China to empirically demonstrate that lower levels of air pollution can reduce stock trading, thus suggesting that air pollution imposes a greater cost on stock market investors. At the same time, abnormal trade performance decreases monotonically with the level of air pollution severity.

Fakoya and Malatji (2020) conducted a study using a sample of the top 30 JSE-listed companies to find that asset management companies focused on increasing shareholders' return on investment, without considering ESG issues. This investment decision was not conducive to the company's adoption of sustainable business practices.

Tang and Zhang (2020) demonstrated that better ESG performance can lead to higher bond credit ratings and thus better bond returns than those of issuers with poorer ESG. The channel of investor attention when corporate bonds are labeled as green bonds media exposure led to increased investors and higher returns. The channel of corporate fundamentals which means green bonds reflect a company's adherence to sustainability.

La et al. (2020) used the Eurostoxx50 index to explore the influence of ESG on stock returns during 2010 to 2018. The finding of this study got different evidence compared to prior studies, and indicated that the ESG commitments played no impact to stock returns for Eurostoxx50 companies. The finding has led to a different perspective on ESG and equity returns.

Cao et al. (2020) used the MSCI ESG KLD STATS database to empirically examine the response of socially responsible (SR) organizations to quantitative value signals. The study found that SR institutions are less responsive to quantitative mispricing signals. Abnormal stock returns are higher when the stock is more widely held by SR institutions.

Tasnia et al. (2020) empirically analyzed the connection of CSR with the stock price volatility using sample data of 37 US banks from 2013 to 2017 and ESG scores from Refinitiv. The study found that CSR had a significantly positively impact on stock price volatility. In addition, the amount of tax gave a significantly positively influence to share price volatility.

Pedersen et al. (2021) combined several large data sets to quantitatively proved that high ESG stocks are more expensive, IPO price underpricing is lower, and the negative impact of ESG on IPO price repression is more significant in countries with more financial disclosure transparency. Additionally, the study used E, S, G, and overall ESG to test the theory's predictions.

Dziadkowiec and Daszyńska-Żygadło (2021) collected data about 235 cases of ESG misconduct related to Dax, and found that investors responded more strongly to ESG

40

news releases after 2009 than before, corporate governance issues are more likely to devalue a company's market than environmental and social issues.

Cerqueti et al. (2021) conducted quarterly from March 2016 to June 2018, using daily data from various sources at the fund and company level, to also find the value preservation advantage of ESG funds, with funds with better ESG performance losing less relative market value than funds with worse ESG performance in the face of external stress.

Garel and Petit-Romec (2021) used the Thomson Reuters Asset 4ESG database to examine cross-sectional data on stock returns during COVID-19 and to explore investors' attitudes towards environmental issues. The study found that companies with an ESG strategy had better stock returns, suggesting that the impact of COVID-19 did not distract investors from environmental issues.

Bolton and Kacperczyk (2021) used 77 countries data to estimate the effect caused by carbon emissions to stock returns. The study found that across all sectors in Asia, Europe and North America, companies have lower stock returns. This relationship can be explained by the strong contraction in earnings forecasts and cash flow projections.

Díaz et al. (2021) investigated the importance of ESG ratings for the returns of different industries during the COVID-19 period. The ESG factor was constructed as the difference in return between the top quarter and the bottom quarter of the ESG portfolio, and they found that the ESG factor significantly explained the return of the industry portfolio in COVID-19.

Cornell (2021) discussed the impact of investor preferences and risk on ESG-rated companies' expected returns, and found that the social benefits of this preference encourage investment in green technologies and help in coping with climate shocks and unexpected changes in environmental regulations, but at the cost of reducing investors' expected returns.

Mohanty et al. (2021) used data from the MSCI ESG Factors Index from December 2007 to August 2020 to find that limiting the investment risk of ESG themes and combining different style characteristics leads to higher alpha. In the ESG Target Index, the ESG

stack of 'quality' factors delivered the highest returns, while the associated 'quality' factors delivered higher excess returns.

Zhang et al. (2021b) investigated the heterogeneity of ESG investments in China. Using the 2016 Guidelines for Building a Green Financial System policy as a quasi-natural experiment, the study found that the high ESG portfolio significantly improved the excess return compared to the low ESG portfolio. This also indicated a higher excess return after the 2016 policy.

Reber et al. (2022) used data from the United States to empirically found that ESG ratings reduced the company's idiosyncratic volatility and downside tail risk in the first year of IPO. The study showed that ESG disclosure can help companies establish reputation capital with investors after listing.

Serafeim and Yoon (2022b) divided company-level ESG information into positive and negative categories and found that stock price markets reacted to financially relevant and significant news, and reacted more strongly to positive news than to negative news. The stock market reacted more to news that receives more attention and to news related to social issues.

Shanaev and Ghimire (2022) employed ESG rating changes on stock returns of US firms over 2016–2021 to find that changes in ESG ratings lead to changes in equity returns. An increase in ESG ratings leads to a significant abnormal return of 0.5% per month, but a downgrade in ESG ratings leads to a risk-adjusted return of -1.2%.

Gregory (2022) used the data of Center for Research in Security Prices (CRSP) to empirically explore the impact of E, S, and G scores on stock returns. The study found that E and G dimensions performed better on stock returns during COVID-19. Companies with good performance on environment and governance can hedge against the negative impact of fiscal policies announced during COVID-19.

Li et al. (2022) employed the event study method by using the data of listed companies in China in 2020, and empirically found that ESG performance significantly increased the accumulated excess returns. Reputation and insurance effects were the important mechanisms of this influence. Additionally, this effect was more obvious in companies with low human capital and poor image.

42

Samaniego and colleagues (2022) utilized the DID method to investigate the association between ESG scores and stock returns, both before and during the COVID-19 pandemic, using a global automotive industry database. The study found that during COVID-19, higher ESG scores were associated with higher stock returns. Sustainable practices during the epidemic reduced stock returns.

Caporale et al. (2022) employed R/S analysis and fractional integration techniques by using the MSCI database from 2007 to 2020 to explore the persistence of two types of indices. The study found that there was no significant difference between the two indexes. Among the emerging market countries, BRIC countries (Brazil, Russia, India, China, and South Africa) had a high sustainability, which may be due to the loose supervision of ESG reports.

2.3.4 ESG and Dynamic Capabilities

Owen and Kemp (2017) empirically analyzed the social management abilities of the mining industry using data from related literature and legacy cases. The study found that considering the dynamic nature of population migration, the mining industry did not have enough social management ability, which led to high risks and high costs.

González-Ramos et al. (2018) employed Partial Least Squares (PLS) Statistical Method by using samples from 86 Spanish and Portuguese companies in the renewable energy sector to empirically explore the relationship between environmental dynamics, innovation capabilities and CSR. The study found that the higher the dynamics of the research environment, the higher the innovation enthusiasm of enterprises, and this initiative is related to a high degree of social responsibility commitment.

Stekelorum et al. (2018) focused on the perspective of dynamic capability by using within-case and cross-case analysts to study how SMEs can extend CSR to the multi-level supply chain. The study found that the ability of "co-evolution" or "reflex control" was the driving force of CSR. Additionally, the obstacles of first-tier and second-tier suppliers to implement dynamic capabilities mainly come from internal driving factors.

Li et al. (2019) employed structural equation model and analytic hierarchy process method by using the data of 298 small and medium-sized enterprises in China to explore the impact of CSR on service innovation and the mechanism of both. The study found

that environmental social responsibility can improve service innovation performance, and dynamic capability was the complete intermediary of this effect.

Ismail et al. (2019) employed regression analysis to examine the relationship between ESG practice and board dynamic capabilities using data from listed companies in the FTSE4Good Bursa Malaysia from 2012-2016. The study found that ESG practices were significantly related to board size, diversity, and independence.

Ismail et al. (2019) used the data from listed companies in Malaysia from 2012 to 2016 to empirically explore the mediating role of absorptive capacity between board capacity and ESG practice. The study found that ESG practice had a significant relationship with board capacity and absorptive capacity. Absorbing competence was mediated by board competence and ESG practice. The board capacity of the study included board size, board diversity and board independence.

Scarpellini et al. (2020)   employed the partial least squares structural equation model and a sample of Spanish companies with more than 50 employees to explore the different environmental capabilities of enterprises applying a circular economy based on the dynamic capability theory. The study found that there was a positive relationship between CS, its environmental accounting practice, its CSR and its accountability level.

Sun and Ding (2020) empirically explored the relationship between CSR and corporate cash flow fluctuations by using data from KLD, Firm Annual Reports, and Business Segment Databases. The study found the dynamic impact of CSR on corporate performance instability. Enterprises with higher marketing abilities will eliminate the negative impact of CSR.

Bowen et al. (2020) employed the case study approach to qualitatively explore how to integrate the customer's CSR practice into the strategy-making process. The study found that CSR was helpful to operate a strategic plan in an uncertain and dynamic business environment. Social media can help to suggest relationships and enhance trust.

Akhtar et al. (2020) used country and firm-level ESG data to empirically examine the interactions between the macro (country) and micro (firm) dynamic capabilities of emerging market multinationals. Key macro and micro dynamic capabilities were found to be positively related to environmental sustainability.

Pan et al. (2021) used the sample data of 174 manufacturing enterprises in China to test the regulatory effect of CSR on the relationship between strategic orientation and digital capabilities by employing a structural equation model. The study found that the CSR of enterprises regulated the relationship above. The greater the contribution of customer focus to digital capability performance, the higher the CSR of the organization.

Forcadell and Aracil (2021) examined and classified 218 CSR interventions of 111 Spanish companies during the COVID-19 epidemic, and assessed the impact of corporate CSR actions on social sustainability during the crisis. The study determined a set of dynamic sustainability capabilities to support the purpose and behavior of enterprises, so as to improve the efficient CSR of post-disaster.

Li et al. (2021) empirically examined how dynamic capabilities affect strategic corporate social responsibility (SCSR) in China. The study found that enterprises above or below the average industry level were less likely to adopt SCSR practices and had lower SCSR adoption performance, using data from 134 Chinese listed companies from 2017 to 2019. These findings can help companies gain a better understanding of dynamic capabilities and how they can contribute to the adoption of SCSR, and to the sustainable development and operation of companies.

Liang et al. (2022) conducted a quantitative study that analyzed data from 78 firms listed on the Korea Exchange (KRX) to explore the relationship between dynamic capabilities and sustainable management performance. The study found that absorptive capacities and adaptive capacities are the mediating variables through implementing ESG strategy, which have a significant impact on sustainable management performance. In particular, the implementation of ESG strategy is an important determinant of sustainable management performance.

Yuan and Cao (2022) investigated 424 manufacturing enterprises in China and studied the impact of corporate social responsibility (CSR) and green dynamic capabilities on green innovation. The study found that green dynamic capabilities played a mediating role between corporate social responsibility and green innovation, which provided new guidance for Chinese manufacturing enterprises to improve green innovation.

Lee et al. (2022) empirically explored the relationship between ESG performance and stock price collapse risk by using the sample data of Korean multinational companies.

The study found that ESG performance and E/S/G performance of multinational companies were all negatively correlated with stock price collapse risk, indicating that the stock price collapse risk was slowed down. The study examined the mitigating effect of the S factor on the risk of stock price collapse.

2.4 Related Work about ESG Ratings

Mandatory disclosure can reduce information asymmetry and help stakeholders increase oversight. When enterprises release the ESG report, under the pressure of external supervision, enterprises will reduce emissions and take the initiative to assume social responsibility. ESG information disclosure will be affected by many factors. At present，many international organizations put forward the ESG rating system and regularly publish related indexes, and representative systems include MSCI, KLD, Dow Jones, FTSE Russell, Townsend Reuters, Refinitiv, and so on. Under the background of the new economic development, some enterprises in China have also put forward ESG rating systems, such as Huazheng, SynTao Green Finance, and Business and Road Integration. These rating systems focus on building standardized indicators that can reflect the ESG practice of Chinese enterprises, thus providing an orderly and feasible organizational framework for ESG evaluation. ESG ratings provide investors with more information and help mitigate information asymmetry, but ESG rating divergence can mislead market participants and affect corporate decisions and market returns.

Avetisyan and Hockerts (2017) analyzed 37 interviews conducted with four ESG rating agencies in the United States, Britain, France, and Switzerland to investigate the reasons for the consolidation of the ESG rating industry and its impact. The study examined the demand of socially responsible investors for reliable data on corporate social responsibility performance and found that the merger of ESG rating agencies has resulted in a decline in this demand, which has somewhat undermined the institutional change sought by the socially responsible investment movement.

Siew (2017) analyzed the company websites, sustainable development and annual reports of Malaysia's real estate and construction industry to explore the transparency of its ESG disclosure. The study found that Malaysian construction companies reported the most corporate governance indicators, and there were basically no details of actual health and

safety performance and their measures in these companies' reports. Therefore, the reliability of Malaysia's real estate and construction market was questionable.

Baldini et al. (2018) found that at the national level, the political system (law and level of corruption), the labor, and the cultural system defined as social cohesion and equal opportunity, significantly affect a company's ESG rating. At the corporate level, the characteristics associated with a company's visibility (analyst coverage, cross-listing, size) affect the company's ESG rating.

McBrayer (2018) used Bloomberg's ESG disclosure data to examine the impact of company management information disclosure on ESG disclosure. The study found that the quality of ESG information disclosure decreased with the increase in management tenure. Additionally, the change of CEO would interrupt the continuity of ESG information disclosure, which showed the median ESG disclosure score increased by about 9.7%.

Yu et al. (2018) used Bloomberg ESG score data to conduct an empirical analysis of a sample of 1,996 large companies from 47 developed and emerging countries and regions to examine the impact of ESG information disclosure on firm value. The study found that the benefits of ESG disclosure outweigh the costs. Moreover, the mechanism of this impact was to reduce investor information asymmetry and agency costs.

Aboud and Diab (2019) used data from S&P/EGX ESG Index, which covers 100 firms in Egypt, to investigate ESG ratings' comprehensive influence on market and financial performance. The study found that high ESG ratings were associated with better financial and market performance, which was more pronounced in the aftermath of the political revolution in 2011. The research also highlighted the economic implications for ESG ratings in emerging economies.

Johnson et al. (2019) investigated the financial effect of ESG by using the data of companies listed on the Johannesburg Stock Exchange from 2011 to 2016 and Bloomberg ESG rating data. The study found that the financial performance of ESG companies in different dimensions is different, and enterprise managers should adopt different methods to solve important business risks.

Olatubosun and Nyazenga (2019) used semi-structured interview data based on pension fund entities, mutual funds, and life insurance companies to explore how Zimbabwe's Responsible Investment (RI) considers ESG criteria when selecting invested companies. It also investigated the possible "green cleaning" behavior and impression management of ESG rating. The study found that due to the weak regulatory environment, venture capital became a marketing tool. Moreover, there were obvious differences between local foreign companies and domestic companies in ESG practice.

Drempetic et al. (2020) argued that a comprehensive survey of ESG performance has been neglected in the existing literature. Based on the Asset4 ESG Evaluation Index System of Thomson Reuters, the study explored the effect of enterprise size on ESG score. It also pointed out that the current ESG score cannot truly measure a company's sustainability performance.

Fu et al. (2020) found that corporate ESG scores affect institutional investor choice. The authors confirm with four government measures to improve ESG that the increase in ESG scores has led to a significant increase in institutional ownership in casinos in Macau, and institutional investors subject to institutional constraints are more likely to invest in ESG-improving companies.

Kim et al. (2020) proved that the political values of institutional shareholders have an impact on their information disclosure policies. The authors used data on employees' political contributions to construct a political ideology score for institutional investors and found that companies with democratic-oriented political ideologies made environmental reports public because of public oversight, and companies with republican-oriented political ideologies are less likely to publish environmental reports. This showed that internal political polarization will affect the company's environmental information disclosure policy.

Koroleva et al. (2020) employed a regression model by using ESG rating data of RAEX institutions of Russian companies from 2018 to 2019 to analyze the relationship between ESG factors and company performance. Based on the resource concept of entrepreneurship, the study found that companies which abide by ESG principles showed better financial performance, and the result was true through return on assets, return on equity and return on investment capital.

Clementino and Perkins (2021) used semi-structured interviews with a sample of Italian companies to find managers' beliefs about adaptation to ESG ratings and the material benefits of achieving high ESG ratings, as well as their alignment with corporate strategy. The findings also contribute to the debate about the impact of ESG ratings.

Widyawati (2021) noted that the quality of measurement of ESG ratings is questionable. In this study, public disclosure information about rating methods and methods was collected from rating agencies from 2009 to 2013 to construct the dimensions of ESG ratings.

Chiaramonte et al. (2021) used the sample of European banks operating in 21 countries from 2005 to 2017 to empirically analyze the influence of ESG rating on bank stability by employing the DID method. The study found that ESG scores reduced the vulnerability of banks during the financial crisis. Banks with higher ESG ratings were more effective. The relationship was also related to the characteristics and operating environment of banks.

Zhang et al. (2021a) examined the correlation between ESG ratings and financial risk across 1531 companies traded on three U.S. exchanges. The study found that companies with higher ESG ratings had higher negative tail risk, but medium-sized companies had the opposite conclusion.

Christensen et al. (2022) examined the causes of ESG divergence. Using data from ESG rating agencies such as MSCI's Invisible Value Assessment (IVA), TR'Asset, and Sustainalytics, the authors applied the OLS regression model to find that ESG disclosures could lead to a wider ESG rating split. Raters differed more on the ESG outcome metrics than on the input metrics. The results also suggested that greater ESG divergence may lead to greater yield volatility and less external financing.

Avramov et al. (2022) used the standard deviation of the ESG ratings of six major suppliers as a proxy for ESG uncertainty. They further employed a regression model to verify that ESG rating divergence increases the α and β coefficients in the CAPM, including the impact on risk-reward trade-offs. In equilibrium, ESG uncertainty leads to an increase in the market premium and a decrease in the demand for stocks.

Serafeim and Yoon (2022) empirically analyzed daily observations of 111,020 companies from 3,126 companies and found that ESG ratings reflect market expectations of future earnings. But when there are ESG rating differences, ESG ratings are unlikely to accurately predict future information. The above research showed that ESG rating divergence not only affects the judgment of investors, but also has a significant impact on corporate earnings, financing costs, and so on.

Berg et al. (2022) comparatively analyzed the six raters' data from KLD (MSCI Stats), MSCI IVA, et al., and proposed the differences into three sources: the number or range of E/S/G is different, the measured way of E/S/G is different and the weight of E/S/G is different. Differences in scope and measurement were to be the main reasons for the divergence, while differences in weights were less important.

Li and Wang (2022) found that there is a synergistic effect between corporate access to finance and social responsibility, which indicates that the purpose of ESG practice is to establish a good image in the public and obtain financing. This showed that high ESG performance enterprises are not really undertaking social responsibility, it is likely to be in order to obtain financing and do the "Face Project".

Raghunandan and Rajgopal (2022) used ESG mutual fund data from 2010 to 2018 in the US to find that ESG scores correlated only with the amount of voluntary ESG disclosure, but not with companies' compliance records or actual carbon emissions levels. The ESG Fund has poorer financial performance than the same asset manager and other funds in the same year. It turns out that companies with good ESG scores are just disclosing more information, not improving their environmental and financial performance.

Basu et al. (2022) used ESG data from Refinitiv to find that ESG-rated "Social cleaning" exists in banks. According to this study, banks with high ESG ratings may not serve social functions as well as those with low ESG ratings, as they are less likely to lend to low-income and disadvantaged individuals, and more likely to reject mortgage applications in poorer areas. These findings suggest the possibility of social exclusion.

Thomas et al. (2022) used EPA toxic data to discover that highly rated companies are generally less polluting. When it comes to meeting profit expectations, highly rated companies will increase pollution for profit while leveraging their good reputation to

mitigate the negative effects of increased pollution. The results showed that the focus on ESG does not deter short-term management behavior.

Li et al. (2023) used the data of listed companies in China from 2009 to 2020 to explore the influence mechanism of ESG rating on corporate innovation in developing countries. This study took a knowledge that the above influence existed in enterprises with high financial investment action. In addition, the outside and inside environmental factors were expanded and analyzed.

Deng et al. (2023) used a sample of 2833 Chinese companies from 2016 to 2020 to explore the consequence of ESG ratings. The benchmark regression found that ESG ratings were positively correlated with TFP. Three possible mechanisms for this relationship were financial constraints, stock price collapse risk and labor productivity.

Gehricke et al. (2023) used Refinitiv ESG database to explore the influence of ESG rating on bond investment return. It is found that the inclusion of ESG investment in the bond portfolio shows a positive impact in the energy sector. Positive returns also allow investors to do good and do well at the same time.

The above evidence suggests that some companies are engaging in symbolic behavior to achieve higher ratings, rather than implementing the ESG concerns of stakeholders, and can be considered to have engaged in "Green-Washing". Therefore, in the process of ESG rating, work should not only consider the quantity of information disclosure, but also pay more attention to the quality of ESG disclosure and the completion of ESG practice. In order to reduce the enterprise "Green-Washing" phenomenon, raters should improve the accuracy of ESG ratings.

2.5 Related work about Technical Achievement Index

TAI was first developed by the 2001 Human Development Report to measure countries' innovation capacity and technological innovation. TAI consists of four secondary indicators: technology creation, new technology diffusion, old technology diffusion and human skills. A large number of academic studies have shown that, in addition to considering the impact of technological innovation on relevant economic and social aspects, the UNDP in the process of designing the technology achievement index, the economic development issues, social development issues and innovation hotspots that are

of common concern to countries at different levels of development are also included in the scope of consideration in the design of indicators. At the same time, TAI also uses the key indicators for measuring technological innovation and formulating development strategies in developing countries as a reference for designing indicators of technological achievement.

Desai et al. (2002) used data from 72 countries to calculate the TAI, and investigated the technological capacity and needs across countries. They found that TAI varies greatly between countries, and there was diversity and dynamism in technological progress in developing countries. Also, based on the TAI values, these countries were classified to four categories.

Archibugi and Coco (2004) compared TAI and the Industrial Performance Scoreboard to devise the overall Technology Index (ArCo), a new technological capability indicator, to explain the technological achievements of developed and developing countries. the ArCo index included technological creation, technological infrastructure and human skills, with eight additional sub-categories. the ArCo allowed countries to be compared over time.

Cherchye et al. (2008) employed TAI as an example and used DEA method to test the robustness of composite indicators, which were often used as national performance benchmarks. At the same time, uncertainty and sensitivity analysis were carried out, and the contribution of uncertain sources different output was analyzed. Based on the findings, this study analyzed different countries' performance.

Ali et al. (2014) employed the Technology Achievement Index 2013 to examine the technological progress of 34 Muslim countries using data from these countries. The ranking of the 34 Muslim countries was summarized, including the ranking on each sub-dimension of the index. The TAI index rankings were used to derive useful information on how the technological situation in these countries has changed over a five-year period.

Bashir et al. (2015) calculated TAI through using data from 21 OIC countries to assess the technology development capacity of these countries. To study technology creation, diffusion of old and new technologies, and human skills in each country, indigenous technology development, technology transfer, and adaptation were deemed essential. The study also assessed each country's progress in capacity-building for technology development over a five-year period (2009-2014).

52

Incekara et al. (2017) employed the method of TAI-16 and TAI-02 by using country-level data to analyze TAI of 105 countries and explored the technical capabilities and performance of these countries. TAI consists of four dimensions and eight sub-indicators. The study created a TAI ranking of 105 countries, in which Switzerland had the highest TAI value of 0.813, while Ethiopia had the lowest TAI value of 0.028.

Ali (2017) calculated the technological achievement index (TAI) of 100 economies from 1995 to 2015, and explored the technological progress in these 21 years. In addition, the study recalculated the human development index (HDI) of 100 economies during this period, and then explored the effectiveness of TAI on HDI. The study found a long-term relationship between technological progress and economic development.

Kumar and Maiti (2018) used Data Envelopment Analysis (DEA) to evaluate the technical efficiency of the Indian steel complex from 2008 to 2013. The study identified 10 indexes, and found that private steel mills with larger production capacity and the most modern technology had higher productivity, which can ensure sustainable achievements and improve their competitiveness in technical efficiency and long-term profitability.

Yurieva et al. (2018) used data from Russian industrial enterprises from 2012 to 2015 to construct the evaluation algorithm of industrial enterprises' innovation attractiveness and its implementation effect. The calculation results of the study showed that the level of environmental uncertainty during the study period was high. It was necessary to use a collaborative method to manage its innovation attraction and reduce the uncertainty level of the industrial enterprise environment.

Acciaro et al. (2018) examined the innovation adoption path of the maritime and port sectors by integrating the H index, I index, innovation analysis system, and qualitative comparative analysis. The study found that the sequencing of innovation goals, and coordination among actors and institutions can influence the achievement, which was helpful to link innovation drivers with actual effects.

Parente (2019) used the data from UNDP and the European Commission to construct a multidimensional index, calculated the human development index of 205 regions in the European Union from 2000 to 2011, and calculated the inequality-adjusted human development achievements. The study found that human development achievements had improved on the whole, but the distribution was unequal and unbalanced.

Ratnapuri and Inayati (2019) used TAI to calculate that countries in the Southeast Asia region have gaps in technological development and explored the reasons for the gaps between countries. The findings showed that Singapore remains the leader in the overall technological achievement index, while Timor-Leste has the lowest overall technological achievement index. The study demonstrated the importance of technological advancement to the economic growth of Southeast Asian countries.

Salam et al. (2019) developed a new technology adoption index, technological innovation index, human capital and skill development index, and used the generalized moment method to explore the relationship between the regional index and economic growth in low-and middle-income countries from 2000 to 2016. The study found that there were different correlations between technology adoption and innovation for low-income countries vs middle-income countries.

Al-Ayouty and Hassaballa (2020) employed the Malmquist index and DEA method to explore the Environmental Total Factor Productivity (ETFP) of Egypt's energy and capital-intensive industries from 2002 to 2014. The study found that ETFP hardly changed, and the decrease in efficiency offset the improvement of technological progress. Excluding environmental factors, there was an overestimated TFP.

Özçatalbaş (2020) discussed the relationship between TAI and HDI based on literature analysis. The study found that countries had different potentials in the sustainable development index. The position of each country in the ranking of the sustainable development index was closely related to its HDI. There was a reasonable balance between the national TAI and the HDI. From the perspective of development, technological production capacity provided these countries with great advantages.

Roy et al. (2021) used the Spearman correlation and DEA to evaluate the efficiency of social and economic development in 146 countries from 2001 to 2015, and explored the relationship between globalization and social and economic development. The study found that the change in productivity was mainly influenced by technological progress. It is possible to achieve double achievements.

Pérez-Castro et al. (2021) selected countries along the Mediterranean Sea as samples to explore the potential relationship between Human Development Index (HDI) and Information and communication technology Development Index (IDI). The study found

that the average growth rates of human and technological development were 23% and 2.5% respectively. In terms of HDI, the differences among countries also narrowed further, with a decrease of 7.4%, while IDI decreased by 5.2%.

Büşra (2022) studied the development of TAI in 72 countries between 1990 and 2019. The study classified the 72 countries into leaders, potential leaders, dynamic adopters and marginalized countries based on the TAI rankings. It was also found that there has been an increase in the number of countries that have joined the ranks of potential leaders over the past few decades. Moreover, the empirical results indicated that there was a statistically significant relationship and a positive correlation between the four sub-indices.

Yakymova et al. (2022) developed the Industry Digital Transformation Index (IDTIu) and calculated the IDTIu scores of 34 European countries based on the data from 2020. In addition, the original benefit of doubt (BoD) model and its two extended models were used to determine the proportion and priority of sub-indices. The study expanded the application range of the index on the development of composite indices for the digital transformation of industries.

According to current practice regarding TAI and TAI-related work, the researchers deal with different units of measurement by normalizing the original data. While calculating the TAI, assigning equal weight to indicators within each dimension is a common practice in the literature. However, this method is subjective, and it may be necessary to rationalize the weighting of sub-indicators to ensure accuracy and consistency. An important information weighting model that has been extensively studied is the Entropy Weighting Method (EWM). The main advantage of EWM is that it avoids the influence of human factors on the index weighting, thus improving the objectivity of the evaluation results compared to other subjective weighting models.

2.6 Related work about Probit Regression

Probit regression is a statistical technique used to model the relationship between a binary dependent variable and one or more independent variables. It is particularly useful when the dependent variable represents a binary outcome, such as "yes" or "no", "success" or "failure", or other mutually exclusive categories. The basic assumption in probit

regression is that the linear predictor of the independent variables is related to the probability of observing a particular outcome by this probit function.

The basic concept of probit regression is to transform the linear predictor into a probability by using the inverse of the probit function. This transformation ensures that the predicted probabilities are between 0 and 1, which is ideal for modelling binary outcomes. The model estimates the coefficients of the independent variables that maximize the probability of observing the given set of outcomes. Probit regression is classified as a type of generalized linear model (GLM) specifically designed for modelling binary data. It shares similarities with logistic regression. Probit regression has several advantages. Firstly, it allows the estimation of probabilities rather than just class predictions, which is valuable for decision making. It also provides a means of quantifying the impact of independent variables on the likelihood of the outcome.

In practice, probit regression is useful in various fields such as economics, social sciences and medical research, particularly when analyzing binary outcomes. It helps to answer questions about the probability of an event occurring given a set of predictor variables, and how different factors influence the probability of the event. Maximum likelihood estimation (MLE) is commonly used to estimate the coefficients in probit regression. MLE identifies the parameter values that maximize the probability of observing the event given the available data. Many statistical software packages offer probit regression as a built-in option, making it easily accessible to researchers and analysts. Probit regression has been utilized in the field of ESG to analyze various aspects related to environmental, social, and governance practices of companies. The literature in this field explores the use of probit regression to model and understand the relationship between ESG factors and different outcomes.

Amel-Zadeh and Serafeim (2018) used heteroscedasticity robust standard error for probit regression to investigate investors' use of ESG information. The results showed that a major barrier to the use of environmental, social and governance information is the lack of reporting standards. Among the different ESG investment styles, negative screening is considered the least favorable for investment.

Li et al. (2018) used probit model to conduct Heckman two-stage regression. The results showed that there is a positive correlation between the level of ESG disclosure and

56

company value, indicating that improving transparency and accountability and enhancing stakeholder trust has played a role in increasing company value.

Hong et al. (2019) used probit regression to test the hypothesis that ESG received a lighter sanction from prosecutors. The measurement estimates suggest that ESG received a lower sanction of $14.3 million, or 65%, all else being equal. Consistent with our exclusion restrictions, state laws are unrelated to bribery revenues.

Crifo et al. (2019) used probit and OLS regression models to find that corporate sustainability seems to be positively related to internal forces (internal directors) and negatively related to external forces (active participation of general expert directors and investors). The results of this study show that it is necessary to educate the board of directors (especially internal directors) and independent directors to deal with corporate sustainability and play a more leading role in this area.

Crespi and Migliavacca (2020) conducted an ordered probit regression to confirm that the ESG scores of financial companies increase linearly over time, which is reinforced by their size and profitability, as well as the economic and social development of the country in which they operate. Our results also suggest that the environmental, social and governance pillars follow an independent model.

Ziolo et al. (2020) discussed the quantitative methods used in ESG risk analysis. The importance of qualitative methods in ESG evaluation is diagnosed through a literature review, induction and deduction. The research results confirm that the use of quantitative tools in ESG research is beneficial for analyzing the economic and financial situation of the company.

Liu and Nemoto (2021) used probit regression to conduct robustness test, and proved that ESG scores are linked to a company's attractiveness as an employer, suggesting that a high ESG score can be a competitive advantage in attracting talent and enhancing shareholder value.

Chouaibi and Zouari (2021) used probit model regression to test the relationship between corporate social responsibility practices and the actual level of earnings management of sample companies included in the ESG index from five European countries. There is a

significant negative correlation between the variables related to corporate moral behavior and the actual level of earnings management.

Zanin (2022) used probit model ordinal logit model explored the effects of ESG score on the credit ratings of firms. The research results showed that the environmental pillar score is the sustainability dimension that is most conducive to improving the goodness of fit of credit rating models. It has a significant positive impact on the credit ratings of all industries studied, with a greater impact on mining and quarrying companies.

Gigante and Manglaviti (2022) developed a linear probit model to explore the impact of ESG performance on corporate debt costs. Using Luft ESG score data, the study found no statistically significant evidence of a discrete jump corresponding to the average ESG score of European non-financial corporate debt costs between 2018 and 2020.

2.7 A Bibliometric and Visual Analysis in the Field of ESG

A comprehensive statistical review of a specific topic can help researchers better understand the basic knowledge and knowledge structure within a subject field (Wan and Dawod, 2022). A bibliometric study mainly analyzes the information on keywords, references, publications, and even the productivity of authors, countries, and institutions. Through bibliometric analysis, researchers can summarize the current situation and development trends of research fields or specific diseases and provide directions and ideas for future research (Lu et al., 2019). The publications were obtained from the Web of Science database. This study concerns ESG as a whole. Considering this factor, this thesis defined the search topic keywords as "ESG" or "environmental, social, and governance" in the title, abstract, keywords, or text of the article. The time span was set from 2004 to 2021. The search was conducted in January, 2022. The criteria for retaining documents were as follows: (1) based on Web of Science categories, relevant literature in non-economic and non-management fields were excluded, and the categories of business, business finance, economics, and management remained; (2) the analysis considered only articles and reviews; and (3) the language of the papers was English. In total, 1,702 publications were obtained, of which 947 publications containing 899 non-economic and management categories were excluded. The selection strategy for including papers is illustrated in Figure 2.1. Finally, 755 articles were downloaded and exported to software for analysis.
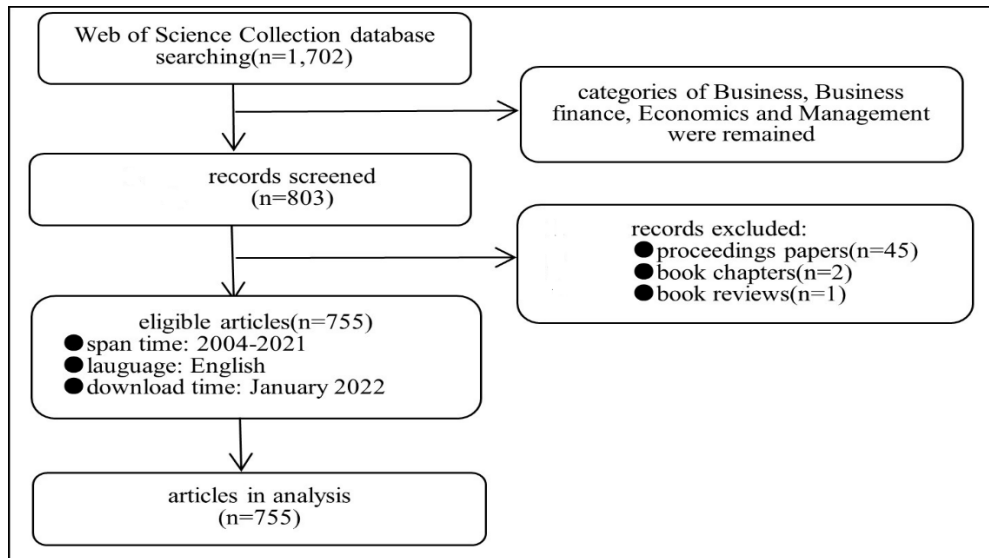
Figure 2.1 Selection process for including articles.

Analysis of publications. The purpose of analyzing temporal characteristics is to reflect the origin and development process of the research topic. During 2004–2021, a large number of papers on ESG were published. Figure 2.2 shows the number of publications published every year, and it can be seen that this number has increased dramatically, especially in the last four years. After the launch of the Global Influential Investment Network in 2009, some influential research institutions and scholars appeared, and their research focused mainly on the influence of domestic market characteristics, country attributes, gender, and CEO characteristics on ESG. The number of articles grew steadily, with more than 60 articles published between 2009 and 2015. The total number of publications from 2016 to 2021 was 675. These results show that the concept of ESG is receiving increasing attention from researchers.
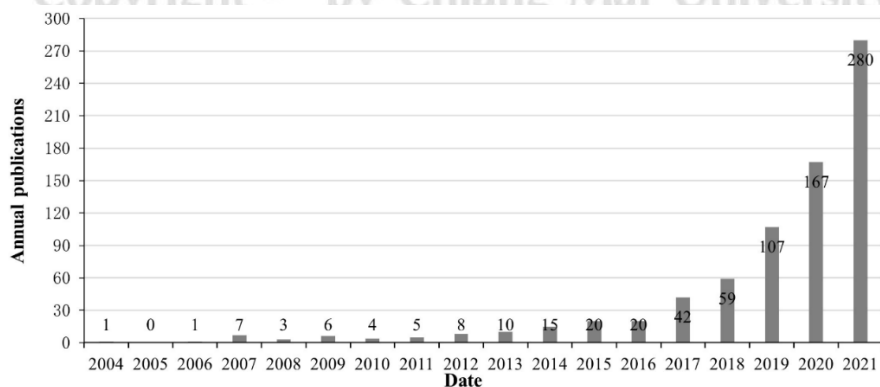
Figure 2.2 ESG papers published annually (2004–2021).

Analysis of citation structure. An analysis of citation structure can identify key authors and articles contributing to ESG research. Table 2.1 lists the 30 highly cited papers from 2004 to 2021. The most cited paper was by Chen et al., who observed that the relationship between CSR and finance is driven by both social and environmental dimensions. The second most cited paper belongs to Hoje and Maretno, who confirm that CSR engagement positively influences firm value and analyze the moderating effect of analysts. Claessens and Yurtoglu are influential works on corporate governance, with a special focus on emerging markets. Post et al. proposed a relationship between board composition and environmental corporate social responsibility (ECSR). In the fifth position, Walls et al. comprehensively explored the link between corporate governance and environmental performance. Meanwhile, the authors with the most cited publications were Serafeim with three papers, Busch with two, Haque with two, Managi with two, Ntim with two, Post with two, and Rahman with two.

Table 2.1 The 30 most cited papers about ESG during 2004–2021.

R	TC	Title	Author/s	C/Y
1	895	Corporate social responsibility and access to finance	Cheng et al. (2014)	111.88
2	508	Corporate governance and firm value: the impact of corporate social responsibility	Jo and Harjoto (2011)	46.18
3	380	Corporate governance in emerging markets: a survey	Claessens and Yurtoglu (2013)	42.22
4	372	Green governance: boards of directors' composition and environmental corporate social responsibility	Post et al. (2011)	33.82
5	371	Corporate governance and environmental performance: are there really a link?	Walls et al. (2012)	37.10
6	268	Corporate governance and social responsibility: a comparative analysis of the UK and the US	Aguilera et al. (2006)	16.75
7	194	Active ownership	Dimson et al. (2015)	27.71
8	164	Board attributes, corporate social responsibility strategy, and corporate environmental and social performance	Shaukat et al. (2016)	27.33
9	161	The contribution of environmental and social standards towards ensuring legitimacy in supply chain governance	Mueller et al. (2009)	12.38

Table 2.1 (continued)

10	152	Socially responsible funds and market crises	Nofsinger and Varma (2014)	19.00
11	145	Corporate governance quality and CSR disclosures	Chan et al. (2014)	18.13
12	142	Environmental disclosure quality: evidence on environmental performance, corporate governance and value relevance	Iatridis (2013)	15.78
13	140	Corporate social responsibility and financial performance: a non-linear and disaggregated approach	Nollet et al. (2016)	23.33
14	129	The integration of corporate governance in corporate social responsibility disclosures	Kolk and Pinkse (2010)	10.75
15	128	Diversity of board of directors and environmental social governance: evidence from Italian listed companies	Cucari et al. (2018)	32.00
16	122	Social reporting and new governance regulation: the prospects of achieving corporate accountability through transparency	Hess (2007)	8.13
17	119	ESG performance and firm value: the moderating role of disclosure	Fatemi et al. (2018)	29.75
18	117	Is environmental governance substantive or symbolic? an empirical investigation	Rodrigue et al. (2013)	13.00
19	114	Measurement issues in environmental corporate social responsibility (ECSR): toward a transparent, reliable, and construct valid instrument	Rahman and Post (2012)	11.40
20	113	Monitoring intensity and stakeholders' orientation: how does governance affect social and environmental disclosure?	Mallin et al. (2013)	12.56
21	112	The impact of environmental, social, and governance disclosure on firm value: the role of CEO power	Li et al. (2018)	28.00
22	108	Environmental responsibility and firm performance: the application of an environmental, social and governance model	Lee et al. (2016)	18.00
23	105	A study of environmental policies and regulations, governance structures, and environmental performance: the role of female directors	Elmagrhi et al. (2019)	35.00
24	102	The performance frontier: innovating for a sustainable strategy: interaction	Eccles et al. (2013)	11.33
25	102	How media coverage of corporate social irresponsibility increases financial risk	Kölbel et al. (2017)	20.40

Table 2.1 (continued)

26	101	The impact of strategic relevance and assurance of sustainability indicators on investors' decisions	Cheng et al. (2015)	14.43
27	101	Why and how investors use ESG information: evidence from a global survey	Amel-Zadeh and Serafeim (2018)	25.25
28	101	Does the voluntary adoption of corporate governance mechanisms improve environmental risk disclosures? evidence from greenhouse gas emission accounting	Peters and Romi (2014)	12.63
29	96	Sustainable development and financial markets: old paths and new avenues	Busch et al. (2016)	16.00
30	91	Business sustainability performance and cost of equity capital	Ng and Rezaee (2015)	13.00

Note: R = Rank; TC = Total citations; C/Y = Citations per year.

In addition, the citation structure was classified and counted, and information was presented from 2004 to 2021 as shown in Table 2.2. Remarkably, publications published from 2011 to 2014 were the most cited. Only 3.58% of the publications had more than 100 citations, and 37.22% had more than 10 citations. However, 79.6% of the papers on ESG were cited at least once. The above result suggests that scholars are increasingly regarding environmental, social, and governance as an integrated sustainability analysis framework and paying more attention to the connection among different dimensions (E/S/G). In addition, many studies increasingly focus on the influence of ESG behavior on a firm's risk, performance, and value.

Table 2.2 Paper citation structure by year (2004–2021).

Year	TP	TC	≥ 200	≥ 100	≥ 50	≥ 20	≥ 10	≥ 5	≥ 1
2004	1	45	0	0	0	1	0	0	0
2005	0	0	0	0	0	0	0	0	0
2006	1	268	1	0	0	0	0	0	0
2007	7	395	0	1	4	7	7	7	7
2008	3	16	0	0	0	0	1	1	2
2009	6	352	0	1	3	5	5	6	6
2010	4	299	0	1	3	4	4	4	4
2011	5	961	2	2	2	3	5	5	5
2012	8	603	1	2	3	4	6	7	8
2013	10	1,009	1	5	6	8	8	9	10
2014	15	1,684	1	4	8	11	14	14	15
2015	20	1,037	0	2	9	16	18	19	20
2016	20	976	0	3	7	11	15	19	19

Table 2.2 (continued)

2017	42	1,437	0	1	12	25	31	35	42
2018	59	1,699	0	4	11	25	39	49	56
2019	107	1,504	0	1	5	22	57	76	99
2020	167	1,405	0	0	2	25	47	83	145
2021	280	904	0	0	1	9	24	57	163
Ratio (%)			0.79%	3.58%	10.07%	23.31%	37.22%	51.79%	79.60%

Note: TP and TC = Total papers and citations; ≥200, ≥100, ≥50, ≥20, ≥10, ≥5, ≥1 = number of papers equal to or greater than 200, 100, 50, 20, 10, 5, and 1 citation.

Analysis of keyword. Keyword analysis is a method used to analyze the relationship between research topics by counting the co-occurrence of keywords, which is helpful in discovering research hotspots and research structure. In our study, author keywords were selected as statistical objects for keyword analysis. Among all 1,872 author keywords, we set those that appeared at least five times for analysis, and only 92 author keywords met the threshold. The co-occurrence network of the major author keywords cluster is shown in Figure 2.3 using VOS viewer software, and the top 30 author keywords occurrences are given in Table 2.3. According to the major author keywords, the main topics can be divided into five aspects: the philosophy of the ESG system (red cluster), factors affecting ESG (green cluster), the financial outcomes of ESG (blue cluster), the association between ESG and CSR (yellow cluster), and ESG investing (purple cluster).
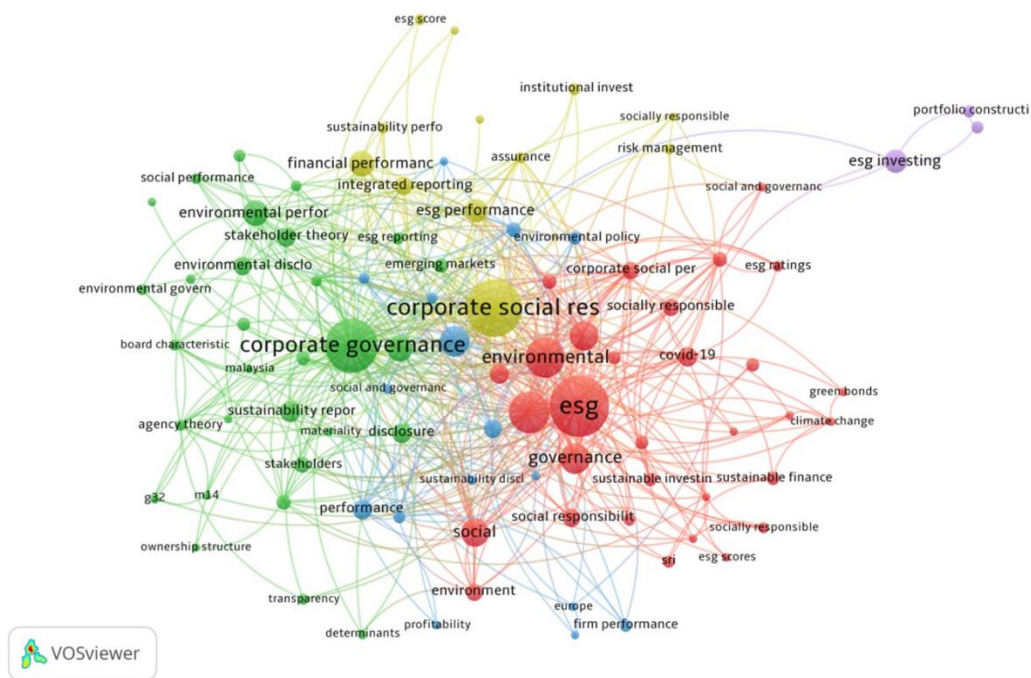
Figure 2.3 Co-occurrence network of major author keywords.

Table 2.3 Top 30 author keyword occurrences.

R	Author Keyword	Cluster	Frequency	Total link strength
1	ESG	1	146	245
2	Corporate social responsibility	2	134	265
3	Corporate governance	2	119	251
4	Sustainability	1	74	154
5	Environmental	3	70	180
6	Governance	1	45	118
7	Sustainable development	1	43	110
8	Social	3	38	131
9	Environmental performance	2	32	67
10	Financial performance	2	31	74
11	ESG disclosure	2	31	63
12	ESG performance	2	27	48
13	ESG investing	1	27	29
14	Sustainability reporting	2	22	44
15	Performance	4	20	58
16	Stakeholder theory	2	20	54
17	Disclosure	3	20	50
18	Firm value	3	19	42
19	COVID-19	1	19	31

Table 2.3 (continued)

20	Social responsibility	1	18	40
21	Integrated reporting	2	18	36
22	Stakeholder engagement	1	17	55
23	Environmental disclosure	3	17	34
24	Environment	3	16	45
25	Corporate social performance	5	16	36
26	Socially responsible investing	1	15	32
27	Stakeholders	2	14	28
28	Corporate financial performance	5	13	32
29	Board of directors	3	13	31
30	Emerging markets	3	13	29

2.8 Summary

The literature review in this chapter explored the relevant theories, concepts and key issues related to ESG ratings and capital markets. The ESG concept encourages stakeholders to focus on long-term value, instead of focusing on economic return and shareholder-first distribution, and promotes corporate transformation and upgrading. This not only reflects the goal of sustainable development of enterprises, but also contributes to the healthy development of the capital market. Based on the theories, this chapter summarizes the research of ESG from three aspects: ESG-related work, ESG ratings-related work, ESG and capital market, ESG and dynamic capabilities, technical achievement index, and profit regression.

In terms of ESG-related work, the existing literature focuses on the relationship between ESG and business activities, corporate governance, enterprise risk, cost of capital, and corporate performance. Most studies have found that ESG practices can improve the efficiency of corporate operations and financial activities, reduce risks, and thus access to more financing channels and greater sustainability, and ultimately bring increased corporate value. In the related work of ESG ratings, the existing literature focuses on the impact of ESG rating differences, the causes, and the existence of the ESG rating "Washing" phenomenon. In the aspect of ESG and capital market, most studies confirm that ESG is positively correlated with the stock market, bond returns, fund stability, and stock returns. Successful ESG practices take into account the interests of stakeholders and

send positive signals, which are viewed positively by investors. In the aspect of ESG and dynamic capabilities, some literature already found the effect of dynamic capabilities on sustainability performance. Additionally, through reviewing TAI, this dissertation would deepen the understanding of technical innovation. Information asymmetry, TAI, and dynamic capabilities will help to better understand the connection between ESG ratings and information efficiency in the capital market as well as the ancillary elements that underpin these relationships would also be worth discussing.

CHAPTER 3

DATA AND METHODOLOGY

3.1 Introduction

The aim of this dissertation is to examine the influence of ESG ratings on information efficiency in the capital market of Chinese listed companies. The dissertation uses the EWM to calculate TAI and dynamic capabilities as moderator variables to assess the connection between ESG ratings and information efficiency. Quantitative methodology was used to address the research questions and hypotheses. Minimum Bayes Factors (MBF) was used to conduct robustness test for empirical results. In this chapter, some research design issues associated was presented with the selected methodology and data selection. Data for computing China's provincial TAI and for empirical study were described. The main variables were defined. Based on the hypotheses, models were established. This chapter began with a description of the methodology and the data collection, followed by the definition of variables, proposed hypotheses and models for empirical analysis. The chapter ended with a summary.

3.2 Methodology

3.2.1 Entropy Weight Method to Compute TAI

EWM is widely used (Liu et al., 2010) and is a numerical weighting method (Zou and Sun, 2006). In comparison to subjective weighting techniques, EWM has the advantage of avoiding the influence of subjective factors on the index weighting, which improves the objectivity of the results and provides a more informative discussion and results. EWM has the advantage of not being subject to the influence of subjective factors on the weighting of the index, and therefore the discussion and results are more meaningful. TAI is a way of assessing the technical performance of areas like country, continent and historical period. In this dissertation, using updated variables and datasets, EWM is used to calculate the weighting of TAI indicators and to construct the provincial TAI for China from 2010 to 2021.

3.2.2 Quantitative Methods for Empirical Analysis

67

This dissertation uses quantitative statistical methods for empirical analysis and testing. The main statistical methods include descriptive statistics, variable correlation analysis, probit regression, and OLS regression. In terms of robustness testing, this dissertation adopts the Heckman two-stage method, independent variable lagged by one year, and instrumental variable estimation to conduct robustness tests. In addition, this study employs a mediation analysis method to examine the underlying mechanism through which ESG ratings impact information efficiency, as measured by NCSP, stock mispricing, and stock price crash risk in the Chinese capital market. This research also aims to address the current gap in understanding the delayed impact and the mechanisms by which ESG ratings influence information efficiency.

3.2.3 Minimum Bayes Factors for Robustness Test

The Bayes factor is a method used in Bayesian statistics for the comparison of models and the testing of hypotheses. The Bayes factor reflects the degree of support for each hypothesis in the current data and may be more appropriate for hypothesis testing in scientific research (Held and Ott, 2016). To avoid potential misinterpretations associated with relying solely on p-values to make decisions, Bayes factors were used in this study (Held and Ott, 2016; Held and Ott, 2018). A key advantage of Bayes factors is that they are not dependent on prior probabilities. The proof of Bayes factors as a function of the p-value can be found in (Held and Ott, 2018). In this dissertation, the robustness of the results was tested using the Bayes factor approach, as recommended by (Katki, 2008). The MBF values are calculated using the following formula:

$$MBF = \exp(-t^2/2) \tag{3.1}$$

where t is the t-statistic.

3.3 Data and Sample Selection

3.3.1 Data for Computing China's Provincial TAI

This dissertation used the TAI, which consists of four main dimensions with two variables each, for a total of eight indicators. To improve upon the existing sub-indicators and account for data availability, this study expanded the sub-indicators to nine. In the development of human skills dimension, this dissertation replaced two indicators with three new ones. Additionally, telephone subscribers and electricity consumption in the

68

diffusion of old innovations dimension were replaced with their natural logarithms. Figure 3.2 was created to show the updated dimensions and sub-indicators of the TAI. To calculate the TAI, data from the China Statistics Yearbook (2010-2021), China Torch Statistics Yearbook (2010-2021), and the Economic Forecasting System (EPS) were used, primarily at the provincial level. Data on high technology exports were taken from the China Torch Statistical Yearbook. Internet users were measured using the ports of broadband Internet access instead of users of broadband Internet access. Tibet did not disclose certain data, so minimum values were used instead. Data from Hong Kong, Macao, and Taiwan China were excluded.
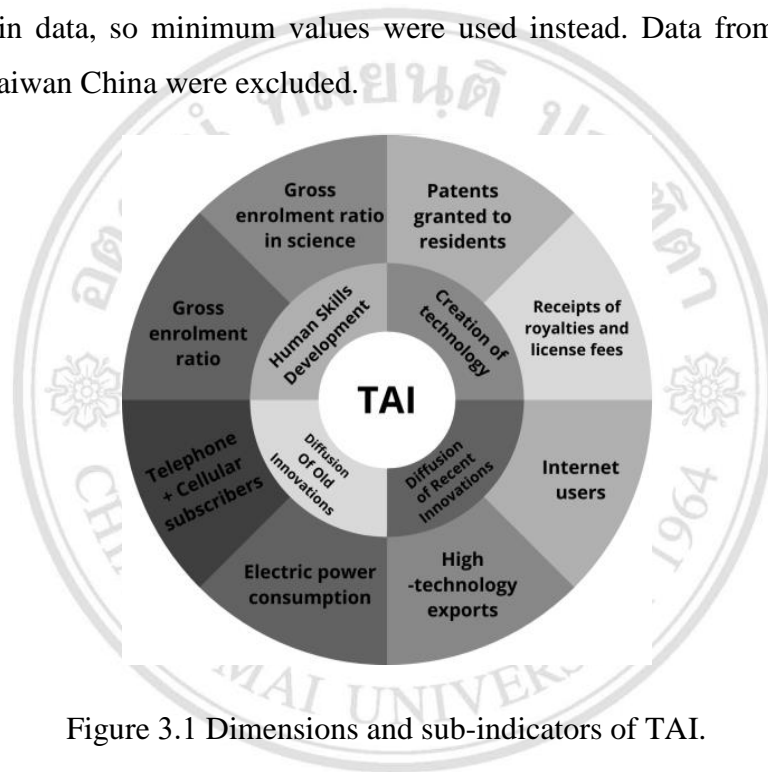
Figure 3.1 Dimensions and sub-indicators of TAI.
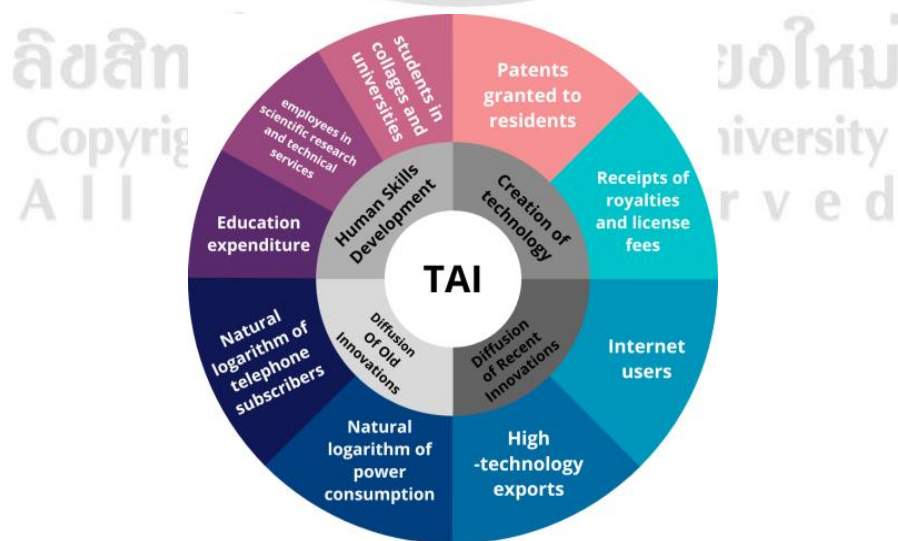
Figure 3.2 Improved dimensions and sub-indicators of TAI.

69

3.3.2 Data for Empirical Study

This dissertation uses data from A-share listed companies in the Chinese stock market between 2010 and 2021 to conduct empirical analysis on the impact of ESG ratings. The ESG rating is composed of the ESG management score and ESG risk score, based on the methodology of Huazheng ESG Ratings. Table 3.1 presents the indicators that make up the ESG rating system, which includes four grades and ten levels (A+, A, A-, B+, B, B-, C+, C, C-, and D). This dissertation assigns a numerical value to each grade and level by assigning A+ to 1, A to 2, A- to 3, B+ to 4, B to 5, B- to 6, C+ to 7, C to 8, C- to 9, and D to 10, allowing for easier analysis of the data.

Table 3.1 ESG ratings system tiers.

Tire 1	Tire 2	Tire 3
E (Environmental)	E1: Environmental Management	certification of environmental management systems, setting water conservation objectives, and promoting green products and services.
	E2: Environmental Disclosure	Energy usage and efficiency, gas emissions and abatement
	E3: Environmental Controversies	Incidents of water/air/solid waste pollution
S (Social)	S1: Employees	Freedom of association and non-discrimination
	S2: Supply Chain	Sustainable supply chain management
	S3: Customer Management	Protection of customer privacy, etc.
	S4: Community	Community communication
	S5: Product	Fair trade products, genetically modified food
	S6: Philanthropy	Enterprise foundation, donation
	S7: Social Controversies	Negative incidents regarding employees/clients/etc.
G (Governance)	G1: Business Ethics	Whistle blowing policy, overseas tax compliance
	G2: Corporate Governance	Transparency and disclosure of information, independence and composition of the board of directors, executive compensation practices, diversity and inclusion at the board level, etc.
	G3: Governance Controversies	Business ethics, corporate governance negative events

70

In this dissertation, ESG ratings data is obtained from the Huazheng ESG ratings in WIND database, while other financial data are sourced from the CSMAR database. To ensure the validity and dependability of the data, the following criteria are utilized to select the sample data: (1) listed companies in the financial and insurance industries are excluded, (2) all types of samples that are ST or *ST are excluded, (3) companies that lack ESG rating information are excluded, and (4) enterprises without data are excluded. In order to reduce the extreme value effect, the shortening of the upper and lower 1% quantities of all continuous variables are done. Finally, 23,975 samples were obtained from ESG ratings and Northbound Capital shareholding preferences, 23,697 samples from ESG ratings and Stock Mispricing, and 20,222 samples from ESG ratings and Stock Price Crash Risk.

3.4 Definition of Variables

3.4.1 Northbound Capital Shareholding Preferences

One of the dependent variables in this dissertation was Northbound Capital Share Preferential (NCSP). As described in the conceptual work of Chapter 1 regarding NCSP, the "Shanghai Stock Connect" opened on 17 April 2014 and the "Shenzhen Stock Connect" opened on 5 December 2016. Since the "Shenzhen-Hong Kong Stock Connect" began operations in 2016, this thesis considers its opening as the policy implementation point (Post). Accordingly, the policy implementation (Post) takes the value of 1 after this point, and 0 otherwise. Regarding northbound capital, if HKSCC Limited is among the top ten shareholders of the sample companies, (Treat) takes the value of 1; otherwise, it takes the value of 0. Northbound capital is commonly referred to as "hot money" or "smart money," and is considered a significant force in the market's investment "windmill." There are several reasons for this phenomenon. First, northbound capital has relatively strong investment and research capabilities. It has the support of professional foreign investment institutions, a mature investment and research system, and a mature stock evaluation standard, so it will not follow the trend like ordinary investors. Second, northbound capital is sensitive to some international events. Because they have been in an international perspective for a long time, they often predict the impact of some international events in a timely manner. Third, the amount of funds from northbound capital is large, which has a certain influence on the market, and the influence on

individual stocks is even more obvious. Due to the above characteristics and influences of northbound capital, the probability of stocks receiving northbound capital earning excess returns is higher. To some extent, the large inflow of northbound funds into the A share market in China will increase investors' confidence in the stock market, while the large outflow of northbound capital from the A-share market will increase investors' pessimism about the stock market. It can be seen that northbound capital holding shares in China company mainly affects the stock market in two ways. The first is the market path. Northbound capital will release some information to the market during the stock market transaction, which will directly affect the risk fluctuation of the stock market. The second is the company way. When northbound capital buys shares of listed companies in the secondary market, it will increase the share price of the company, so the company can get more funds, which will improve the investment and production of the company, and when northbound capital hold a certain amount of shares of listed companies, they can participate in corporate governance, improve or reduce the value of the company, and then affect the share price, and ultimately affect the return of the whole market. Therefore, the shareholding preferences of northbound capital reflects the ability of market investors to obtain and disclose corporate information, and represents the information efficiency in the capital market.

As listed companies presently only provide information regarding their top ten shareholders, (Treat) takes the value of 1 when HKSCC Limited is among the top ten largest shareholders of the sample companies, and 0 otherwise. Consequently, this thesis selects the double-difference interaction term (Post_Treat) to assess the NCSP and explore the link between ESG ratings and NCSP among listed companies in China.

3.4.2 Stock Mispricing

Stock mispricing was one of the dependent variables in my dissertation. Following the previous studies (Rhodes-Kropf et al., 2015; Pantzalis and Park, 2014), this dissertation used the market-to-book ratio decomposition method to measure stock mispricing. According to Rhodes-Kropf et al. (2015), as shown in Equation 3.2, this dissertation decomposed the market-to-book into two components: a measure of price to fundamentals (M/V), and a measure of fundamentals to book value (V/B).

$$\frac{M_{i,t}}{B_{i,t}} = \frac{M_{i,t}}{V_{i,t}} \times \frac{V_{i,t}}{B_{i,t}} \quad (3.2)$$

where i, t denotes firm and year, respectively. M is market value, V is actual value, and B is book value. Equation 3.3 is obtained by taking the logarithm on both sides of Equation 3.2.

$$m_{i,t} - b_{i,t} = (m_{i,t} - v_{i,t}) + (v_{i,t} - b_{i,t}) \quad (3.3)$$

where m, v, and b represent the natural logarithm of the market value, actual value, and book value, respectively. The first component (m-v) captures the part of book-to-value associated with the level of stock mispricing. Furthermore, stock mispricing can be divided into short-term enterprise-level mispricing and long-term industry-level mispricing. Thus, the market-to-book ratio can be divided into three parts as shown in Equation 3.4:

$$m_{i,t} - b_{i,t} = ov_{Firm_{i,s}} + ov_{Indu_{i,s}} + Growth_{i,t} = [m_{i,t} - v(\theta_{i,t}; \beta_{j,t})] \\ + [v(\theta_{i,t}; \beta_{j,t}) - v(\theta_{i,t}; \beta_j)] + [v(\theta_{i,t}; \beta_j) - b_{i,t}] \quad (3.4)$$

where $m_{i,t} - v(\theta_{i,t}; \beta_{j,t})$ is the stock mispricing at the firm level. $v(\theta_{i,t}; \beta_{j,t}) - v(\theta_{i,t}; \beta_j)$ is the stock mispricing at the industry level. $v(\theta_{i,t}; \beta_j) - b_{i,t}$ is a real growth opportunity for the firm.

$$m_{i,t} = \beta_0 + \beta_{1jt} b_{i,t} + \beta_{2jt} In(NI)^+_{i,t} + \beta_{3jt} I_{(<0)} In(NI)^+_{i,t} + \beta_{4jt} Lev_{i,t} + \varepsilon_{i,t} \quad (3.5)$$

$$v(\theta_{i,t}; \beta_{j,t}) = \beta_0 + \beta_{1jt} b_{i,t} + \beta_{2jt} In(NI)^+_{i,t} + \beta_{3jt} I_{(<0)} In(NI)^+_{i,t} + \beta_{4jt} Lev_{i,t} \quad (3.6)$$

$$\bar{\beta}_j = \frac{1}{T} \sum \hat{\beta}_{jt} \quad (3.7)$$

$$v(\theta_{i,t}; \bar{\beta}_j) = \bar{\beta}_0 + \bar{\beta}_{1j} b_{i,t} + \bar{\beta}_{2j} In(NI)^+_{i,t} + \bar{\beta}_{3j} I_{(<0)} In(NI)^+_{i,t} + \bar{\beta}_{4j} Lev_{i,t} \quad (3.8)$$

where In(NI)+ is the natural logarithm of the absolute value of the firm's net profit, I(<0) In(NI)+s is the signaling function when the firm's net profit is negative, and LEV is the leverage ratio. This dissertation computer regression coefficients according to Equation 3.5, then use the regression coefficients to computer the actual value according to

73

Equation 3.6, to computer the mean coefficients of the same industry according to Equation 3.7. Equation 3.8 are used to calculate the long-term firm value.

$$Misp_{i,t} = \mid In(\frac{M_{i,t}}{V_{i,t}}) \mid = \mid m_{i,t} - v_{i,t} \mid = \mid ov_{Firm_{i,t}} + ov_{Indu_{i,t}} \mid = \mid [m_{i,t} - v(\theta_{i,t}; \beta_{j,t})] + \tag{3.9}$$
$$[v(\theta_{i,t}; \beta_{j,t}) - v(\theta_{i,t}; \overline{\beta}_j)] \mid$$

Finally, this dissertation substituted the calculated real firm value and long-term firm value into Equation 3.9 to calculate the stock mispricing. The higher the Misp value, the greater the deviation from the true value of the stock pricing, that is, the greater the stock mispricing.

3.4.3 Stock Price Crash Risk

Stock price crash risk was one of the dependent variables in my dissertation. Following the previous study (Kim and Zhang, 2016), I used two indicators to measure the stock price crash risk, one of which was NCSKEW, indicating the negative market-adjusted weekly rate of return; Another indicator was DUVOL, measuring the volatility of stock price increases and decreases. The calculation process was as follows:

First, this dissertation built Equation (3.10) to calculate the market-adjusted weekly rate of return based on the residual $\varepsilon_{i,t}$.

$$r_{i,t} = \beta_0 + \beta_1 r_{c,w-2} + \beta_2 r_{c,w-1} + \beta_3 r_{c,w} + \beta_4 r_{c,w+1} + \beta_5 r_{c,w+2} + \varepsilon_{i,t} \tag{3.10}$$

where $r_{i,t}$ represents the weekly rate of return of a single stock i in week t and rc,w represents the rate of return of all shares in the week w when calculated on a weighted average of the market value in circulation. At the same time, in order to reduce the impact of non-synchronization in stock trading, a two-phase lag indicator ($r_{i,t}$+1 and rc,w+2) and a two-phase indicator (rc,w-1 and rc,w-2) were added. Based on Equation 3.10, the residual $\varepsilon_{i,t}$ was calculated. The market-adjusted return of stock i in week t is measured by $W_{i,t}$ according to Equation (3.11).

$$W_{i,t} = \ln(1 + \varepsilon_{i,t}) \tag{3.11}$$

74

Then, two indicators are constructed as follows.

The first indicator is NCSKEW, which measures the negative bias of individual stocks after the negative skewness of weekly returns after adjustment by the market. This indicator is calculated according to Equation (3.12).

$$NCSKEW_{i,t} = -[g(g-1)^{\frac{3}{2}} \sum W_{i,t}{}^2]/[(g-1)(g-2)(\sum W_{i,t}{}^2)^{\frac{3}{2}}] \ (3.12)$$

where g denotes the number of weeks in year t for firm i. A larger NCSKEW indicates a greater risk of a stock price crash. The higher the NCSKEW, the greater the stock price crash risk.

The second indicator is DUVOL, which is a measure of the difference in volatility between price rises and price falls. It is calculated by dividing the sample of all data into two phases (up and down) and taking the higher of the market-adjusted weekly return W of stock i or the average annual return. This indicator is calculated according to equation (3.13), with a larger DUVOL and a higher risk of a stock price crash.

$$DUVOL_{i,t} = \log\{[(g_u - 1) \sum_{Down} W_{i,w}{}^2]/[(g_d - 1) \sum_{Up} W_{i,w}{}^2]\} \ (3.13)$$

where gu or gd respectively represent the number of weeks in which the weekly return of a stock i is higher or lower than the average return of the year.

3.4.4 ESG Ratings

ESG rating information is the comprehensive evaluation result of enterprise ESG performance by rating agencies, which mainly serves investment research and reflects rating agencies' understanding of ESG concepts and trends. The application objects of ESG ratings initially included issuers of stocks and bonds, and then gradually extended to fund portfolios. Participants in ESG rating activities can be divided into ESG disclosure standard setters, specialized data providers, ESG rating agencies and data set setters, which involve activities such as standard setting, framework setting, data collection and processing, rating and data integration. The participants in ESG ratings activities are showed in Figure 3.3.

ESG ratings refer to the collection and processing of ESG raw data by rating agencies; Convert the original data into quantifiable and comparable individual ESG performance

75

data according to the defined rating framework; Combined with the different weights given by rating agencies to each index, the ESG rating score of the enterprise is calculated. Rating agencies can directly take the ESG rating score as the final rating result, or further standardize the original score and convert the ESG score into the corresponding ESG ratings.

ESG Disclosure Standard Setter
- Involving standard setting and framework setting.
- The main institutions include GRI, SASB, ISSB and other international standard-setting organizations, as well as regional standard-setting organizations.

ESG rating agency
- Involving frame setting, data acquisition and processing, grading and data integration.
- The main institutions are mostly commercial organizations, including international ESG rating agencies such as MSCI, Sustainalytics and Refinitiv, and China ESG rating agencies such as Huazheng and SynTao.

Specialized Data Provider
- Involving data acquisition and processing, grading and data integration.
- The main institutions include WRDB water resources database, Truscott environmental data provider and biodiversity observation database.

Data integrator
- Relates to data acquisition and processing, data integration
- The main institutions include international ESG data integration service providers such as Bloomberg and Fact set, and China suppliers such as WIND.

Figure 3.3 Participants in ESG ratings activities.

The independent variable in my dissertation was the ESG ratings selected from the Huazheng ESG ratings in the WIND database. Currently, the Huazheng ESG ratings data have been recognised and applied by the practice and academia (Lin et al., 2021). Huazheng ESG ratings have taken into account the reality of China's capital market by referring to the mainstream ESG evaluation framework in the world. These grades contain 9 levels ranging from "C", "CC", "CCC" to "A", "AA", "AAA". In this dissertation, C is assigned to level 1, CC to level 2, CCC to level 3, B to level 4, BB to level 5, BBB to level 6, A to level 7, AA to level 8 and AAA to level 9. The higher the ESG score, the better the company appears to perform in terms of ESG.

3.4.5 Information Asymmetry

Information asymmetry was the mediating variable in my dissertation. Referring to the literature (Hutton et al., 2009), this dissertation employed the modified Jones model to detect earnings management as the proxy variable for information asymmetry according to Equation 3.14.

$$\frac{TA_{i,t}}{A_{i,t-1}} = \beta_0 \frac{1}{A_{i,t-1}} + \beta_1 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + \beta_2 \frac{PPE_{i,t}}{A_{i,t-1}} + \varepsilon_{i,t} \quad (3.14)$$

where TA denotes the difference between the operating profit and the net cash flow from operating activities, PPE denotes the firm's net fixed assets, $REV_{i,t}$ denotes the change in operating income for firm i from year t to year t-1, $\Delta REC_{i,t}$ denotes the change value of accounts receivable for firm i in year t compared with year t-1, $A_{i,t-1}$ denotes the total assets for firm i in year t-1, β_0, β_1 and β_2 denote the OLS estimates. ε *it* is the residual, the absolute value of which to measure earnings management AbsDA. The higher the AbsDA value, the higher the degree of earnings management, and the higher the degree of information asymmetry.

3.4.6 Technical Achievement Index

TAI was one of the moderator variables in my dissertation. Based on the construction of China's TAI, this dissertation employed TAI to measure the technical abilities and performances of 31 provinces using the provincial data from 2010 to 2021 for China. In this section, i used the EWM to calculate the weighting of dimensions and sub-indicators and then computed the TAI. The findings obtained helped me to set the TAI variable to analysis the moderating effect between ESG ratings and information efficiency in the Chinese stock market.

Most literature on TAI currently applies a subjective weighting method where each dimension's indicators are given equal weight (Bashir et al., 2015). However, rationalizing the weighting of sub-indicators is a crucial step in calculating TAI accurately. In this dissertation, the EWM method was employed to calculate TAI weights for dimensions and indicators. To objectively measure indicator weight using EWM, data is dimensionless and processed according to Equation 3.15. As all indicators are positive, direction does not need to be changed. However, since there may be orders of magnitude differences between indicator values, the data needs to be converted to a value between 0 and 1 using the following formula:

$$\chi_{i,t,k} = \frac{X_{i,t,k} - Min\{X_k\}}{Max\{X_k\} - Min\{X_k\}} \quad (3.15)$$

where i, t, and k denote sample, year, and indicator. In the EWM, k indicators and i samples are set in the evaluation, and the measured value of the kth indicator in the ith sample and tth year is recorded $\chi_{i,t,k}$. The standardized value of the kth index in the ith sample and tth year is denoted as $\delta_{i,t,k}$, and its calculation method is as follows:

$$\delta_{i,t,k} = \frac{\chi_{i,t,k}}{\sum_{i=1}^{s}\sum_{t=1}^{a}\chi_{i,t,k}} \quad (3.16)$$

The entropy value φ_k of the kth index is defined as follows:

$$\varphi_k = -\frac{1}{Lnn}\sum_{i=1}^{s}\sum_{t=1}^{a}(\delta_{i,t,k} \times Ln\delta_{i,t,k}) \quad (3.17)$$

where n denotes the number of the sample. a is the annual number of each province, and s is the number of provinces. The range of entropy value φ_k is [0,1]. The coefficient of variation γ_k is defined as follows:

$$w_k = \frac{\gamma_k}{\sum_{k=1}^{h}\gamma_k} \quad (3.19)$$

The entropy weight obtained is the weight of each of the indicators of the TAI. Finally, the results have been formed. The weights of the indicators calculated by the EWM are shown in Table 3.2. In accordance with the weights, this dissertation composes the provincial TAI for China from 2010 to 2021 (see Appendix A). The higher the value of the TAI, the higher the technical performance of the province. Conversely, the lower the TAI, the lower the technical performance.

Table 3.2 the Indicators Weight of TAI.

Dimension	Weight	Sub-indicators	Sub-weight
Creation of Technology	0.5657	Patents granted to residents	0.2175
		Receipts of royalties and license fees	0.3482
Diffusion of Recent Innovations	0.0806	High-technology exports	0.0379
		Internet users	0.0427

78

Table 3.2 (continued)

		Natural logarithm of telephone subscribers	0.0903
Diffusion of Old Innovations	0.1370	Natural logarithm of power consumption	0.0467
Human Skills development	0.2167	Education expenditure	0.0943
		students in colleges and universities	0.0358
		employees in scientific research and technical services	0.0866

Source: Calculation

Appendix A shows the development of all the estimated dimensions of China's TAI from 2010 to 2021. It can be seen that the diffusion of recent innovation is at the top of the list, followed by the diffusion of old innovation, human skill development, while the index of technological creation is the lowest, with little change below 0.1. From the perspective of the trend of change, the recent diffusion of innovation and the development of human skills show a fluctuating upward trend. In these four dimensions, the diffusion index of old innovation only fluctuates. This also shows the importance of the diffusion of new inventions for the growth of TAI. It is worth noting that China's TAI has been hovering around 0.2, which is very different from the high growth of the Chinese economy in the last 10 years. However, the diffusion of technology and human skills has been steadily increasing in recent years, indicating that investment in technological innovation platforms and innovative talents has been increasing in recent years.

This dissertation analyzes the changes of provincial administrative regions in China from 2010 to 2021, dividing the 31 provinces into six administrative regions for detailed examination. The northern region currently leads in TAI, but with slow growth averaging at 0.3677. Within the northern region, Beijing has the highest average TAI value of 0.9713, while Hebei has the lowest at 0.149, indicating an unbalanced input-output structure of technological innovation in northern China. The eastern region ranks second in TAI and has shown steady growth since 2014. Meanwhile, the northwest, south-central, and southwest regions have consistently exhibited low TAI levels and slow growth. Notably, TAI in northeast China has decreased significantly since 2017, indicating a need for increased government attention to address issues such as talent outflow and insufficient technology investment that affect innovation and development in the region.

The values showed a wide variation between provinces. The highest TAI value was 0.9653 for Beijing, which ranked first. The lowest value was 0.0412 for Yunnan, which ranked last. This shows that technological attainment has developed very unevenly across Chinese provinces. In addition, this dissertation improved the classification criteria as follows, unlike previous literature, considering the large population base of China. The TAI values of 31 provinces are divided into leading provinces (TAI > 0.5), potential leading provinces (TAI = 0.35-0.49), dynamically adopting provinces (TAI = 0.15-0.34) and marginalized provinces (TAI < 0.15). Using this classification, there are two leading provinces with the TAI above 0.5, four potential leading provinces with the TAI between 0.35 and 0.49, fourteen dynamically adopting provinces with the TAI between 0.15 and 0.34 and eleven marginal provinces with the TAI below 0.15.

Leading provinces (TAI > 0.5): This group includes the provinces with the most rapid technological progress. Leading provinces have great advantages in terms of a country's scientific and technological innovation. These provinces include Beijing and Shanghai, located in the north and east of China respectively.

The provinces of Zhejiang, Tianjin, Jiangsu, and Guangdong are potential leaders in China's technological progress, with a TAI range of 0.35-0.49. These provinces prioritize the role of high-end talent and take various measures to expedite the dissemination of new technologies. Notably, these provinces are located in eastern China, and serve as a crucial pillar for the country's technological advancement.

Nearly half of China's provinces fall into the category of dynamic adopters, with a TAI range of 0.15-0.34. These provinces exhibit a level of human skills and innovation diffusion comparable to potential leading provinces, such as Shandong, Chongqing, Hubei, and Fujian.

On the other hand, marginalized provinces are located mainly in the southwest, northwest, and northeast regions of China, with a TAI below 0.15. These provinces have a significantly low level of technological progress, indicating a long way to go in terms of disseminating new technologies and developing human skills.

In this dissertation, TAI was the moderator variable. Based on the construction of China's TAI as calculated, this dissertation used TAI to measure the technical capability and achievement of 31 provinces using the provincial data from 2010 to 2021 for China. In

this section, EWM was used to calculate the weights of dimensions and sub-indicators, and TAI was calculated. The obtained results helped to set the TAI variable for the analysis of the moderating effect between ESG ratings and information efficiency for the Chinese capital market.

3.4.7 Dynamic Capabilities

Dynamic Capabilities was one of the moderator variables in my dissertation. Dynamic capabilities are the ability of a company to building, integrating and reconfiguration its inside and outside resources and capabilities to respond to rapid changes in the environment (Teece et al., 1997). A review of the literature revealed that the definition and dimensional delineation of dynamic capabilities by scholars has not yet been unified, but some key underlying constructs, such as the ability to integrate and reconfigure, have been widely agreed upon by scholars and have passed the test in empirical studies. Based on the literature, this dissertation defined dynamic capabilities as the abilities of companies to learn and absorb, change and reconfigure, and coordinate and integrate internal and external resources and capabilities to respond to rapid changes in the external environment.

Thus, this dissertation measured the dynamic capabilities from three elements: learning and absorption capabilities, transformation and reconstruction capabilities, and coordination and integration capabilities, so as to investigate the effect of comprehensive dynamic capabilities on ESG ratings and capital market information efficiency for the Chinese capital market. Learning and absorption capabilities were measured by the proportion of employees with a bachelor's degree or higher, which was denoted as EDU. Transformation and reconstruction capacities were measured by the proportion of intangible assets expressed by net intangible assets divided by total assets, which was denoted as INTA. Coordination and integration capacities were measured by the turnover rate of total assets expressed by operating income divided by total assets, which was denoted as TAT. And finally, this dissertation used the EWM method to calculate the weight of the three elements. Same with the calculation of TAI weight in this chapter, the comprehensive dynamic capabilities are defined as follows

$$DC_{i,t} = \sum_{k=1}^{h} w_k \times \chi_{i,t,k} \tag{3.20}$$

where i, t, and k denote sample, year, and indicator. DC denotes dynamic capabilities. w denotes weight. c denotes the dimensionless values. The higher the DC value, the greater the dynamic capabilities of the company.

3.4.8 Accounting Conservatism

Accounting conservatism was one of internal environmental factor in my dissertation. As an accounting principle, accounting conservatism is the fundamental principle of accounting (Watts, 2003), which is very important for the preparation of financial reports, the quality of accounting information and management decision making. The essence of accounting conservatism is the asymmetry in the response of accounting surplus to "good news" and "bad news". If accounting surplus reacts more quickly to "bad news" than to "good news", this implies accounting conservatism. When accounting surplus is robust, stakeholders can quickly capture the information that violates the contract and reduce the loss in time by changing or terminating the contract. Therefore, accounting conservatism can effectively reduce information asymmetry and play the role of corporate governance, thus protecting the interests of investors. Robust accounting information is one of the important ways to effectively reduce information asymmetry and agency costs, which is conducive to improving the investment efficiency of firms (Lara et al., 2016) and limiting the abuse of cash by managers (Louis et al., 2016). Accounting conservatism can not only play the role of internal governance and effectively curb overinvestment, but also alleviate underinvestment, which plays an important role in curbing overinvestment of enterprises. At the same time, accounting conservatism is not only a measure of the quality of accounting information, but also an effective corporate governance mechanism. A perfect financial reporting system can provide information users with more detailed and comprehensive financial information, so that investors can have a comprehensive understanding of the company's financial situation (Shen et al., 2021). Existing research shows that corporate managers are motivated to improve stakeholders' impression of the company through corporate social responsibility, which leads to the shortcomings of vague corporate social responsibility information, exaggerating positive social benefits or avoiding negative corporate information, and reduces the information carrying capacity of corporate social responsibility reports (Aprilia et al., 2023). This may lead to a reduction in the value of corporate social responsibility reports, which may lead to a reduction in information efficiency in the capital market. It can be seen that corporate

accounting conservatism may have a certain regulatory effect between ESG rating and information efficiency. This dissertation chose to use the extended model C_Score (Khan and Watts, 2009), based on the modified Basu (1997) model, to measure the accounting conservatism. The calculation was as follows:

$$EPS_{i,t} / P_{i,t-1} = \mu_0 + \mu_1 RET_{i,t} + \mu_2 D_{i,t} + \mu_3 D_{i,t} \times RET_{i,t} + \varepsilon_{i,t} \quad (3.21)$$

$$G\_Score_{i,t} = \mu_1 = \alpha_1 + \alpha_2 SIZE_{i,t} + \alpha_3 MB_{i,t} + \alpha_4 LEV_{i,t} \quad (3.22)$$

$$C\_Score_{i,t} = \mu_3 = \beta_1 + \beta_2 SIZE_{i,t} + \beta_3 MB_{i,t} + \beta_4 LEV_{i,t} \quad (3.23)$$

$$EPS_{i,t} / P_{i,t-1} = \mu_0 + \mu_2 D_{i,t} + (\alpha_1 + \alpha_2 SIZE_{i,t} + \alpha_3 MB_{i,t} + \alpha_4 LEV_{i,t}) \times RET_{i,t}$$
$$+ (\beta_1 + \beta_2 SIZE_{i,t} + \beta_3 MB_{i,t} + \beta_4 LEV_{i,t}) \times D_{i,t} \times RET_{i,t} + \varepsilon_{i,t} \quad (3.24)$$

$EPS_{i,t}$ denotes the earnings per share of company i in year t, $P_{i,t-1}$ denotes the stock price of company i at the end of year t 1, and $RET_{i,t}$ denotes the stock return of the company i in year t. D_i takes the value of 1 if $RET_{i,t} < 0$ and 0 otherwise. $SIZE_i$ denotes the size of company i, which is obtained from ln (total assets). LEV_i denotes the gearing ratio of company i, and MB_i denotes the ratio of bookings to market of company i. The *G_Score* and *C_Score* models are shown in Equations (3.22) and (3.23), respectively. μ_1 represents the speed of the company's response to good news and ($\mu_2 + \mu_3$) represents the speed of the company's response to bad news; thus, μ_3 reflects the incremental speed of the company's response to a bad report compared to its response to a good report, which reflects the level of accounting conservatism of the company. Equations (3.22) and (3.23) are then substituted into Equation (3.21) to obtain Equation (3.24) for regression to find the coefficients β_1, β_2, β_3, and β_4. Finally, the parameter values are substituted back into Equation (3.23) to find the company' annual *C_Score* value, and where the larger the value is, the more conservative the company's accounting is.

3.4.9 Nature of Different Property Rights

The development of China's capital market is closely related to the reform process of state-owned enterprises (SOEs). In the initial stage of the development of China's stock market, it is necessary to serve the reform of SOEs in the specific historical stage of

China's economic transformation. In the mid-1990s, the reform of SOEs in China entered a new historical stage, and how to use the stock market to solve the difficulties of SOEs at that time, especially the capital problem, was highly valued. For a long time after the formal establishment of China's stock market, different property rights of enterprises did not compete fairly in issuing shares, and SOEs enjoyed considerable priority. The purpose of the stock market was not only to optimize the allocation of resources, but also to serve the reform of SOEs. Under such a specific institutional background, the vast majority of listed companies in China during this period were restructured from SOEs. With the continuous progress of the transformation process, supporting all kinds of high-quality enterprises to use the capital market equally has become an inevitable requirement for the development of the capital market to enter a new stage. From the perspective of enterprises, on the one hand, the development of non-SOEs has become the driving force of economic growth in transition, but with the economic transformation, the market is becoming more and more perfect, and it is increasingly difficult for private enterprises to obtain development funds by relying on their own accumulation. The development of private enterprises increasingly needs the support of formal financing channels such as the capital market. The improvement in the policy environment has also provided strong support for all kinds of high-quality enterprises to use the capital market on an equal footing. For a long time, it has been difficult for non-SOEs to establish an "equal market dominant position", which is reflected in the fact that bank loans are mainly given to SOEs, and the issuance of shares is also a "priority for SOEs". In order to realize the transformation smoothly, non-SOEs need to be developed vigorously. Therefore, the national policy began to attach great importance to supporting the development of non-SOEs through the capital market, and clearly stipulated that the securities issuance and listing system should be improved, and non-SOEs should be treated on an equal footing with SOEs.

As the above analysis, influenced by historical, social and cultural reasons, enterprises in China can be divided into two types according to the nature of property rights: SOEs and non-SOEs. As the ultimate controllers of these two types of enterprises are different, there are great differences in their development goals, positioning and governance models. Many documents have proved that SOEs in China have more social responsibilities than non-SOEs, and SOEs have a natural political relationship with the government (Zhang et

al., 2022); therefore, this dissertation further divides the enterprises in the sample into SOEs and non-SOEs according to the nature of ownership. This is helpful to examine the influence of ESG ratings on information efficiency under different ownership characteristics. In this dissertation, SOEs are defined as 1; otherwise, they are defined as 0.

3.4.10 Impact of COVID-19

COVID-19 has had a serious impact on global economic development (Ding et al., 2021) and has negatively affected companies in most industries in China (Xue et al., 2021). COVID-19 has caused a huge impact on the volatility and liquidity of capital markets in all countries (Huang et al., 2020), significantly affecting the investment, financing, dividend policies, and disclosure behaviour of listed companies (Chen et al., 2022). COVID-19 is a prerequisite for testing a company's crisis scenario, especially the effects on the company's financial behaviour and capabilities to respond to the crisis. Faced with the adverse impact of COVID-19, it is worth discussing how ESG ratings will affect the information efficiency of the capital market. Thus, this dissertation discusses the influence of ESG ratings on the information efficiency of China's capital market in two different time ranges defined as after COVID-19 and the pre-COVID-19 period.

3.4.11 Control Variables

According to the prior literature on this subject, this dissertation selected different control variables for the empirical models.

From the perspective of northbound capital shareholding preferences (NCSP), the following control variables were selected. Firm size (Size): companies of different sizes will affect their attractiveness to northbound capital due to differences in market share, risk resilience and market attention. Firm age (Age): firm age equals the number of years since the company began operation. The older the company, the better its governance structure. Firms with large ages are better able to communicate their fundamental information to stakeholders. Operating income (Lnincome): operating income represents the growth of a business. The higher the operating income the better the performance of the company owned by the company and the more favourable it will be to investors. The proportion of shares outstanding (PSO): the proportion of shares outstanding is the proportion of the total share capital of a listed company that is outstanding. The greater

85

the proportion of a company's shares outstanding, the more the share price reflects the true value of the company. Stock return (Return): average stock return is the average weekly returns of firms over the year. There is no doubt that stock returns are one of the determinants of stock pricing. Tobin's Q: The higher a company's market value, the more it can attract investors' attention, and the better the company's ability to create wealth, which can reduce the company's internal financing constraints and financial risks. Moreover, companies with sufficient financial resources are preferred by institutional investors. Additionally, this dissertation also controls the industry effect (Industry) and the year effect (Year).

From the perspective of stock mispricing, this dissertation selected the following control variables. Firm size (Size): companies of different sizes will affect their attractiveness to northbound capital due to differences in market share, risk resilience and market attention. Firm age (Age): firm age equals the number of years since the company began operation. The older the company, the better its governance structure. Firms of large ages are better able to communicate their fundamental information to stakeholders. Leverage (Lev): Leverage is measured as total debt divided by total assets. The level of debt reflects the company's capital structure and risk level and is an important factor affecting the share price. Business growth (Growth): Business growth is measured by the growth rate of a company's operating income. A growing company has a stable and consistent growth rate in earnings. Independent Director Ratio (IDR): The ratio of independent directors measured by the number of independent directors to the total number of directors. Ownership concentration (OC): Ownership concentration is measured as the sum of the shareholdings of the three largest shareholders. Investor sentiment (IS): Investor sentiment is measured by the average daily turnover of tradable shares. Audit quality (Big4): measures audit quality using Big Four audit firms, which equals 1 if the company's annual report is audited by a Big Four audit firm, otherwise 0. In addition, this dissertation also controls for the industry effect (Industry) and the year effect (Year).

From the perspective of stock price crash risk, this dissertation selected the following control variables. Firm size (Size): companies of different sizes will affect their attractiveness to northbound capital due to differences in market share, risk resilience and market attention. Firm age (Age): firm age equals the number of years since the company began operation. The older the company, the better its governance structure. Firms with

large ages are better able to communicate their fundamental information to stakeholders. Leverage (Lev): Leverage is measured as total debt divided by total assets. It is an important factor affecting the share price as it reflects the company's capital structure and risk level. Market value to Book value (MB): The market value to book value is measured by the total market value at the end of the period divided by the book value of equity at the end of the period. Return on total assets (ROA): ROA is the ratio of current net profit to total assets at the end of the period. Operating cash flow (CFO): Operating cash flow is the ratio of net cash flow from operating activities to total assets at the end of the period. The largest shareholder ratio (First): the largest shareholder is equal to the shareholding ratio of the largest shareholder. In addition, this dissertation controls the industry effect and the year effect.

3.5 Hypotheses

3.5.1 ESG Ratings and Northbound Capital Shareholding Preference

Stakeholder theory clarifies the role and responsibility category of companies in society, and it also helps to explain the motivation and goal of companies to fulfil their social responsibilities. At the same time, individuals and groups that are affected in the process of realizing business objectives are regarded as stakeholders, such as government departments, local communities, environmentalists and other entities in the category of stakeholders. The idea of enterprises assuming social responsibilities and fulfilling social obligations that go beyond profit maximization embodies the comprehensiveness and inclusiveness of stakeholder theory, and is consistent with the concept of meeting the economic requirements of shareholders and enterprise development and taking into account the needs of other stakeholders. As stakeholders are the main body of social control, companies can maintain a positive relationship with stakeholders by fulfilling their social responsibilities, thereby increasing the value of the company (Bekaert and Harvey, 2000). In addition, investors, especially some institutional investors, are more willing to invest in companies with excellent social responsibility performance.

Legitimacy mechanism is also a reason to encourage enterprises to fulfil their social responsibilities, which is very important to ensure the long-term prosperity of enterprises. Legitimacy not only refers to the role of legal system, but also includes the influence of institutional environment such as cultural system, concept system and social expectation

87

on the organizational behaviour of enterprises. The legitimacy mechanism not only restricts the behaviour of enterprises, but also helps enterprises to gain social recognition, enhance social status and promote resource exchange between enterprises and stakeholders. This also explains, in part, why more and more companies are willing to assume social responsibility and fulfil social obligations. By taking the initiative to undertake social responsibilities and fulfil social obligations, enterprises can gain government support and public recognition, thus maintaining a sustainable competitive advantage and attracting more investors (Lin et al., 2014). At the same time, when enterprises fulfil their environmental protection and social responsibilities, they can form positive moral capital among stakeholders, enhance their sense of identity with the enterprise, provide protection for the enterprise in times of crisis, and reduce operational risks (Adamska and Dabrowski, 2016).

According to the signal theory, enterprises can send positive signals to the market by fulfilling their social responsibilities, which can enhance their competitiveness. Therefore, from the perspective of their own development, enterprises are motivated to send signals to the market by actively fulfilling their social responsibilities, which is conducive to improving the reputation and influence of enterprises (Cheng et al., 2014), further gaining the trust of consumers and investors, establishing long-term cooperative relationships, and improving financial performance (Kim and Li, 2021), thus laying the foundation for long-term sustainable development of enterprises (Matallín-Sáez et al., 2004). For example, although ERKE's income in the past was lower than that of many other sports brands, the company directly donated 50 million yuan in resources when a flood occurred in Henan. This behaviour sparked a heated discussion among netizen, who began to buy many ERKE's products, resulting in its brand value ranking second in the industry. Through ESG investment, enterprises have maintained good relations with various stakeholders, established mutual trust and stable cooperation with partners, created a more honest and responsible corporate image, conveyed to the outside world that enterprises are in a state of long-term sustainable development, accumulated a good reputation and brand effect, increased the government's trust in enterprises, reduced unnecessary government supervision and intervention in enterprises, attracted potential partners and consumers, and enabled enterprises to enter a virtuous cycle of development

88

mode and create a competitive advantage in the market. Based on the above analysis, this dissertation proposes H1a.

Hypothesis 1a. ESG rating is positively correlated with NCSP, which means that the higher the ESG rating is, the more significant the NCSP will be.

Capital markets have serious information asymmetry between creditors and debtors (Leary and Roberts, 2010). In accordance with signal theory, when there is serious information asymmetry in the market, the positive signals from the debtor to the outside world can increase creditors' confidence in the company's development prospects. Excellent ESG performance can convey to the outside world that the company is willing to pursue stable operations and long-term development, gain the trust and recognition of the market, and help increase the value of the company (Barone et al., 2014). At the same time, companies with strong ESG performance are able to reduce information asymmetry and attract institutional investors concerned about asset security and stable working capital, thereby increasing the ownership ratio of institutional investors. As representatives of institutional investors, NCSP have a strong interest in social capital and may play the role of a market flag for other institutional investors. The behaviour of NCSP sends a positive signal to the outside world, builds the company's reputation, and enhances the capital market's confidence in companies. This can not only improve the risk resilience of firms, but also have a positive impact on firm value. Therefore, this dissertation proposes hypothesis 1b.

Hypothesis 1b. Information asymmetry plays a role of mediation between ESG ratings and NCSP.

In the context of the low carbon development of China, enterprises are facing stricter and stricter environmental regulations. In order to meet the requirements of environmental legality and green transformation, enterprises tend to adopt green innovation strategy (Berrone et al., 2013). In order to meet the expectations and demands of different stakeholders, enterprises will actively undertake environmental responsibility through green innovation and improve the performance of environmental responsibility, so as to achieve a win-win situation for environmental protection and economic performance of enterprises. Provinces with high TAI have created a good environment for green innovation of enterprises, which can alleviate information asymmetry and improve

89

NCSP. Enterprises with good social responsibility can strengthen the relationship with stakeholders, help them to obtain funds and technical support for green innovation, gain competitive advantage and realize sustainable development of enterprises (Schuler and Cording, 2006). Therefore, the provinces with high TAI have created the advantage of obtaining innovative resources for enterprises' green innovation, and enterprises can improve their performance by improving their technological innovation capabilities. Additionally, good corporate governance contributes to enterprise innovation. The more effective the incentive and restraint mechanism formulated by an enterprise with good corporate governance is, it will help to reduce the principal-agent conflict, reduce the information asymmetry, pay attention to enterprise innovation, increase R&D investment, and realize the sustainable development of enterprises (Broadstock et al., 2021). Thus, I propose Hypothesis 1c.

Hypothesis 1c. TAI moderates the strength of the mediated relationship between ESG ratings to NCSP via information asymmetry, such that relation is stronger for regions with high-as opposed to low-levels of TAI.

Based on the "strategy-capabilities" matching perspective, this dissertation holds that the implementation of ESG strategy requires enterprises to take learning and absorption abilities, transformation and reconstruction abilities and coordination and integration abilities as the support to help enterprises improve operational efficiency. Dynamic capabilities are embedded in the management process of an organization, and the effect of ESG strategy implementation is affected by dynamic capabilities. Good ESG performance also depends on the support of enterprise resources and capabilities. Only when ESG strategy adapts to the enterprise's abilities or resources can it play the best role. Therefore, in the process of improving ESG performance, enterprises need strong dynamic abilities to match it. If the enterprise's dynamic abilities are not strong, then the enterprise will lose the vitality of learning and the efficiency of organizational learning will be affected.

Enterprises with quick learning and absorption abilities can help them adapt to and create their own advantages, dynamically respond to the uncertain factors and threats of turbulent environment, and develop new technologies and new products, so as to improve the shareholding preference of northbound capital. When an enterprise expands across

90

fields, it needs to have the ability to integrate and allocate resources to match it. Otherwise, it will make it difficult for the enterprise to coordinate the ESG balance, which is not conducive to the research and development of new technologies and new products. Due to the diversification of enterprises, enterprises are required to have the ability of integration and coordination to help them improve the efficiency of internal ESG, thus helping them shorten the research and development time of new technologies and new products, improve the internal innovation efficiency of enterprises, and thus improve northbound capital shareholding preferences.

Therefore, enterprises constantly improve the learning and absorption abilities, integration and coordination abilities of the organization. On the one hand, they match the external environment of enterprises and dynamically respond to environmental threats and uncertain factors; On the other hand, it can dynamically match the needs of internal integration, allocation and coordination, effectively solve the problem of balance between breadth and depth, and lay the foundation for the improvement of performance. Thus, this dissertation proposes Hypothesis 1d.

Hypothesis 1d. Dynamic capabilities moderate the strength of the mediated relationship between ESG ratings to NCSP via information asymmetry, such that relation is stronger for companies with high-as opposed to low-levels of dynamic capabilities. And among these dynamic capabilities, learning absorption abilities and coordination and integration abilities have played a stronger role.

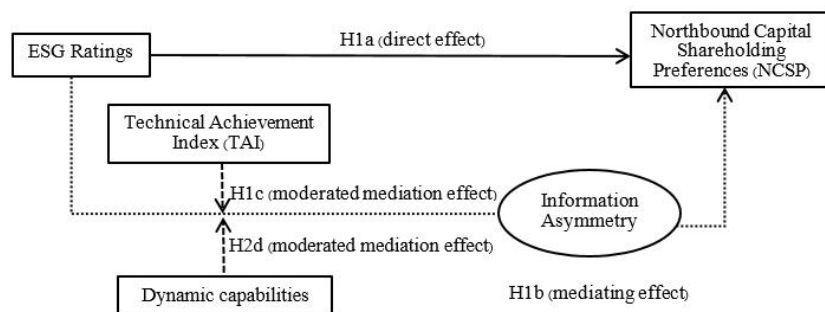The four hypotheses for ESG ratings and NCSP are summarized in Figure 3.4.

Figure 3.4 Conceptual framework for ESG ratings and northbound capital shareholding preferences.

91

3.5.2 ESG Ratings and Stock Mispricing

ESG has an impact on the system risk of enterprises, and this impact is more significant in enterprises with higher product differentiation. Good ESG performance contributes to the low risk of companies (Albuquerque et al., 2019). Enterprises with higher ESG performance are more flexible, and enterprises with higher ESG levels perform better in the 2008 financial crisis, which shows that ESG performance can improve the anti-risk ability of enterprises (Lins et al., 2017). Higher ESG performance have wider investors and will face lower lawsuit risks and eventually leading to lower capital costs (Hong and Kacperczyk, 2009). The impact of ESG performance on the credit rating of corporate bonds depends on the country where the enterprise is located and the importance it attaches to ESG (Stellner et al., 2015). Companies with poor performance in the environment generally have lower credit ratings and lower yields (Seltzer et al., 2020). ESG can reduce the specific legal risks of the company and have a higher market valuation (Hong and Liskovich, 2015). In addition, ESG rating increases the specific risks of enterprises. When enterprises improve their ESG rating, they will lose their flexibility, which will lead to a decrease in the benefits to stakeholders. Previous studies find a significant association between ESG and the stock market. When caught in ESG negative events, firms experience a decline in the capital market (Capelle-Blancard and Petit, 2019). ESG performance has value relevance to banks (Miralles-Quirós et al., 2019) and companies performance (Torre et al., 2020). ESG rating reduces the risk of the stock price collapse, and financing constraints play a regulatory role (Bae et al., 2021). Investors are paying more holding preference to higher ESG performance (Budsaratragoon and Jitmaneeroj, 2021), regard ESG as a 'quality' factor (Mohanty et al., 2021), and obtain higher future excess returns (Zhang et al., 2021). This dissertation deduces Hypothesis 2a.

Hypothesis 2a. ESG rating is negatively related to stock mispricing, which means that the better the ESG rating is, the lower the level of stock mispricing will be.

According to information asymmetry theory, the information asymmetry between companies and investors is not conducive to better decision-making (Cho et al., 2013). From the perspective of information effect, good ESG performance shows that the enterprises are responsible to the society, and then the corporate governance level is well.

92

Based on the sustainable development, enterprises with good ESG performance can achieve better communication with investors, effectively transfer information, and then improve the quality of information disclosure (Lin et al., 2016). Better ESG rating firms focus more on environmental and social responsibility, which in turn improve corporate disclosure. ESG disclosure can usefully ease the information asymmetry to investors (Siew et al., 2016), which improve the information efficiency of capital markets, and thus reduce stock mispricing.

ESG ratings contain incremental information that investors can not get from the public domain. However, because of the prevalence of information asymmetry problems and the absolute information superiority of companies (Cho et al., 2013), managers have both the motivation and the ability to engage in opportunistic behaviour such as manipulation of information disclosure, as a result, the stock mispricing can reflect the fundamental information of the enterprises well, which weakens the resource allocation function of the capital market. The rating information not only has the important reference value to the bond investor, but also has the guiding function to the stock investor's decision-making idea (Boot et al., 2006). ESG ratings reduce the cost and time for investors to analyze and process information, and reflect the real value of the company in a timelier manner. It can be seen that companies with good ESG ratings have significantly more public and private information in the financial market than companies with bad ESG ratings. The information asymmetry is higher, which help alleviate stock mispricing caused by information asymmetry. Firms having good ESG ratings focus on long-term returns in their decision-making process and mitigate potential systemic risks (Bae et al., 2021). The lower level of information asymmetry helps investors to mitigate the stock mispricing. Thus, I propose hypothesis 2b.

Hypothesis 2b. Information asymmetry plays a role of mediation between ESG ratings and stock mispricing.

ESG ratings improve the internal and external information environment of companies, and improve stock mispricing by reducing information asymmetry. Thus, this dissertation expects that the impact of ESG ratings on stock mispricing may vary across technical capabilities and dynamic capabilities. TAI is a comprehensive index of the technological performance of a country or region. It consists of four parts, including technological

93

innovation, diffusion of old technology, diffusion of new technology and human resources. TAI is known for its simplicity and directness in the assessment of the technical capabilities (Nasir et al., 2011). In the provinces with high TAI, the resources of innovation are relatively abundant, and the access to information is faster. The incremental information contained in ESG ratings can be more effectively communicated to the market when the regional TAI of the enterprise is high. External investors are better able to identify, filter and judge the financial and non-financial information of a company's operations, effectively reducing information asymmetry. This is helpful for investors to deeply understand the strategic decision-making of enterprises and make investment judgments that are beneficial to the sustainable development of enterprises. In areas with a high TAI, it is more likely to reduce the gap between the true value of a stock and its price, thus reducing the level of stock mispricing. This suggests that when the provincial TAI is higher, the ESG ratings alleviate information asymmetry to a greater degree, which in turn is more likely to reduce stock mispricing. Accordingly, the following hypothesis advanced.

Hypothesis 2c. TAI moderates the strength of the mediated relationship between ESG ratings to stock mispricing via information asymmetry, such that relation is stronger for regions with high-as opposed to low-levels of TAI.

Teece (2007) defined dynamic capabilities as "the abilities of an enterprise to absorb, reform and restructure, coordinate and integrate internal and external resources through learning". Dynamic capabilities are helpful for enterprises to realize strategic update, and to quickly integrate and allocate resources to obtain sustainable competitive advantage. Enterprises with strong dynamic abilities can quickly integrate and allocate external resources to cope with the changes of the external environment when facing the unknown pressure. Dynamic abilities are the basic abilities of an enterprise, and the abilities of learning and absorbing and the abilities of change and reconstruction will strengthen the adaptability to policies and environment. The Comprehensive Reform Plan for Promoting Ecological Civilization (CRPPEC) published in China in 2015 required listed companies to release environmental protection information compulsorily. Under the general environment of promoting new development concepts and advocating that enterprises should focus on social responsibility in the process of development, the adaptability of enterprises will improve the level of independent disclosure and reduce information

94

asymmetry. At the same time, the abilities of coordination and integration will strengthen the contact of various stakeholders, improve information transparency and reduce information asymmetry, which will be more conducive to reducing stock mispricing of listed companies. Thus, I propose hypothesis 2d.

Hypothesis 2d. Dynamic capabilities moderate the strength of the mediated relationship between ESG ratings to stock mispricing via information asymmetry, such that relation is stronger for companies with high-as opposed to low-levels of dynamic capabilities. And among these dynamic capabilities, learning absorption abilities and coordination and integration abilities have played a stronger role.

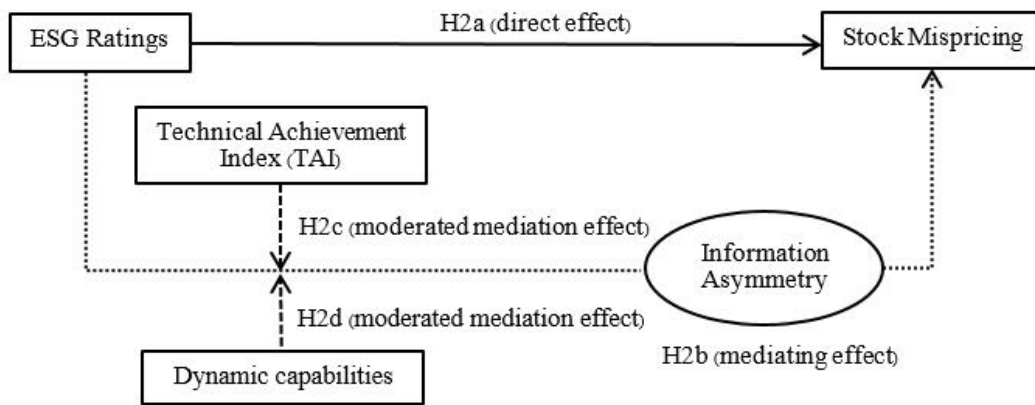The four hypotheses for ESG ratings and stock mispricing are summarized in Figure 3.5.

Figure 3.5 Conceptual framework for ESG ratings and stock mispricing.

3.5.3 ESG Ratings and Stock Price Crash Risk

The stock price crash risk is caused by both endogenous and exogenous factors. However, the endogenous factors have paid less attention to the impact of information transparency and guarantee function, and the exogenous factors lack consideration of investor sentiment in the capital market (Liu, 2016; Li et al., 2017). Therefore, this dissertation explores the mechanisms from the perspective of information transparency, investor sentiment and guarantee role. The higher the ESG ratings, the more it helps to reduce information asymmetry, which is referred to as the "information effect". Additionally, ESG ratings help companies establish good communication channels with investors, which in turn affects investor attention and sentiment. This dissertation refers to the "sentiment effect". According to the "information effect", the stock crash risk is caused

95

by insider manipulation of information about corporate attributes (Jin and Myers, 2006), which includes both hiding negative information and exaggerating positive information (Courtis, 1998).

Based on the path analysis of the "information effect", ESG ratings transmit more information to external investors, which helps investors understand the business operation and sustainable development, and thus can significantly reduce the stock price crash risk (Kim and Zhang, 2016). Good ESG performance can release positive signals, which will help investors make correct investment decisions, and thus help to reduce the possibility of stock price crashes. Based on the path analysis of "emotional effect", ESG ratings affect investors' attention and mood, and then affect the risk of a stock price crash. Management may be more inclined to strengthen investor relations through ESG ratings, so as to reduce the impact of adverse events on investor sentiment. The higher the ESG ratings, the higher the information transparency, and the more favorable it is for investors to make scientific investment decisions (Bourveau and Schoenfeld, 2017). Higher ESG ratings enable investors to obtain more information about enterprises and make rational investment decisions. This can reduce the heterogeneous beliefs among investors, calm investor sentiment, and thus inhibit the stock price crash risk (Ben et al., 2020).

In addition, when ESG ratings play a "guarantee" role, it has a certain inhibiting effect on the the stock price crash of listed companies. ESG ratings show investors the sustainable development capability of the company. If the ESG rating is good, it will bring moral capital and reputation capital to the company, create a positive image to the outside world, and play a "guarantee role" of the ESG rating. According to principal-agent theory, managers are more likely to hide negative news in their own interest. Once the negative news breaks, the company's image will plummet, resulting in a sharp drop in stock price and even a stock market crash. The moral and reputation capital brought by a good ESG rating can reduce the impact of negative news on investors, and a high ESG rating represents good financial performance. Investors increase their tolerance and trust in the company based on both its corporate image and financial performance, attribute the occurrence of negative events to the "unintentional" behaviour of managers, and give company a buffer time to adjust their own behaviour patterns, thus avoiding the situation of a stock price drop in a short period of time and reducing the risk of stock price crash. Thus, this dissertation proposes H3a.

96

Hypothesis 3a. ESG rating is negatively related to stock price crash risk, which means that the better the ESG rating is, the lower the level of stock price crash risk will be.

According to the relevant theoretical research on the causes of stock price crash risk, the stock price crash is mainly caused by information asymmetry. According to the signaling theory, due to the information asymmetry in the capital market, with the increase of market competition, companies have the motivation to show their own business and financial situation to the market, and typically take a number of actions to communicate relevant information to the market in order to differentiate themselves from other companies. After receiving these signals, the market will respond in time. ESG ratings represent the disclosure quality of enterprise information. The quality of information disclosure, as a standard for companies to show a good internal control environment, is a signal that benefits enterprises. Therefore, a higher ESG ratings can effectively appease investors' emotions, thus enhancing the trust of external media and investors in the relevant financial and business development information voluntarily disclosed by the company. This is conducive to weakening the uncertainty faced by the company in making decisions, alleviating the predicament of excessive stock price bubble, and making the stock price reasonably reflect the actual operating conditions of the company.

Chen et al. (2001) analyzed that the information owned by internal managers and external investors is not equal in the market. The management may conceal the bad news of the enterprise out of self-interest, and the unequal information is the main factor leading to stock price collapse risk. According to the stakeholder theory, companies with higher ESG ratings tend to have more transparent information settings, and the less bad news accumulates, the lower the risk of a stock price crash in the future. From an institutional perspective, ESG ratings may encourage managers to conceal bad news and reduce the authenticity of information disclosure, thereby creating a greater stock price crash risk. Asymmetric information will cause investors to misjudge the value of listed companies because they have insufficient information. In the future, when this information breaks out, it is likely to cause the stock price to fall rapidly. As a comprehensive rating index, ESG ratings can fully reflect the company's information disclosure ability. Therefore, ESG ratings can reduce information asymmetry, and thus suppressing the risk of stock price crash. Then, this dissertation proposes H3b.

97

Hypothesis 3b. Information asymmetry plays a role of mediation between ESG ratings and stock price crash risk.

Companies with good ESG performance can promote knowledge transformation and improve the level of technological innovation by strengthening financial support. Technical innovation activities are active in provinces with high technical achievement, and sustained financial support can realize the sustainable development of technical innovation. The better ESG performance, the easier it is for companies to gain the trust and recognition of external financial providers, which can enhance borrowing capacity to a certain extent. It is conducive to increasing financial support and financial guarantee for the process of technical innovation. Technical innovation is widely regarded as a knowledge-intensive activity, which has higher requirements for the regional foundation of technical innovation achievements (Cassiman and Veugelers, 2006). Companies with better ESG ratings are more likely to establish broader and deeper relationships with their stakeholders. The knowledge network formed by regions with high technical achievements is stronger, which can promote the integration and transformation of internal knowledge. At the same time, it can also promote the inflow of external knowledge. Areas with high technical achievements can create a good corporate culture and working atmosphere, which will motivate employees' willingness and behavior to innovate. Additionally, compared with companies with insufficient technical innovation, companies in areas with high technical achievements often bring excess returns, which will attract investors' attention (Cohen et al., 2013). The high degree of investors' attention means that they will invest more time to interpret corporate and market information. This will help to reduce the risk of stock price crash, information disclosure and practice of technical innovation achievements, and make stakeholders get good expectations, which will enhance their confidence in the good development of companies (Aghion et al., 2013). The enhanced confidence of stakeholders will help to alleviate the impact of future uncertain events or negative events, and then reduce the stock price crash risk caused by market fluctuations or investor panic. Thus, this dissertation proposes H3c.

98

Hypothesis 3c. TAI moderates the strength of the mediated relationship between ESG ratings to stock price crash risk via information asymmetry, such that relation is stronger for regions with high-as opposed to low-levels of TAI.

Whether ESG ratings can mitigate the risk of a stock price crash depends not only on reducing information asymmetries, but also on the strength of a company's dynamic capabilities. It is the capital market's assessment of a company's fundamentals that creates the risk of a stock price crash. From the perspective of resources, companies need a lot of resources such as capital, talents and technology to maintain its healthy fundamentals, and the degree of enterprise's response to ESG ratings depend on its resources and capabilities. Enterprises with strong dynamic abilities can adjust and change the existing mode, operation system and resource allocation mode in time, and then realize fundamental optimization in optimizing production process and changing business model. However, enterprises with low dynamic abilities limit managers' decision-making choices because of their lack of resources and capabilities, which makes them unable to maintain good corporate fundamentals, leading to the occurrence of "bad news", thus causing the stock price crash risk. Therefore, the companies can continuously improve its dynamic capabilities and improve its own resources, and can positively adjust the relationship between ESG ratings and the stock price crash risk. Thus, this dissertation proposes H3d.

Hypothesis 3d. Dynamic capabilities moderate the strength of the mediated relationship between ESG ratings to stock price crash risk via information asymmetry, such that relation is stronger for companies with high-as opposed to low-levels of dynamic capabilities. And among these dynamic capabilities, learning absorption abilities and coordination and integration abilities have played a stronger role.

The four hypotheses for ESG ratings and stock price crash risk are summarized in Figure 3.6
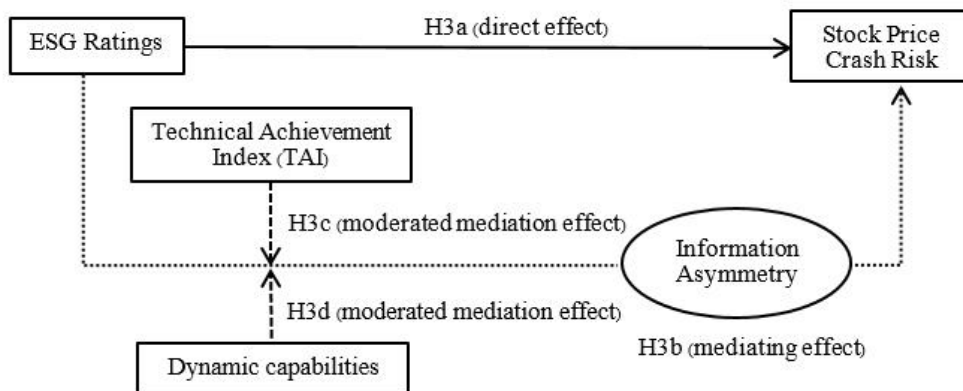
99

Figure 3.6 Conceptual framework for ESG ratings and stock price crash risk

3.6 Models for Empirical Analysis

3.6.1 Models for Hypothesis 1a-1d

One aim of this dissertation is to examine the relationship between ESG ratings and NCSP for Chinese listed companies. Using the mediation effect test procedures proposed by Wen et al. (2004), the following models are established.

As NCSP is a binary dependent variable, this dissertation uses a probit model to explore the impact of ESG ratings on the likelihood of NCSP. A probit model can be used to model the relationship between one or more numerical or classification predictor variables and classification outcomes. For the probit model, the following relationship is assumed to test H1a (the impact of ESG ratings on northbound capital shareholding preferences for Chinese listed companies):

$$\Pr(NCSP = 1 \mid X_{i,t}) = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(1)} \quad (3.25)$$

$$\lambda Controls_{i,t} = \lambda_1 Size_{i,t} + \lambda_2 Age_{i,t} + \lambda_3 LnIncome_{i,t} + \lambda_4 Return_{i,t} + \lambda_5 Tobinq_{i,t} + \lambda_6 CSR_{i,t}$$

where NCSP denotes northbound capital shareholding preferences; ESG denotes ESG ratings measured by China Huazheng ESG rating database; Controls denotes control variables; Year denotes the year effect; Industry denotes the industry effect. ε_it is the residual.

100

To test H1b (information asymmetry plays a role of mediation effect between ESG ratings and NCSP for Chinese listed companies), this dissertation uses the following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(2)} \quad (3.26)$$

$$\Pr(NCSP = 1 \mid X_{i,t}) = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 AbsDA_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(3)} \quad (3.27)$$

where AbsDA denotes information asymmetry.

To test H1c (the moderating roles of TAI) and H1d (the moderating roles of dynamic capabilities), this dissertation uses following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 TAI_{i,t} + \beta_3 ESG_{i,t} \times TAI_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(4)} \quad (3.28)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 DC_{i,t} + \beta_3 ESG_{i,t} \times DC_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(5)} \quad (3.29)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 EDU_{i,t} + \beta_3 ESG_{i,t} \times EDU_{i,t} + \beta_4 INTA_{i,t} + \beta_5 ESG_{i,t} \times INTA_{i,t} + \beta_6 TAT_{i,t} + \beta_7 ESG_{i,t} \times TAT_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \sum Province + \varepsilon_{i,t}^{(6)} \quad (3.30)$$

where TAI denotes technical achievement index; DC denotes dynamic capabilities; EDU denotes learning and absorption capabilities; INTA denotes transformation and reconstruction capabilities; TAT denotes coordination and integration capabilities.

3.6.2 Models for Hypothesis 2a-2d

To examine H2a (the impact of ESG ratings on stock mispricing), this dissertation uses the following regression model:

$$Misp_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(1)} \quad (3.31)$$

$$\lambda Controls_{i,t} = \lambda_1 Size_{i,t} + \lambda_2 Age_{i,t} + \lambda_3 Lev_{i,t} + \lambda_4 Growth_{i,t} + \lambda_5 IDR_{i,t} + \lambda_6 OC_{i,t} + \lambda_7 IS_{i,t} + \lambda_8 Big4_{i,t}$$

where Misp denotes stock mispricing; ESG denotes ESG ratings measured by China Huazheng ESG rating database; Controls denotes control variables; Year denotes the year effect; Industry denotes the industry effect. ε_it is the residual.

To examine H2b (information asymmetry plays a role of mediation effect between ESG ratings and stock mispricing for Chinese listed companies), this dissertation uses the following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(2)} \quad (3.32)$$

$$Misp_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 AbsDA_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(3)} \quad (3.33)$$

where absDA denotes information asymmetry.

To examine H2c (the moderating roles of TAI) and H2d (the moderating roles of dynamic capabilities), this dissertation uses the following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 TAI_{i,t} + \beta_3 ESG_{i,t} \times TAI_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(4)} \quad (3.34)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 DC_{i,t} + \beta_3 ESG_{i,t} \times DC_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(5)} \quad (3.35)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 EDU_{i,t} + \beta_3 ESG_{i,t} \times EDU_{i,t} + \beta_4 INTA_{i,t} + \beta_5 ESG_{i,t} \times INTA_{i,t} + \beta_6 TAT_{i,t} + \beta_7 ESG_{i,t} \times TAT_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \sum Province + \varepsilon_{i,t}^{(6)} \quad (3.36)$$

where DC denotes dynamic capabilities; EDU denotes Learning and absorption capabilities; INTA denotes transformation and reconstruction capacities; TAT denotes coordination and integration capacities.

3.6.3 Models for Hypothesis 3a-3d

To examine H3a (the impact of ESG ratings on stock price crash risk for Chinese listed companies), this dissertation uses the following regression model:

$$F\_NCSKEW_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(1)} \quad (3.37)$$

$$\lambda Controls_{i,t} = \lambda_1 Size_{i,t} + \lambda_2 Age_{i,t} + \lambda_3 Lev_{i,t} + \lambda_4 MB_{i,t} + \lambda_5 ROA_{i,t} + \lambda_6 CFO_{i,t} + \lambda_7 CAPX_{i,t}$$
$$+ \lambda_8 First_{i,t} + \lambda_9 Manager_{i,t}$$

where F_NCSKEW denotes stock price crash risk; ESG denotes ESG ratings measured by China Huazheng ESG rating database; Controls denotes control variables; Year denotes the year effect; Industry denotes the industry effect. ε_it is the residual.

To examine H3b (information asymmetry plays a role of mediation effect between ESG ratings and stock price crash risk for Chinese listed companies), this dissertation uses the following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(2)} \quad (3.38)$$

$$F\_NCSKEW_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 AbsDA_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry + \varepsilon_{i,t}^{(3)} \quad (3.39)$$

To examine H3c (the moderating roles of TAI) and H3d (the moderating roles of dynamic capabilities), this dissertation uses the following regression models:

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 TAI_{i,t} + \beta_3 ESG_{i,t} \times TAI_{i,t} + \lambda Controls_{i,t} + \sum Year +$$
$$\sum Industry + \varepsilon_{i,t}^{(4)} \quad (3.40)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 DC_{i,t} + \beta_3 ESG_{i,t} \times DC_{i,t} + \lambda Controls_{i,t} + \sum Year$$
$$+ \sum Industry + \varepsilon_{i,t}^{(5)} \quad (3.41)$$

$$AbsDA_{i,t} = \beta_0 + \beta_1 ESG_{i,t} + \beta_2 EDU_{i,t} + \beta_3 ESG_{i,t} \times EDU_{i,t} + \beta_4 INTA_{i,t} + \beta_5 ESG_{i,t} \times$$
$$INTA_{i,t} + \beta_6 TAT_{i,t} + \beta_7 ESG_{i,t} \times TAT_{i,t} + \lambda Controls_{i,t} + \sum Year + \sum Industry$$
$$+ \sum Province + \varepsilon_{i,t}^{(6)} \quad (3.42)$$

where DC denotes dynamic capabilities; EDU denotes Learning and absorption capabilities; INTA denotes transformation and reconstruction capacities; TAT denotes coordination and integration capacities.

3.7 Summary

In this chapter, this dissertation stated the research design. This chapter described the quantitative methodology for empirical analysis, the EWM for the TAI and the MBF method for robustness test. This chapter also explained the method used to collect the

data and the variables to be used in the dissertation. Based on the research literature, the definition of the variables was explained and their selection was justified. And then this chapter formulated the hypotheses of this dissertation and developed empirical models. This chapter provided the basis for the results of the data analysis of the dissertation that are presented in chapter 4.

104

CHAPTER 4

RESULTS

4.1 Introduction

The purpose of this dissertation was to investigate the relationship between ESG ratings and the information efficiency of the capital market for listed companies in China. This quantitative study aimed to improve understanding of this relationship between companies' sustainable development capability and Chinese capital market. This chapter examined whether ESG ratings impact information efficiency, what's the mechanism by which ESG ratings explain the information efficiency, and what factors affect the information transmission effect of ESG ratings in Chinese listed companies. This dissertation further explored the above questions from the three perspectives about information efficiency as NCSP, stock mispricing, and stock price crash risk. The intend of this dissertation was to inform ESG researchers and managers of listed companies in China to pay attention to the impact of ESG ratings on information efficiency of capital market and practice ESG concepts.

For this dissertation, there were three research questions. The first Question focused on the relationship between ESG ratings and NCSP, what mechanism played on this relation, and heterogeneity analysis based on internal environment and external environment. Question 2 involved the connection from ESG ratings to stock mispricing, the mechanism analysis played on this relation, and heterogeneity analysis from the perspective of accounting conservatism, the nature of different property rights. Question 3 were addressed via stock price crash risk which was a proxy variable of information efficiency for Chinese capital market. Each research question required related hypothesis which were tested statistically. This dissertation employed descriptive statistics, baseline regression, robustness tests, mediation effect analysis, and moderated mediation test to empirically the impact of ESG ratings on information efficiency for Chinese listed companies. The heterogeneity analysis included internal environment (including accounting conservatism and the nature of different property rights) and external environment (including COVID-19) played on the relation between ESG ratings and information efficiency in capital market. The results of these statistical analyses were presented in this chapter.

4.2 ESG Ratings and Northbound Capital Shareholding Preference

4.2.1 Descriptive Statistics

Table (4.1) presents the descriptive statistics for all variables utilized in the ESG ratings and NCSP models. The average NCSP was 0.1539, indicating that 15.4% of the sampled companies benefited from Northbound capital investments. ESG ratings ranged from one (lowest) to nine (highest), revealing notable differences in ESG performance among the sample companies. The mean ESG rating was 6.5227, indicating good ESG performance among Chinese listed companies, albeit with significant variations among different firms. It is noteworthy that some companies pay less attention to fulfilling ESG responsibilities. The standard deviation (SD) of the ESG rating was 1.1816, suggesting substantial variations in ESG ratings among the sampled listed companies. The minimum, maximum, and mean of information asymmetry (AbsDA) were 0.0006, 0.2793, and 0.0560 respectively, which indicated the degree of information asymmetry among enterprises was quite different, and some enterprises had a high degree of information asymmetry. Technical achievement index (TAI) of the best province was 0.9865, the worst was 0.0377, and the mean was 0.3296, which meant China's TAI's unequal and inadequate development among provinces. Dynamic capabilities (DC) were ranged from 0.0589 to 0.5389, that meant different enterprises faced a high degree lag. Some enterprises had a bad dynamic capability. The mean accounting conservatism score (C_Score) for the sample companies was negative, indicating the need for improvement in their accounting conservatism practices. Regarding the control variables, the mean firm size (Size) was approximately 22.3323, while the mean firm age (Age) was around 11.4259. The stock returns ratio (Return) for the top companies was 1.8857, while the worst-performing companies had a ratio of -0.7115. Other control variables were in a reasonable range and consistent with existing research findings.

Table 4.1 Descriptive statistics for ESG ratings and NCSP.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	max
NCSP	23,975	0.1539	0.3609	0.0000	1.0000
ESG	23,975	6.5227	1.1816	1.0000	9.0000
AbsDA	23,975	0.0560	0.0562	0.0006	0.2793
TAI	23,975	0.3296	0.2433	0.0377	0.9865
DC	23,975	0.2127	0.0940	0.0589	0.5389

106

Table 4.1 (continued)

EDU	23,975	0.2811	0.2080	0.0080	0.8875
INTA	23,975	0.0475	0.0521	0.0000	0.3299
TAT	23,975	0.6094	0.4166	0.0693	2.4941
COVID_19	23,975	0.2374	0.4255	0.0000	1.0000
State	23,975	0.4036	0.4906	0.0000	1.0000
C_Score	23,975	-0.1828	0.1220	-0.5876	0.0240
Size	23,975	22.3323	1.2939	19.6807	26.2497
Age	23,975	11.4259	7.1671	2.0000	31.0000
LnIncome	23,975	21.6294	1.4502	18.2354	25.6684
Return	23,975	0.0519	0.4719	-0.7115	1.8857
Tobinq	23,975	4.1772	3.4406	1.2030	27.2538
CSR	23,975	0.8061	0.2226	0.1807	1.0000

Note: Table (4.1) shows the results of the descriptive statistics for the variables for ESG ratings and NCSP.

4.2.2 Baseline Regression

Table (4.2) presents the baseline regression results for Equation (3.25) investigating the impact of ESG ratings on NCSP. Column (1) only includes ESG ratings and NCSP, while column (2) adds control variables, and column (3) further controls for year and industry effects. As demonstrated in column (1), the coefficient of ESG ratings is significantly positive at the 1% level (coefficient = 0.2464, t-value = 22.47), indicating that corporate ESG ratings positively affect NCSP. After introducing control variables in column (2), the coefficient of ESG ratings remains significantly positive at the 1% level (coefficient = 0.0281, t-value = 2.47). Furthermore, controlling for year and industry effects in column (3), the coefficient of ESG ratings is still significantly positive at the 1% level (coefficient = 0.1276, t-value = 9.72). These positive and significant coefficients support H1a. Regarding economic significance, the results suggest that a one-level increase in ESG ratings can result in a 12.8% increase in NCSP, indicating that higher ESG ratings correspond to higher NCSP.

Table 4.2 Regression results of ESG ratings on NCSP.

VARIABLES	(1)	(2)	(3)
	NCSP	NCSP	NCSP
ESG	0.2464***	0.0281**	0.1276***
	(22.47)	(2.47)	(9.72)
Age		-0.0041	-0.0575***
		(-0.32)	(-4.01)
LnIncome		0.2341***	0.2561***
		(10.68)	(8.26)

107

Table 4.2 (continued)

VARIABLES	(1)	(2)	(3)
Return		0.1592***	0.1159***
	NCSP	NCSP	NCSP
		(15.19)	(8.26)
Tobinq		0.0257**	0.1232***
		(2.11)	(9.11)
CSR		0.0591***	0.0077
		(4.49)	(0.48)
Constant	-1.0578***	-1.2854***	-0.6456***
	(-102.24)	(-103.93)	(-5.16)
Controls	NO	YES	YES
Year	NO	NO	YES
Industry	NO	NO	YES
Observations	23,975	23,975	19,326
pseudo R-squared	0.031	0.184	0.315

Note: ***, and ** indicate 1%, and 5% significance levels, respectively.

4.2.3 Robustness Tests

4.2.3.1 Minimum Bayes Factor

MBF has the advantage that they do not depend on the prior probability. The proof of the MBF as function of the p-Value is given by Held and Ott (2016). According to Held and Ott (2018), this dissertation used the MBF to conduct robustness test. The MBF values were calculated using the formula (3.1). The coefficient of ESG rating on NCSP was 0.128 and MBF value less than 1/300, which indicated that there was decisive strength of evidence against null hypothesis according to the evidence categories of Held and Ott (2018). These positive and significant coefficients support the H1a. It suggested that ESG ratings can significantly increase NCSP.

4.2.3.2 Instrumental Variable (IV) Estimation

The ESG rating of each listed company will be influenced by the ESG performance of other listed companies in the city where it is located, therefore, the ESG performance of other companies is not directly related to the NCSP obtained by this company. Referring to Benlemlih and Bitar (2018), this dissertation used the average ESG rating (IV_ESG) of other listed companies in the city where the companies are registered in the same year as an Instrumental Variable (IV) to conduct 2SLS regression. The regression results were reported in columns (1) and (2) of Table (4.3). In the first step, the coefficient of IV_ESG was significantly positive (0.7100) at the level of 1%, indicating that the instrumental

variable met the correlation requirements. In the second step, the ESG coefficient was significantly positive (0.1286) at the level of 1%, and the regression result remained unchanged, which showed that the conclusion of ESG rating on NCSP was robust.

4.2.3.3 Heckman Two-Stage Method

This dissertation employed the Heckman two-stage approach to address potential endogeneity issues between ESG rating and NCSP. To follow the approach used by Li et al. (2021), the first step involved converting the ESG rating into a dummy variable (Dum_ESG) based on the annual average of the ESG rating. If the ESG rating was higher than the annual average, Dum_ESG was assigned a value of 1, otherwise, it was assigned a value of 0. The Inverse Mills Ratio (IMR) was calculated using the Probit model. In the second step, the IMR value was included as a control variable in Equation (3.25) to participate in the regression. The results of the Heckman two-stage test are presented in columns (3) and (4) of Table (4.3) and indicate that the findings in Table (4.2) remained unchanged.

4.2.3.4 Independent Variable Lagged by One Year

Due to the potential lag in the feedback process between ESG ratings and NCSP, and the fact that ESG rating information is usually published at the end of the year, meaningful information may not be provided to investors until the following year. Therefore, this dissertation also regressed the ESG rating with a one-period lag, and the results are presented in column (5) of Table (4.3). The results are generally consistent with the previous empirical results, demonstrating the robustness of the findings obtained through substitution.

Table 4.3 Robustness tests for ESG ratings on NCSP.

VARIABLES	(1) ESG	(2) NCSP	(3) Dum_ESG	(4) NCSP	(5) NCSP
IV_ESG	0.7100*** (130.10)				
ESG		0.1286***		0.1368***	
VARIABLES	(1) ESG	(2) NCSP	(3) Dum_ESG	(4) NCSP	(5) NCSP
		(6.46)		(10.32)	
IMR				-3.7274*** (-10.02)	

Table 4.3 (continued)

L_ESG					0.1185***
					(8.80)
Constant	-.0004	-0.4297**	0.2872***	-0.1550	-2.5775***
	(-0.01)	(-2.48)	(3.25)	(-0.55)	(-16.97)
Controls	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	16,743	16,743	19,326	19,326	19,324
pseudo R-squared	0.612	-	0.105	0.320	0.314

Note: ***, and ** indicate 1%, and 5% significance levels, respectively.

4.2.4 Mediation Effect Analysis

Following the mediation effect test procedures proposed by Wen et al. (2004), this study utilized Equations (3.26) and (3.27) to examine the mediation effect of information asymmetry. As shown in column (1) of Table (4.4), the regression coefficient of the ESG rating and information asymmetry was -0.0924 at the 1% confidence level, indicating a significant reduction in information asymmetry due to a high ESG rating. Similarly, column (2) of Table (4.4) reported a regression coefficient between information asymmetry and the NCSP of -0.0425 at the 1% significance level, suggesting a decrease in NCSP due to information asymmetry. These results confirmed that information asymmetry mediates the relationship between companies' ESG performance and the NCSP, validating H1b. This implies that companies with strong ESG performance exhibit lower information asymmetry, leading to better dissemination of information to investors and ultimately enhancing the NCSP.

Table 4.4 Regression results obtained for mediation effect and moderated mediation effect about ESG ratings and NCSP.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	AbsDA	NCSP	AbsDA	AbsDA	AbsDA
ESG	-0.0924***	0.1245***	-0.0927***	-0.0913***	-0.0925***
	(-11.51)	(9.42)	(-11.54)	(-11.37)	(-11.53)
AbsDA		-0.0425***			
VARIABLES	(1)	(2)	(3)	(4)	(5)
	AbsDA	NCSP	AbsDA	AbsDA	AbsDA
		(-3.10)			
TAI			0.0111		
			(1.46)		
ESG×TAI			-0.0138*		

110

Table 4.4 (continued)

			(-1.89)		
DC				0.0131	
				(1.63)	
ESG×DC				-0.0177**	
				(-2.49)	
EDU					0.0489***
					(5.21)
ESG×EDU					-0.0217***
					(-2.71)
INTA					-0.0382***
					(-5.28)
ESG×INTA					-0.0078
					(-1.22)
TAT					0.1287***
					(6.31)
ESG×TAT					-0.0129
					(-1.58)
Constant	-0.0112	-2.5814***	-0.0039	-0.0105	0.0254
	(-0.16)	(-16.98)	(-0.06)	(-0.15)	(0.37)
Controls	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	19,326	19,326	19,326	19,326	19,326
Adjusted R-squared	0.065	0.316	0.065	0.066	0.072

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.2.5 Moderated Mediation Test

Hypothesis 1c predicted that TAI moderated the strength of the mediated relationship between ESG ratings to NCSP via information asymmetry. In order to test H1c, this dissertation first referred to Cohen et al. (2003) to test the moderation effect by using Equation (3.28). The results were presented in column (3) of Table (4.4), which showed that the interaction term between ESG ratings and TAI was negatively and significantly related to information asymmetry at 10% level (coefficient = -0.0138 with t value = -1.89). The test results proved that TAI moderates the above relation, such that relationship was stronger for regions with high-as opposed to low-levels of TAI.

Hypothesis 1d predicted that dynamic capabilities moderated the strength of the mediated relationship between ESG ratings to NCSP via information asymmetry. In order to test H1d, this dissertation used Equation (3.29) to test the moderation effect of dynamic capabilities. The results were presented in column (4) of Table (4.4), which showed that the interaction term between ESG ratings and dynamic capabilities was negatively and

111

significantly related to information asymmetry at 5% level (coefficient = -0.0177 with t value = -2.49). The test results proved that dynamic capabilities play a moderating to the effect of ESG ratings on information asymmetry, such that relationship was stronger for companies with high-as opposed to low-levels of dynamic capabilities.

In order to test which capabilities contributed the most among the three dynamic capabilities, as learning and absorption capabilities (EDU), transformation and reconstruction capabilities (INTA), and coordination and integration capabilities (TAT), this dissertation used Equation (3.30) to conduct regression analysis. Column (5) of Table (4.4) indicated that the interaction regression coefficient between ESG and the EDU was -0.0217 at the 1% significance level (the corresponding t-value was -2.71), the interaction regression coefficient between ESG and the INTA was -0.0078 with no significance, and the interaction regression coefficient between ESG and the TAT was -0.0129 with no significance. These results showed that the learning and absorption capabilities played the most important effect.

4.3 ESG Ratings and Stock Mispricing

4.3.1 Descriptive Statistics

Descriptive statistics for ESG rating and stock mispricing are shown in Table (4.5). The mean value of stock mispricing is 0.3204, presenting that there is an essentially difference in the stock mispricing. The mean value of ESG is 6.5372, a rating between 'BBB-A', with a standard deviation of 1.1726, indicating that firms in our sample showed vary large variance. The highest ESG rating was night while the lowest was one, indicating that there were differences in the ESG performance among the sample companies. The minimum, maximum and mean of information asymmetry are 0.0006, 0.2793 and 0.0552 respectively, which indicated the degree of information asymmetry among enterprises was quite different, and some enterprises had a high degree of information asymmetry. Other variables are similar to the descriptive statistics of ESG rating and NCSP.

Table 4.5 Descriptive statistics for ESG ratings and stock mispricing.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	max
Misp	23,697	0.3204	0.2580	0.0049	1.3443
ESG	23,697	6.5372	1.1726	1.0000	9.0000
AbsDA	23,697	0.0552	0.0552	0.0006	0.2793

Table 4.5 (continued)

TAI	23,697	0.3306	0.2435	0.0377	0.9865
DC	23,697	0.2127	0.0938	0.0589	0.5389
EDU	23,697	0.2815	0.2079	0.0080	0.8875
INTA	23,697	0.0473	0.0517	0.0000	0.3299
TAT	23,697	0.6099	0.4156	0.0693	2.4941
COVID_19	23,697	0.2375	0.4255	0.0000	1.0000
State	23,697	0.4025	0.4904	0.0000	1.0000
C_Score	23,697	-0.1829	0.1214	-0.5876	0.0240
Size	23,697	22.9283	1.1189	20.8205	26.4169
Age	23,697	18.4962	5.7397	2.0000	63.0000
Lev	23,697	0.4391	0.2034	0.0552	0.9363
Growth	23,697	0.1778	0.4439	-0.5805	3.1335
IDR	23,697	0.3759	0.0536	0.3333	0.5714
OC	23,697	0.4840	0.1518	0.1674	0.8587
IS	23,697	0.0238	0.0188	0.0024	0.1111
Big4	23,697	0.0626	0.2422	0.0000	1.0000

Note: Table 4.5 shows the results of the descriptive statistics for the variables for ESG ratings and stock mispricing.

4.3.2 Baseline Regression

Table (4.6) reports the baseline regression results for Equation (3.31). In column (1), this dissertation just regresses ESG ratings and stock mispricing. In column (2), this dissertation adds control variables. In column (3), this dissertation further adds control variables and fix year and industry effects. As shown in column (1), the coefficient of ESG ratings is significantly negatively at 1% level (coefficient is -0.0523, with t value is -8.38), indicating that corporate ESG ratings have a negative impact on stock mispricing. After adding control variables, the coefficient of ESG ratings in column (2) is still significantly negatively at 1% level (coefficient is -0.0698 with t value is -10.36). Further control year and industry effect, the coefficient of ESG rating in column (3) is significantly negative at 1% level (coefficient is -0.0705 and t value is -10.10). These negative and significant coefficients support the H2a. As for economic significance, the results indicate that one level increasing in ESG ratings can lead to 7.0% decrease in stock mispricing. It suggests that the higher the ESG ratings, the lower the stock mispricing.

Table 4.6 Regression results of ESG ratings on stock mispricing.

VARIABLES	(1)	(2)	(3)
	Misp	Misp	Misp
ESG	-0.0523***	-0.0698***	-0.0705***
	(-8.38)	(-10.36)	(-10.10)

Table 4.6 (continued)

Size		0.1760***	0.1747***
		(17.14)	(15.79)
Age		-0.0044	0.0067
		(-0.67)	(0.89)
Lev		-0.2181***	-0.1942***
		(-23.66)	(-19.34)
Growth		-0.0049	0.0062
		(-0.68)	(0.85)
IDR		0.0049	0.0029
		(0.79)	(0.47)
OC		-0.0232***	-0.0107
		(-3.43)	(-1.56)
IS		0.0792***	0.0340***
		(9.40)	(3.80)
Big4		-0.1460***	-0.1433***
		(-5.07)	(-5.01)
Constant	-0.0203***	-0.0125*	-0.4190*
	(-3.15)	(-1.89)	(-1.70)
Controls	NO	YES	YES
Year	NO	NO	YES
Industry	NO	NO	YES
Observations	23,697	23,697	23,697
Adjusted R-squared	0.003	0.049	0.083

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.3.3 Robustness Tests

4.3.3.1 Minimum Bayes Factor

The advantage of using MBF is that it does not rely on prior probability, as shown in the proof provided by Held and Ott (2016). To conduct a robustness test, this dissertation utilized the MBF, as recommended by Held and Ott (2018). The MBF values were calculated using the formula (3.1). The coefficient of ESG rating on stock mispricing was -0.071 and MBF value less than 1/300, which indicated that there was decisive strength of evidence against null hypothesis according to the evidence categories of Held and Ott (2018). These negative and significant coefficients support the H2a. It suggested that ESG ratings can significantly reduce stock mispricing.

4.3.3.2 IV Estimation

Considering that the influence of a company's ESG rating on its stock mispricing may be affected by endogenous problems, this thesis uses two-stage least squares (2SLS) for the endogenous test. The average ESG rating (IV_ESG) of other listed companies in the city

114

where each company was registered in the same year was selected as the instrumental variable for the 2SLS regression. As the ESG ratings of listed companies in the same city interact with each other, it meets the selection criteria of a tool variable. Two-stage least squares regression is used and the results were shown in column (1) and (2) of table (4.7). In the first step, the coefficient of IV_ESG was significantly positive (0.6987) at the level of 1%, indicating that the instrumental variable met the correlation requirements. In the second step, the ESG coefficient was significantly negative (-0.0563) at the level of 1%, and the regression result remained unchanged, which showed that the conclusion of ESG rating on stock mispricing was robust.

4.3.3.3 Heckman Two-Stage Method

The Heckman two-stage method is a statistical technique commonly used to correct for selection bias in regression analysis. In the context of this study, selection bias may arise as investors who place a greater emphasis on ESG factors may be more likely to purchase stocks with higher ESG ratings, creating a potential correlation between ESG ratings and stock mispricing that is not causal. To account for this potential endogeneity between ESG ratings and stock mispricing, this study employed the Heckman two-stage method. The first stage involves estimating a selection model that predicts the likelihood of a stock being included in the analysis based on its ESG rating and other relevant variables, thus helping to correct for any selection bias that may exist. Referring to prior study, in the first step, this dissertation converted ESG ratings into a dummy variable (Dum_ESG) which is the annual average of the ESG ratings. When the ESG ratings were higher than the annual average, Dum_ESG was 1, and it was 0 otherwise. Through the Probit model, the Inverse Mills Ratio (IMR) was calculated. In the second stage, this dissertation estimates the regression, which would be the relationship between ESG ratings and stock mispricing, while controlling for the selection bias estimated in the first stage. This dissertation input the IMR value into Equation (3.31) as a control variable to participate in the regression. The regression results of the Heckman two-stage test are reported in columns (3) and (4) of Table (4.7), where the coefficient of ESG ratings was still remain significant at 1% level, suggesting that the results in Table (4.6) remained constant.

4.3.3.4 Independent Variable Lagged by One Year

Considering the possible robustness of the ESG ratings and stock mispricing, whether the ESG ratings of the past year is related with stock mispricing is need to test due to a delay in the process of ESG ratings feedback to stock market. Therefore, this dissertation used one-year lagged ESG rating (L_ESG) to conduct the regressions again. The results shown in column (5) of Table (4.7) still remained significant negative at 1% level, which further support that the results were generally consistent with those obtained in Table (4.6).

4.3.3.5 Using fixed effect model

In order to alleviate the endogenous bias caused by missing variables at the company level, this dissertation further re-examined the company and annual two-way fixed effects, and controlled the clustering effect at the company level. The results in column (6) of Table (4.7) showed that the regression coefficient of ESG rating was still significantly negative at 1%, implying that the ESG rating had a negative relationship with the stock mispricing and that hypothesis 2a is valid.

Table 4.7 Robustness tests for ESG ratings on stock mispricing.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	ESG	Misp	Dum_ESG	Misp	Misp	Misp
IV_ESG	0.6987***					
	(123.09)					
ESG		-0.0563***		-0.0728***		-0.0288**
		(-5.19)		(-10.50)		(-2.48)
IMR				3.1167***		
				(17.86)		
L_ESG					-0.0664***	
					(-9.09)	
Constant	-0.0970	-0.4904**	-0.6723	-4.3039***	-0.0081	0.0358
	(-0.49)	(-1.97)	(-1.17)	(-12.64)	(-0.14)	(0.15)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
Observations	20,402	20,402	23,697	23,697	23,688	23,697

116

Table 4.7 (continued)

Adjusted R-squared	0.612	0.082	0.117	0.100	0.082	0.094

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.3.4 Mediation Effect Analysis

Hypothesis 2b predicted the mediation role of information asymmetry in the relationship between ESG ratings and stock mispricing. This dissertation conducted multiple regression analysis to test Hypothesis 2b. According to Wen and Ye (2004), this dissertation used Equation (3.32) and Equation (3.33) to test the mediating effect of information asymmetry. The results were presented in column (1) and (2) of table (4.8), which showed that ESG ratings were negatively related to information asymmetry at 1% level (coefficient = -0.0724 with t value = -10.13), ESG ratings were negatively related to stock mispricing at 1% level (coefficient = -0.0646 with t = -9.30), and information asymmetry was positively related to stock mispricing at 1% level (coefficient = 0.0813 with t value = 11.10). Thus, Hypothesis 2b was supported, which suggested that information asymmetry mediated the effect of ESG ratings on stock mispricing. That meant corporate ESG ratings can reduce stock mispricing by alleviating information asymmetry.

Table 4.8 Regression results obtained for mediation effect and moderated mediation effect about ESG ratings and the stock mispricing.

VARIABLES	(1) AbsDA	(2) Misp	(3) AbsDA	(4) AbsDA	(5) AbsDA
ESG	-0.0724***	-0.0646***	-0.0732***	-0.0713***	-0.0752***
	(-10.13)	(-9.30)	(-10.26)	(-9.98)	(-10.48)
AbsDA		0.0813***			
		(11.10)			
TAI			0.0249***		
			(3.59)		
ESG×TAI			-0.0167**		
			(-2.54)		
DC				0.0079	
				(1.15)	
ESG×DC				-0.0179***	
				(-2.93)	
EDU					0.0643***
					(7.53)
ESG×EDU					-0.0265***
					(-3.67)

117

Table 4.8 (continued)

INTA					-0.0437***
					(-7.09)
ESG×INTA					-0.0022
					(-0.43)
TAT					0.0221***
					(2.87)
ESG×TAT					-0.0099
					(-1.39)
Constant	0.4654	-0.4568*	0.4736	0.4421	0.4156
	(0.79)	(-1.76)	(0.80)	(0.75)	(0.69)
Controls	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	23,697	23,697	23,697	23,697	23,697
Adjusted R-squared	0.063	0.088	0.064	0.064	0.069

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.3.5 Moderated Mediation Test

Hypothesis 2c predicted that TAI moderated the strength of the mediated relationship between ESG ratings to stock mispricing via information asymmetry. In order to test H2c, this dissertation first referred to Cohen et al. (2003) to test the moderation effect by using Equation (3.34). The results were presented in column (3) of Table (4.8), which showed that the interaction term between ESG ratings and TAI was negatively and significantly related to information asymmetry at 1% level (coefficient = -0.0179 with t value = -2.93). The test results proved that TAI moderates the above connection, such that relationship is stronger for regions with high-as opposed to low-levels of TAI.

Hypothesis 2d predicted that dynamic capabilities moderated the strength of the mediated relationship between ESG ratings to stock mispricing via information asymmetry. In order to test H2d, this dissertation used Equation (3.35) to test the moderation effect of dynamic capabilities. The results were presented in column (4) of Table (4.8), which showed that the interaction term between ESG ratings and dynamic capabilities was negatively and significantly related to information asymmetry at 5% level (coefficient = -0.0179 with t value = -2.93). The test results proved that dynamic capabilities moderate the effect of the two variables, such that relationship is stronger for companies with high-as opposed to low-levels of dynamic capabilities.

In order to test which capabilities contributed the most among the three dynamic capabilities, as learning and absorption capabilities (EDU), transformation and

118

reconstruction capabilities (INTA), and coordination and integration capabilities (TAT), this dissertation used Equation (3.36) to conduct regression analysis. Column (5) of Table (4.8) indicated that the interaction regression coefficient between ESG and the EDU was -0.0265 at the 1% significance level (the corresponding t-value was -3.67), the interaction regression coefficient between ESG and the INTA was -0.0022 with no significance, and the interaction regression coefficient between ESG and the TAT was -0.0099 with no significance. These results showed that the learning and absorption capabilities played the most important effect.

4.4 ESG Ratings and Stock Price Crash Risk

4.4.1 Descriptive Statistics

Table 4.9 reported the descriptive statistics for ESG ratings and stock price crash risk. The mean value of stock price crash risk (F_NCSKEW) was -0.2342, which was similar to the descriptive analysis results of existing studies. The standard deviation (SD) of the stock crash risk was 0.5532, indicating that the stock price crash varied greatly among different enterprises. The mean, standard deviation, minimum, and maximum of ESG ratings (ESG) was 6.5358, 1.1687, 1, and 9, indicating that listed companies in China generally performed well in ESG, but there were great differences in ESG performance among different enterprises, and some enterprises paid less attention to fulfilling ESG responsibilities. The descriptive statistics of other variables were similar to that of NCSP and stock mispricing.

Table 4.9 Descriptive statistics for ESG ratings and stock price crash risk.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	N	mean	sd	min	max
F_NCSKEW	20,219	-0.2342	0.5532	-1.7601	1.1599
ESG	20,219	6.5358	1.1687	1.0000	9.0000
AbsDA	20,219	0.0557	0.0559	0.0006	0.2793
TAI	20,219	0.3257	0.2444	0.0377	0.9865
DC	20,219	0.2107	0.0934	0.0589	0.5389
EDU	20,219	0.2726	0.2037	0.0080	0.8875
INTA	20,219	0.0478	0.0518	0.0000	0.3299
TAT	20,219	0.6133	0.4191	0.0693	2.4941

119

Table 4.9 (continued)

COVID_19	20,219	0.1392	0.3461	0.0000	1.0000
State	20,219	0.4093	0.4917	0.0000	1.0000
C_Score	20,219	-0.1768	0.1212	-0.5876	0.0240
Age	20,219	18.0356	5.6363	2.0000	53.0000
Lev	20,219	0.4442	0.2069	0.0552	0.9363
Size	20,219	7.7839	1.2407	4.3567	11.1791
MB	20,219	4.1204	3.3344	1.2030	27.2538
ROA	20,219	0.0340	0.0632	-0.2836	0.2005
CFO	20,219	0.0473	0.0679	-0.1733	0.2419
CAPX	20,219	0.0441	0.0449	-0.0337	0.2218
First	20,219	0.3479	0.1478	0.0848	0.7430
Manager	20,219	0.2530	0.4348	0.0000	1.0000

Note: Table 4.9 shows the results of the descriptive statistics for the variables for ESG ratings and stock price crash risk.

4.4.2 Baseline Regression

Table (4.10) reported the regression results of ESG ratings and the stock price crash risk. Among them, in table (4.10), column (1) reported the results without control variables, column (2) reported the results with control variables, and column (3) reported the results of controlling the fixed effect of industry and year. The results showed that the regression coefficients of ESG ratings in column (1) and column (2) were -0.0488 (with t value is -7.23) and -0.0228 (with t value is -3.21), respectively, which were significant at 1% significance level. After controlling the fixed effect of industry and year, the regression coefficient of ESG ratings in column (3) was -0.0258 (with t value is -3.50), which was significant at 1% significance level. All the above results showed that the ESG performance of enterprises reduced the stock price crash risk, indicating that enterprises' better performance of ESG responsibilities would help reduce the stock price crash risk and promoted the stability of Chinese capital market. Hypothesis 3a was verified. These findings have significant for companies, investors and government agencies. Enterprises should pay attention to improving their own ESG performance, fully integrate the construction of ESG system into their daily operations, improve the moral level of managers, enable them to consciously fulfil their social and environmental responsibilities, improve the governance level of senior executives, reduce the negative

news of enterprises, enhance the transparency of information within enterprises, and curb the risk of stock price crash. Investors should continue to optimize ESG investment strategy, combine ESG performance with corporate performance, establish a long-term interest investment concept, give full play to the value of ESG performance, and treat ESG performance scientifically and rationally to avoid losses. Government should improve the mechanism of ESG information disclosure and scientific application, standardize the disclosure of ESG performance from the system, effectively strengthen the scientific and perfection of the ESG system, so as to promote the stable development of China's stock market.

Table 4.10 Regression results of ESG ratings on stock price crash risk.

VARIABLES	(1) F_NCSKEW	(2) F_NCSKEW	(3) F_NCSKEW
ESG	-0.0488***	-0.0228***	-0.0258***
	(-7.23)	(-3.21)	(-3.50)
Size		-0.0437***	-0.0402***
		(-5.17)	(-4.52)
Age		-0.0249***	-0.0259***
		(-3.29)	(-3.15)
MB		0.0625***	0.0657***
		(7.95)	(7.97)
ROA		0.0078	0.0013
		(1.01)	(0.17)
CFO		-0.0133*	-0.0076
		(-1.69)	(-0.95)
CAPX		0.0293***	0.0304***
		(3.93)	(3.99)
Lev		-0.0666***	-0.0629***
		(-7.29)	(-6.32)
First		-0.0165**	-0.0122*
		(-2.24)	(-1.65)
Manager		0.0580***	0.0488***
		(3.64)	(3.09)

121

Table 4.10 (continued)

Constant	-0.0134*	-0.0187**	0.0849
	(-1.92)	(-2.28)	(0.25)
Controls	NO	YES	YES
Year	NO	NO	YES
Industry	NO	NO	YES
Observations	20,219	20,219	20,219
Adjusted R-squared	0.002	0.014	0.057

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.4.3 Robustness Tests

4.4.3.1 Minimum Bayes Factor

Similar to NCSP and stock mispricing, this dissertation used MBF robustness testing method to analyse the stock price crash risk. The MBF values of ESG ratings were calculated using the formula (3.1). The coefficient of ESG rating on stock price crash risk was -0.025 and MBF value less than 1/300, which indicated that there was decisive strength of evidence against null hypothesis according to the evidence categories of Held and Ott (2018). These negative and significant coefficients support the H3a. It suggested that ESG ratings can significantly reduce stock price crash risk.

4.4.3.2 IV Estimation

Similar to NCSP and stock mispricing, this dissertation also used instrumental variable estimation to conduct robustness testing, and analyzed the results of the regression coefficient among ESG ratings and stock price crash risk. The regression results were reported in columns (1) and (2) of Table (4.11). In the first step, the coefficient of IV_ESG was significantly positive (0.7119) at the level of 1%, indicating that the instrumental variable met the correlation requirements. In the second step, the ESG coefficient was significantly negative (-0.0353) at the level of 1%, and the regression result remained unchanged, which showed that the conclusion of ESG ratings on stock price crash risk was robust.

4.4.3.3 Heckman Two-Stage Method

Similar to NCSP and stock mispricing, this dissertation also used the Heckman two-stage method to conduct robustness testing, and analyzed the results of the regression

122

coefficient among ESG ratings and stock price crash risk. In the first step, this dissertation used the Probit model to calculate the IMR. In the second step, this dissertation input the IMR value into Equation (3.37) as a control variable to participate in the regression. The regression results of the Heckman two-stage test are reported in columns (3) and (4) of Table (4.11), where the coefficient of ESG ratings was still remain significant at 1% level, suggesting that the results in Table (4.10) remained constant.

4.4.3.4 Independent Variable Lagged by One Year

Considering the possible robustness of the ESG ratings and stock price crash risk, whether the ESG ratings of the past year is related with stock price crash risk is need to test due to a delay in the process of ESG ratings feedback to stock market. Therefore, this dissertation used one-year lagged ESG rating (L_ESG) to conduct the regressions again. The results shown in column (5) of Table (4.11) still remained significant negative at 1% level (with the coefficient was -0.0231), which further support that the results were generally consistent with those obtained in Table (4.10).

4.4.3.5 Alternative Dependent Variable

To ensure reliable results, the core dependent variable in this dissertation was modified. In measuring stock price crash risk, the DUVOL was selected as the indicator, which calculates the difference in volatility between share price increases and decreases using Equation (3.13). The regression coefficients for the main variables were presented in column (6) of Table (4.11). The newly calculated measure of stock price crash risk was used in another regression analysis, and the results showed minimal change in the coefficients of the main variables, affirming the robustness of the regression findings.

Table 4.11 Robustness tests for ESG ratings on stock price crash risk.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	ESG	F_NCSKEW	Dum_ESG	F_NCSKEW	F_NCSKEW	F_DUVOL
IV_ESG	0.7119***					
	(118.68)					
ESG		-0.0353***		-0.0264***		-0.0147**
		(-3.11)		(-3.57)		(-1.98)
IMR				0.4350**		
				(1.97)		
L_ESG					-0.0231***	

123

Table 4.11 (continued)

					(-2.97)	
Constant	-0.0465	0.0883	-0.4494	-0.4049	0.0222	-0.0001
	(-0.27)	(0.26)	(-0.79)	(-0.96)	(0.35)	(-0.00)
Controls	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES
Observations	17,355	17,355	20,219	20,219	20,210	20,219
Adjusted R-squared	0.613	0.060	0.094	0.057	0.057	0.049

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.4.4 Mediation Effect Analysis

Hypothesis 3b predicted the mediation role of information asymmetry in the relationship between ESG ratings and stock price crash risk. Referring to the theoretical analysis, it can be seen that good ESG performance can create a good information environment for enterprises and reduce the degree of information asymmetry, thus inhibiting the management's cover-up behavior and alleviating the stock price crash risk. According to Wen and Ye (2004), this dissertation used Equation (3.38) and Equation (3.39) to test the mediating effect of information asymmetry. The results were presented in column (1) and (2) of table (4.12), which showed that ESG ratings were negatively related to information asymmetry at 1% level (coefficient = -0.0339 with t value = -4.60), ESG ratings were negatively related to stock mispricing at 1% level (coefficient = -0.0250 with t = -3.39), and information asymmetry was positively related to stock mispricing at 1% level (coefficient = 0.0244 with t value = 3.32). Thus, Hypothesis 3b was supported, which suggested that information asymmetry mediated the effect of ESG ratings on stock price crash risk. It can be seen that the mitigation effect of ESG performance on the stock price crash risk was produced by reducing information asymmetry to a certain extent, and information asymmetry played a conductive role in this relationship.

Table 4.12 Regression results obtained for mediation effect and moderated mediation effect about ESG ratings and stock price crash risk.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	AbsDA	F_NCSKEW	AbsDA	AbsDA	AbsDA
ESG	-0.0339***	-0.0250***	-0.0352***	-0.0343***	-0.0358***
	(-4.60)	(-3.39)	(-4.77)	(-4.64)	(-4.77)

124

Table 4.12 (continued)

AbsDA	0.0244***				
	(3.32)				
TAI		0.0164**			
		(2.25)			
ESG×TAI		-0.0146**			
		(-2.13)			
DC			0.0195***		
			(2.65)		
ESG×DC			-0.0183***		
			(-2.89)		
EDU				0.0377***	
				(4.03)	
ESG×EDU				-0.0245***	
				(-3.25)	
INTA				-0.0362***	
				(-5.38)	
ESG×INTA				-0.0032	
				(-0.59)	
TAT				0.0806***	
				(9.53)	
ESG×TAT				-0.0137*	
				(-1.95)	
Constant	0.6156	0.0699	0.6189	0.5735	0.5319
	(0.94)	(0.20)	(0.94)	(0.88)	(0.84)
Controls	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES
Observations	20,219	20,219	20,219	20,219	20,219
Adjusted R-squared	0.101	0.058	0.101	0.101	0.108

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.4.5 Moderated Mediation Test

Hypothesis 3c predicted that TAI moderated the strength of the mediated relationship between ESG ratings to stock price crash risk via information asymmetry. In order to test H3c, this dissertation first referred to Cohen et al. (2003) to test the moderation effect by using Equation (3.40). The results were presented in column (3) of Table (4.12), which showed that the interaction term between ESG ratings and TAI was negatively and

125

significantly related to information asymmetry at 1% level (coefficient = -0.0146 with t value = -2.13). The test results proved that TAI was a moderator from ESG ratings to information asymmetry, such that relationship is stronger for regions with high- as opposed to low-levels of TAI.

Hypothesis 3d predicted that dynamic capabilities moderated the strength of the mediated relationship between ESG ratings to stock price crash risk via information asymmetry. In order to test H3d, this dissertation used Equation (3.41) to test the moderation effect of dynamic capabilities. The results were presented in column (4) of Table (4.12), which showed that the interaction term between ESG ratings and dynamic capabilities was negatively and significantly related to information asymmetry at 1% level (coefficient = -0.0183 with t value = -2.89). The test results proved that dynamic capabilities are moderator to the mediating role of information asymmetry, such that relationship is stronger for companies with high-as opposed to low-levels of dynamic capabilities.

In order to test which capabilities contributed the most among the three dynamic capabilities, as learning and absorption capabilities (EDU), transformation and reconstruction capabilities (INTA), and coordination and integration capabilities (TAT), this dissertation used Equation (3.42) to conduct regression analysis. Column (5) of Table (4.12) indicated that the interaction regression coefficient between ESG and the EDU was -0.0245 at the 1% significance level (the corresponding t-value was -3.25), the interaction regression coefficient between ESG and the INTA was -0.0032 with no significance, and the interaction regression coefficient between ESG and the TAT was -0.0137 at the 10% significance level (the corresponding t-value was -1.95). These results showed that the learning and absorption capabilities and coordination and integration capabilities played the most important effect.

4.5 Heterogeneity Analysis

4.5.1 Heterogeneity Analysis Based on Accounting Conservatism

Accounting conservatism means that accounting information should truly, objectively, reliably and completely reflect the economic, business and financial conditions of companies, follow accounting standards and principles, and not exaggerate or conceal the financial conditions of companies. ESG is the core of corporate social responsibility (Gilchrist et al., 2021), which means that companies should consider environmental, social and governance factors in the process of operation and management. The

information efficiency of the capital market means that the capital market can effectively reflect the value of companies, i.e., the share price can accurately reflect the financial situation, operating conditions and future prospects of companies.

The influence of ESG ratings on the information efficiency of the capital market mainly depends on the following aspects. First, the influence of ESG ratings on the financial condition and operational risk of enterprises: if an enterprise performs well in ESG, such as environmental protection, social responsibility and governance, its financial condition and operational risk may be more stable, thus improving the value and stock price of the enterprise (Chava, 2014). On the other hand, if a company's ESG rating is poor, such as environmental problems, social responsibility problems or governance problems, its financial status and operational risks may be more unstable, thus reducing the value and stock price of the company. The second is the capital market's reaction to the ESG ratings. The capital market can react positively or negatively to a company's ESG rating. If investors believe that the company's ESG performance is excellent, they will increase their willingness to invest in the company (Leuz et al., 2009), which will increase the company's share price. On the other hand, if investors believe that the company's ESG performance is poor, they may decrease their willingness to invest in the company, and thus decrease the company's share price. The third is the impact of accounting conservatism on ESG ratings. If a company's accounting information truly, objectively, reliably and completely reflects its ESG performance, the capital market can more accurately reflect the value of the company (Armstrong et al., 2010) and improve the information efficiency of the capital market. On the other hand, if a company's accounting information exaggerates or conceals its ESG performance, it may lead to a mispricing of the company's value in the capital market and reduce the information efficiency of the capital market. Accounting conservatism has a significant impact on ESG ratings, mainly in the following ways Improving the reliability and accuracy of ESG ratings. Accounting conservatism requires companies to conduct accounting in accordance with accounting standards and principles to ensure the authenticity, objectivity, reliability and integrity of accounting information. If a company can conduct accounting in accordance with accounting standards and principles and ensure the authenticity, objectivity, reliability and integrity of information, its ESG performance will be more reliable and accurate. For example, if an enterprise conducts business according to the requirements of

127

environmental protection (Guay and Verrecchia, 2018), accounting conservatism requires the enterprise to include environmental protection costs in its accounting, which reflects its performance in environmental protection (Zhang et al., 2022). The second is to help companies better manage ESG risks. Accounting conservatism requires enterprises to conduct accounting in accordance with accounting standards and principles, and reflect the financial status and operating results of enterprises in accordance with the requirements of authenticity, objectivity, reliability and integrity. This helps companies to better manage ESG risks, to identify and assess the impact of ESG risks on companies, and to take appropriate measures to control and manage them. For example, the incorporation of environmental and social responsibility costs into costs or expenses in accounting helps companies to better manage environmental and social responsibility risks and avoid potential losses caused by them. The third is to improve the transparency and comparability of ESG information. Accounting conservatism requires companies to prepare their accounts in accordance with accounting standards and principles and to reflect the financial position and results of operations of companies in accordance with the requirements of authenticity, objectivity, reliability and integrity. This helps to improve the transparency and comparability of ESG information (Gardberg and Fombrun, 2006) and enables investors to better understand the ESG performance and risks of companies. For example, calculating the environmental and social responsibility costs of companies according to accounting standards and principles can improve the comparability of ESG information and enable investors to more accurately compare the ESG performance and risks of different companies (Minor and Morgan, 2011).

In the capital market, investors often pay attention to the ESG performance of companies because these factors can have an important impact on the long-term performance and value of companies (Kim et al., 2012). However, ESG performance may be distorted by many factors (Gao et al., 2014), such as insufficient publicity and disclosure of the company itself (Hong and Andersen, 2011), corporate fraud (Harjoto, 2017), corruption (Luo, 2018), or an opaque regulatory environment. Therefore, accounting conservatism can be used as a check and balance mechanism to regulate the impact of ESG performance on capital market information efficiency. In particular, accounting conservatism can help companies to identify and assess ESG risks and challenges more objectively and comprehensively, and to provide for and disclose these risks and challenges

128

appropriately. This helps to improve investors' confidence and reliability in companies' ESG performance, thereby enhancing the capital market's ability to absorb and respond to ESG information (Zhang, 2008). In addition, accounting conservatism can also encourage companies to manage ESG risks and challenges more prudently, thereby reducing the uncertainty and adverse effects caused by ESG risks and challenges. This will help to improve the long-term stable performance and value of companies (Lara et al., 2009), thus achieving a better return on investment and also increasing the capital market's attention and focus on companies' ESG performance. In conclusion, accounting conservatism can adjust the influence of ESG ratings on the information efficiency of the capital market, improve the transparency, reliability and absorptive capacity of ESG information, and promote the sustainable development of enterprises and the capital market.

Based on the above analysis, it suggests that firms with greater accounting conservatism are more likely to impact information efficiency in capital market. Therefore, from the perspective of information efficiency in the capital market for China, this dissertation selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of accounting conservatism on the relationship between ESG ratings and information efficiency, and the results were shown in Table (4.13).

In column (1) of Table (4.13), using NCSP as a proxy variable for information efficiency, it can be seen that the coefficient of correlation between ESG ratings and accounting conservatism was 0.0465, which was significant at the 1% level. This showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilising the NCSP of the capital market.

In column (2) of Table (4.13), using stock mispricing as a proxy variable for information efficiency, it can be seen that the coefficient of correlation between ESG ratings and accounting conservatism was 0.0164, which was also significant at the 1% level. This showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilising the stock mispricing of the capital market.

In column (3) of Table (4.13), using stock price crash risk as a proxy variable for information efficiency, it can be seen that the coefficient of correlation between ESG ratings and accounting conservatism was -0.0009, which was no significant at any level. This showed that accounting conservatism did not have a moderating effect on the

relationship between ESG ratings and capital market information efficiency for China, using the stock price crash risk as a proxy variable. These findings showed that the effect of accounting conservatism on ESG performance and information efficiency is different in the Chinese capital market. The possible reason is that the role of accounting conservatism in improving information transparency and quality is insufficient.

Table 4.13 Regression results obtained for heterogeneity analysis based on accounting conservatism.

| VARIABLES | (1) | (2) | (3) |
	NCSP	Misp	F_NCSKEW
ESG	0.1359***	-0.0677***	-0.0213***
	(9.73)	(-9.64)	(-2.89)
C_Score	0.1397***	0.2542***	0.0754***
	(5.07)	(18.70)	(6.95)
ESG×C_Score	0.0465***	0.0164***	-0.0009
	(3.81)	(2.69)	(-0.14)
Constant	-2.6013***	-0.6209***	0.0500
	(-16.60)	(-2.67)	(0.14)
Controls	YES	YES	YES
Year	YES	YES	YES
Industry	YES	YES	YES
Observations	19,326	23,697	20,219
Adjusted R-squared	0.317	0.102	0.059

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.5.2 Heterogeneity Analysis Based on the Nature of Different Property Rights

The heterogeneity of property rights has unique characteristics in China. The governance structure of SOEs is managed and controlled by the government (Kim et al., 2012). The ownership of non-SOEs can be owned by individuals, families, partnerships, non-governmental organizations and other non-governmental organizations, and their governance structure is relatively independent. SOEs tend to focus on national interests and economic goals, and pay attention to stability and long-term development. Non-SOEs pay more attention to market demand and competitive advantage. SOEs usually emphasize public interests and pay attention to stability and employee welfare. Non-SOEs

pay more attention to individual interests and personal development, and pay attention to performance and return. SOEs are subject to government intervention in resource allocation. Non-SOEs pay more attention to the effective use of resources and the improvement of operational efficiency, and pay attention to market feedback and the drive for innovation.

The advantage of SOEs is that their resources and capital channels are usually more stable and reliable, and they receive strong support from the government, so they can play an important role in some areas, such as public infrastructure construction and strategic industries. In addition, SOEs usually have economies of scale and a strong sense of social responsibility, which can better meet the needs of the public. The advantages of non-SOEs lie in their flexible operation, high decision-making efficiency, sensitive market response and strong innovation ability. Non-SOEs can make business strategies and development directions more independently, and respond more quickly to market changes and competition. In general, there are differences between SOEs and non-SOEs in ownership, business philosophy, organizational culture and resource allocation, which may affect their business performance and market competitiveness. Therefore, this dissertation further classified the companies in the sample into SOE and non-SOEs companies according to the nature of their ownership. This helped investigate the effect of the ESG ratings on the information efficiency for Chinese listed companies under the differing natures of ownership. This dissertation defined the SOEs as 1; otherwise, defined them as 0. this dissertation defined the information efficiency of the capital market as NCSP, stock mispricing, and stock price crash risk, respectively.

Column (1) in Table (4.14) showed that the coefficient of the correlation between ESG ratings and state was -0.0405 while the information efficiency defined as NCSP, which was no significant at any confidence level. This showed that the shareholding preference of northbound capital in sample listed companies paid little attention on the nature of property rights.

Column (2) in Table (4.14) showed that the coefficient of the correlation between ESG ratings and state was -0.0667 while the information efficiency defined as stock mispricing, which was significant at 1% confidence level. This proved that the impact of ESG ratings to stock mispricing in SOE companies are better than that in non-SOE

131

companies. Since SOE companies' ESG practices focus on responding to government requirements and fulfilling policies rather than obtaining economic benefits, investors believe that they should perform well in ESG practices. To demonstrate to the outside world that they are actively managing their ESG responsibilities and responding to stakeholder needs and demands, SOE enterprises are becoming more proactive in disclosing ESG information, which helps to curb stock mispricing.

Column (3) in Table (4.14) showed that the coefficient of the correlation between ESG ratings and state was -0.0038 while the information efficiency defined as stock price crash risk, which was no significant at any confidence level. This showed that the stock price crash risk in sample listed companies were not based on the nature of property rights.

Table 4.14 Regression results obtained for heterogeneity analysis based on the nature of different property rights.

VARIABLES	(1)	(2)	(3)
	NCSP	Misp	F_NCSKEW
ESG	0.1423***	-0.0610***	-0.0177**
	(10.64)	(-8.66)	(-2.37)
State	-0.1911***	-0.0961***	-0.1014***
	(-5.70)	(-6.38)	(-6.03)
ESG×State	-0.0405	-0.0667***	-0.0038
	(-1.58)	(-5.12)	(-0.27)
Constant	-2.5549***	-0.4122*	0.1037
	(-16.87)	(-1.65)	(0.29)
Controls	YES	YES	YES
Year	YES	YES	YES
Industry	YES	YES	YES
Observations	19,326	23,697	20,219
Adjusted R-squared	0.318	0.085	0.059

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.5.3 Impact Analysis around the COVID-19 Period

ESG performance and information efficiency of capital market are closely related to adverse exogenous shocks around the world. In the face of adverse exogenous shocks,

enterprises with good ESG performance will actively fulfill their social responsibilities and will attract investors' extra attention. During the COVID-19 period, the donation behavior of enterprises and rapid management decision-making will undoubtedly resonate with investors, thus attracting more attention from investors. According to the theory of signal transmission, if enterprises don't give up their investment in environmental, social responsibility and corporate governance during the COVID-19 period, they can signal that enterprises are constantly changing in the crisis and bravely taking responsibility, which can enhance the confidence of the investors and improve the stock performance. Additionally, ESG behaviour such as corporate giving will attract additional attention from investors, which will help improve the information efficiency of their stocks. During the COVID-19 outbreak, many members of the public and various social groups made donations of money and materials and became important participants in the Chinese stock market. Donations from companies will undoubtedly have a positive impact on investors and thus attract more attention from investors. Investors are imperfectly rational people with cognitive limitations, according to behavioural finance theory. Under the premise that investors with limited attention can only receive a certain amount of stock information, they are more likely to buy stocks that they are familiar with or that attract their attention, which is conducive to improving the stock performance of the donor companies.

Table (4.15) presented the results on the differential impact of ESG ratings on information efficiency defined as NCSP, stock mispricing, and stock price crash risk, over the COVID-19 period. This dissertation defined 2020 and beyond years as post-COVID-19, and the other years as pre-COVID-19.   In column (1) of Table (4.15), when information efficiency is defined as NCSP, the regression coefficient of the correlation between ESG ratings and NCSP was -0.0148, which was no significant at any confidence level. This result indicated that there was no differential impact of ESG ratings on NCSP before and after the COVID-19 period. This result demonstrates that during the COVID-19 period, northbound capital did not show significant ESG preference.

In column (2) of Table (4.15), when information efficiency is defined as stock mispricing, the regression coefficient of the correlation between ESG ratings and stock mispricing was 0.0710, which was significant at 1% confidence level. This result indicated that there was the differential impact of ESG ratings on stock mispricing before and after the

133

COVID-19 period. ESG performance had a greater impact on stock mispricing in the post-COVID-19 period than in the pre-COVID-19 period has a greater impact on stock mispricing, which may be related to the increase in investor confidence due to better ESG performance.

In column (3) of Table (4.15), when information efficiency is defined as stock price crash risk, the regression coefficient of the correlation between ESG ratings and stock price crash risk was 0.0645, which was significant at 1% confidence level. This result indicated that there was the differential impact of ESG ratings on stock price crash risk before and after the COVID-19 period. These test results suggest that, after the COVID-19 epidemic, a company's active commitment to ESG responsibility will gain more attention from investors and will have a positive impact on its stock mispricing and stock price crash risk. This is an altruistic act of giving back to society, while also boosting share prices and achieving a balance between altruism and self-interest. Therefore, companies should take a more positive attitude towards improving their ESG performance.

Table 4.15 Regression results obtained for impact analysis around the COVID-19 period.

VARIABLES	(1) NCSP	(2) Misp	(3) F_NCSKEW
ESG	0.1305***	-0.0734***	-0.0218***
	(9.14)	(-10.51)	(-2.96)
COVID_19	1.9380***	0.4153*	0.1821
	(20.16)	(1.69)	(0.54)
ESG×COVID_19	-0.0148	0.0710***	0.0645***
	(-0.62)	(5.01)	(3.87)
Constant	-2.1274***	-0.3232*	0.1271
	(-15.15)	(-1.66)	(0.48)
Controls	YES	YES	YES
Year	YES	YES	YES
Industry	YES	YES	YES
Observations	19,326	23,697	20,219
Adjusted R-squared	0.315	0.084	0.058

Table 4.15 (continued)

Note: ***, **, and * indicate 1%, 5%, and 10% significance levels, respectively.

4.6 Summary

This chapter presented the research findings in relation to the research questions posed in the earlier chapter. The intend of the research questions was to improve the understanding of the relationship between ESG ratings and information efficiency in capital market for Chinese listed companies. An additional aim of this dissertation was to understand the different effects of the impact of ESG ratings on information efficiency in different environments, including accounting conservatism, the nature of different property rights, and COVID-19. Multiple regressions were run to understand what extent and what paths, during years ranging 2020-2021, was there an explanatory relationship between ESG ratings and information efficiency in capital market for Chinese listed companies, defined as NCSP, stock mispricing, and stock price crash risk.

From the perspective of ESG ratings and NCSP, there were three hypotheses associated with the first research question. For hypothesis 1a, the findings showed that corporate ESG ratings had a significantly positively impact on NCSP after controlled other variables, year and industry effect, which was significant at 1% level. The results remained unchanged after using the MBF, instrumental variable estimation, Heckman two-step method, lagging the independent variable by One year, and using Logit model. The results indicate that one level increasing in ESG ratings can lead to 12.8% increase in NCSP. It suggests that the higher the ESG ratings, the higher the NCSP. For hypothesis 1b, the results proved that information asymmetry played a mediating effect between the ESG ratings of companies and the NCSP, which was significant at 1% level. This also showed that enterprises with good ESG performance have low information asymmetry, which can better convey business information to investors and enhance NCSP. For hypothesis 1c, the test results proved that TAI moderated the connection from ESG ratings to information asymmetry, which was significant at 10% level, such that relationship was stronger for regions with high-as opposed to low-levels of TAI. For hypothesis 1d, the test results proved that dynamic capabilities moderated the two variables, which was significant at 5%, such that relationship was stronger for companies with high-as opposed to low-levels of dynamic capabilities. Further study results showed that the learning and absorption capabilities played the most important effect, which was significant at 1% level.

135

From the perspective of ESG ratings and stock mispricing, this dissertation also proposed three hypothesis which were associated with the second research question. For hypothesis 2a, the results showed that there was a significantly negative relationship between ESG ratings and stock mispricing, which was significant at 1% level. After a series of robustness test, including the MBF, instrumental variable estimation, Heckman two-step method, lagging the independent variable by One year, and using fixed effect model, the results remained unchanged. As for economic significance, the results indicated that one level increasing in ESG ratings can lead to 7.0% decrease in stock mispricing. It suggested that the higher the ESG ratings, the lower the stock mispricing. For hypothesis 2b, the results showed that information asymmetry played a mediating effect between the ESG ratings of companies and the stock mispricing, which was significant at 1% level. That meant corporate ESG ratings can reduce stock mispricing by alleviating information asymmetry. For hypothesis 2c, the interaction term between ESG ratings and TAI was negatively and significantly related to information asymmetry at 1% level, that proved TAI played a moderating role, such that relationship was stronger for regions with high- as opposed to low-levels of TAI. For hypothesis 2d, the findings showed that the interaction term between ESG ratings and dynamic capabilities was negatively and significantly related to information asymmetry at 5% level, that proved that dynamic capabilities can moderate the above variables, such that relationship was stronger for companies with high-as opposed to low-levels of dynamic capabilities. Further study results showed that the learning and absorption capabilities played the most important effect, which was significant at 1% level.

From the point of view of ESG ratings and the risk of a stock price crash, there were three hypotheses related to the third research question. For hypothesis 3a, the regression coefficient of ESG ratings on the risk of a stock price crash was significantly negative at the 1% level of significance. The results remained unchanged after the use of the MBF, the estimation of instrumental variables, the Heckman two-step method, the lagging of the independent variable by one year and the change of the dependent variable. The results proved that the ESG performance of the companies reduced the risk of stock price crash, indicating that the better performance of the ESG responsibilities of the companies would help to reduce the risk of stock price crash and promote the stability of the Chinese capital market. Regarding Hypothesis 3b, the findings suggested that information asymmetries

136

were mediating the effect of ESG ratings on stock price crash risk. It can be seen that the mitigating effect of ESG performance on stock price crash risk was through the reduction of information asymmetry to a certain extent, and information asymmetry had a conductive role in this relationship. For Hypothesis 3c, the results proved that TAI moderates the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry, such that the relationship is stronger for regions with high versus low levels of TAI. Regarding hypothesis 3d, the results showed that dynamic capability moderates the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry, which is significant at the 10% level. The further results showed that the learning and absorptive capabilities and the coordination and integration capabilities had the most important effect, which were significant at the 1% and 10% levels, respectively.

As heterogeneity analysis based on accounting conservatism, this chapter selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of accounting conservatism on the relationship between ESG ratings and information efficiency. The results were as followed. Based on NCSP, the coefficient of correlation between ESG ratings and accounting conservatism was significant at the 1% level, which showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the NCSP of the capital market. Based on stock mispricing, the coefficient of correlation between ESG ratings and accounting conservatism was also significant at the 1% level. This showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the stock mispricing of the capital market. Based on stock price crash risk, the coefficient of correlation between ESG ratings and accounting conservatism was no significant at any level. This showed that accounting conservatism did not have a moderating effect on the relationship between ESG ratings and capital market information efficiency for China. The findings showed that the effect of accounting conservatism on ESG performance and information efficiency is different in the Chinese capital market. The possible reason is that the role of accounting conservatism in improving information transparency and quality is insufficient.

As heterogeneity analysis based on the nature of different property rights, this chapter selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore

the impact of the nature of different property rights on the relationship between ESG ratings and information efficiency. The results were as followed. Based on NCSP, the coefficient of the correlation between ESG ratings and state was no significant at any confidence level, which showed that the shareholding preference of northbound capital in sample listed companies paid little attention on the nature of property rights. Based on stock mispricing, the coefficient of the correlation between ESG ratings and state was significant at 1% confidence level, which proved that the impact of ESG ratings to stock mispricing in SOE companies are better than that in non-SOE companies. Based on stock price crash risk, the coefficient of the correlation between ESG ratings and state was no significant at any confidence level, which showed that the stock price crash risk in sample listed companies were not based on the nature of property rights.

As heterogeneity analysis around the COVID-19 period, this chapter selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of the COVID-19 on the relationship between ESG ratings and information efficiency. The results were as followed. Based on NCSP, the coefficient of the correlation between ESG ratings and NCSP was no significant at any confidence level, which indicated that there was no differential impact of ESG ratings on NCSP before and after the COVID-19 period. Based on stock mispricing, the coefficient of the correlation between ESG ratings and stock mispricing was significant at 1% confidence level, which indicated that there was the differential impact of ESG ratings on stock mispricing before and after the COVID-19 period. Based on stock price crash risk, the coefficient of the correlation between ESG ratings and stock price crash risk was significant at 1% confidence level, which indicated that there was the differential impact of ESG ratings on stock price crash risk before and after the COVID-19 period.

In chapter 5, a summary finding was provided. Followed by the implication, this dissertation tried to form the future research about ESG ratings.

CHAPTER 5

EVALUATION AND DISCUSSION

The purpose of this dissertation was to investigate the relationship between ESG ratings and the information efficiency of the capital market for listed companies in China. The dissertation employed the quantitative method for empirical analysis, the EWM for TAI calculation, and the Minimum Bayes Factor (MBF) for robustness testing. Of course, other methods were also employed to test robustness. The dissertation was a quantitative design using data gathering from two data sources. The first data source was obtained from the China Statistical Yearbook (2010-2021), China Torch Statistical Yearbook (2010-2021), and Economy Prediction System (EPS) Database. By using this data from 2010 to 2021 as the study sample, this dissertation computed the China's Provincial TAI, to the best of my knowledge, this is the first time the provincial TAI has been calculated. The second data source was WIND database for gathering Huazheng ESG ratings, while other financial data was obtained from the CSMAR database during 2010 to 2021 period. The use of ESG ratings was consistent with previous study (Wang et al., 2021; Lin et al., 2021; Tang, 2022; Tian and Tian, 2022; Deng et al., 2023). This dissertation evaluated the following variables: ESG ratings and information efficiency as measured by NCSP, stock mispricing and stock price crash risk, respectively. On the basis of benchmark regression, this dissertation further explored the mediating effect of information asymmetry, the moderating effect of TAI and dynamic capabilities. Additionally, the heterogeneity analysis included the impact of accounting conservatism, the nature of different property rights, and COVID-19.

This dissertation examined the relationship between ESG ratings and information efficiency in capital market for Chinese listed companies. The focus of this dissertation was to determine if there was a relationship between ESG ratings and information efficiency defined as NCSP, stock mispricing and stock price crash risk. Most scholars were positive about the economic consequences of enterprises' ESG rating or ESG performance. Previous studies have shown that good ESG performance can enhance the transparency of corporate information, improve the level of internal governance, and mitigate the agency problem (Eccles et al., 2014); it can aid in alleviating financing constraints faced by enterprises (Zhong and Gao, 2017), decreasing the cost of debt

(Eliwa et al, 2021) and mitigating financial risks (Shakil, 2021), fostering the development of high-quality enterprises (Ge et al., 2022), and ultimately promoting financial performance (Zhou et al., 2022) and enterprise value (Alareeni and Hamdan, 2020). As a form of non-financial investment, ESG investment not only enhances the social standing of companies, but also provides additional mechanisms and tools for companies to manage risks (Starks, 2009). Another study showed that good ESG performance help to improve the downside risks of firms (Verheyden et al., 2016) and prevented certain legal risks (Hong et al., 2019). However, some scholars have argued to the contrary. Becchetti et al. (2015) believed that although ESG activities reduced stakeholder risk, they increased the risk of firm characteristics, making stock returns more difficult to predict. In particular, in the absence of uniform standards for ESG information disclosure and legal system guarantees, managers may use loopholes to engage in rent-seeking behaviour, hypocrisy and information concealment (Brooks and Oikonomou, 2018). Over-investment in environmental protection, social responsibility and other activities to establish a good reputation had improved the ESG performance of companies, but it had increased the costs of companies and crowded out the resources available for investment, resulting in reduced investment efficiency (Liu et al., 2022). This sacrificed the interests of shareholders (Chen et al., 2018) and negatively affected the value of the company (Buchanan et al., 2018). It can be seen that existing studies have not reached a consensus on the economic consequences of firms' ESG performance, especially few studies payed attention to the relationship between listed firms' ESG ratings and information efficiency in Chinese capital market. In light of this, this dissertation intended to carry out exploratory research in this regard.

Amid efforts to attain carbon peak and carbon neutrality targets, and the opening up of China's capital market, an emerging country, the relationship between Environmental, Social, and Governance (ESG) ratings and information efficiency in capital market is a topic worthy of discussion. The capital market is essentially an information market, and its basic function is to guide the optimal allocation of resources by using the signal feedback mechanism of securities prices. The signal feedback effect of the security price depends on its efficiency in reflecting information. Due to the existence of information asymmetry, enterprise information is often not fully and timely transmitted to the capital market, which weakens its guiding function for resource allocation. Therefore, how to

improve the information efficiency in stock prices has become a key issue for the development of the capital market. ESG ratings serve as a crucial information intermediary in the capital market, facilitating the effective dissemination and diffusion of corporate information while improving stock pricing efficiency. Nevertheless, current literature reveals a research gap regarding the connection between ESG ratings and information efficiency in the Chinese listed company capital market.

The research question and the following sub-questions were based on existing research. The research questions and sub-questions were applicable to China, an emerging market. The general question addressed in this dissertation was whether and by what mechanism ESG ratings explain the information efficiency for Chinese listed companies. An additional question answered in this thesis was how internal and external factors affect the relationship between ESG ratings and information efficiency. The goal of this dissertation was to draw the attention of the Chinese capital market to ESG ratings, and to inform corporate managers and policy makers to improve the quality of ESG information disclosure, and promoted the construction and development of the ESG system. After defining the information efficiency in capital market as northbound capital shareholding preferences (NCSP), stock mispricing and stock price crash risk, this dissertation developed three research questions. Specifically, after establishing three variables of information asymmetry, TAI, and dynamic capabilities, this dissertation investigated the mediating effect of information asymmetry, and the moderated mediation effect of TAI and dynamic capabilities, respectively. Regarding the heterogeneity analysis, this dissertation examined the impact of accounting conservatism, the nature of different property rights, and COVID-19 on ESG ratings and information efficiency in capital market for Chinese listed companies. Previous studies have not put the above variables into a framework to examine the impact of ESG ratings on information efficiency in capital market for Chinese listed companies yet, and thus this dissertation here is the first systematic study on this topic.

The first question was an analysis about the relationship between ESG ratings and NCSP. Compared to the existing literature, Cornell (2021) discussed that the social benefits of the preference encourage investment in green technologies and help in coping with climate shocks and unexpected changes in environmental regulations, but at the cost of reducing investors' expected returns. Cao et al. (2022) discovered that SR institutions'

141

heightened focus on ESG can potentially impact the stock return model, and they observed that the mispricing signals for stocks held by SR institutions led to larger abnormal returns. Goldstein et al. (2022) used the expected equilibrium model to find that both traditional and green investors know about financial and ESG risks, but they have different preferences. Due to the heterogeneity of their preferences, the traditional investors and the green investors engage in opposite transactions on the basis of the same information. The dissertation's answer to the first question not only extends the relevant literature on ESG investment preferences, but also provides a new perspective for studying Northbound Capital, an important Chinese capital market participant. The results of the first question showed that ESG ratings had a significant positive impact on NCSP in the Chinese capital market, which suggested that the higher the ESG ratings, the higher the NCSP. The results also proved that information asymmetry played a mediating effect between ESG ratings and NCSP. The test results provided evidence that TAI can moderate the mediating role of information asymmetry, such that the relationship was stronger for regions with high as opposed to low levels of TAI. The test results provided evidence that dynamic capabilities moderated the relation from ESG ratings to information asymmetry, such that the relationship was stronger for companies with high as opposed to low levels of dynamic capabilities. Further investigation revealed that learning and absorptive capabilities had the most important effect.

The second question focused on the relationship between ESG ratings and stock mispricing. Mǎnescu (2011) used US firm data found that only community relations in ESG had a positive impact on risk-adjusted stock returns, which was not a compensation for risk but may be due to mispricing. Henriksson et al. (2019) discussed the method of mispricing in portfolios and found that, at the portfolio level, the overall portfolio tilts toward good ESG and away from bad ESG, rather than classifying the ESG of a single company. Bofinger et al. (2022) found that high ESG ratings were associated with high fund prices; the pursuit of higher fund sustainability leaded to excessive pricing of active funds. Stock mispricing was the reaction of stock price deviating from the real value of enterprises. The greater the divergence in investor opinion (Berkman et al., 2009) and the higher the agency cost (Pantzalis et al., 2014), the greater the degree of stock mispricing. The information efficiency of capital market is mainly embodied in the ability of securities prices to reflect information. The more fully the price reflects the information,

142

the more efficient the market information is. Therefore, this dissertation' answer to the second question deepens the understanding of the drivers of stock mispricing, which plays a guiding role for ESG investment in China's capital market. The results of the second question are different from the first. From the perspective of ESG ratings and stock mispricing, this dissertation found that ESG ratings had a significant negative impact on stock mispricing in the Chinese capital market. It suggested that the higher the ESG ratings, the lower the stock mispricing. The results also showed that information asymmetry played a mediating effect between ESG ratings and stock mispricing. That was, ESG ratings of companies can reduce stock mispricing by reducing information asymmetry. The results proved that TAI moderated the role of information asymmetry, such that the relationship was stronger for regions with high as opposed to low levels of TAI. The results also supported those dynamic capabilities moderated the above variables, such that the relationship was stronger for companies with high as opposed to low levels of dynamic capabilities. Further results showed that learning and absorptive capabilities had the most important effect.

The third question focused on ESG ratings and stock price crash risk. Currently, the existing research mainly focused on agency problem (Callen and Fang, 2015) and management information hiding (Jebran et al., 2019), analyzing the causes of stock price crash risk from two perspectives. Murata and Hamori (2021) used the sample of major market index components in Europe, the United States and Japan, and the research showed that ESG information disclosure reduced the risk of future stock price crash; however, the effect and predictive ability of ESG information disclosure varies across regions. Bae et al. (2021) studied how the relationship between ESG rating and the risk of stock price crash was affected by the degree of financial constraints. Feng et al. (2022) considered stakeholder and institutional explanations and discussed the relationship between ESG rating and the risk of stock price crash. However, few studies have linked the ESG rating of Chinese companies with the stability of capital market in the context of sustainable development, especially the lack of mechanism analysis. The stability of the capital market is related to the security of China's economic development, and the ESG performance of companies is the key content under the "double carbon" goal. Therefore, it is of great significance to combine Chinese "carbon neutral and peak carbon dioxide emissions" framework with the prevention and resolution of systemic financial risks, so

143

as to solve the lack of motivation for enterprises' green transformation, reduce the risk of stock price crash and promote high-quality economic development. The results of the third question are similar to those of the second question, except for individual differences. From the perspective of ESG ratings and stock price crash risk, this dissertation found that ESG ratings had a significant negative impact on stock price crash risk in the Chinese capital market, suggesting that the better performance of corporate ESG responsibilities would help reduce the risk of stock price crash and promote the stability of the Chinese capital market. The results suggested that information asymmetry mediated the effect of ESG ratings on stock price crash risk. For TAI, the results proved that TAI moderated the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry, such that the relationship was stronger for regions with high versus low levels of TAI. With respect to dynamic capabilities, the results showed that dynamic capabilities moderated the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry. Further results showed that learning and absorptive capabilities and coordination and integration capabilities had the most important effect.

The first heterogeneity analysis focused on accounting conservatism. Accounting conservatism is a fundamental principle in business accounting, with the objective of assessing the quality of accounting information (Watts, 2003). Previous literature has indicated that accounting conservatism can enhance investment efficiency (Lara, 2016) and prevent management from misusing cash (Louis, 2012). In unfavorable macroeconomic conditions and financial constraints, management tends to prioritize accounting conservatism over corporate social responsibility (CSR). However, Shen et al. (2021) demonstrated that CSR can effectively promote accounting conservatism in China. Despite the close relationship between CSR and accounting conservatism, the role of ESG, beyond its association with social responsibility, remains under-explored. It is worth investigating the potential role of accounting conservatism in the connection between ESG ratings and information efficiency in the Chinese capital market. Based on NCSP, the results showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the NCSP of the capital market. Based on stock mispricing, the results indicated that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the stock mispricing.

144

Based on stock crash risk, the results showed that accounting conservatism did not have a moderating effect on the relationship between ESG ratings and capital market information efficiency for China. These interesting results indicated that the effect of accounting conservatism on ESG performance and information efficiency was different in the Chinese capital market. The possible reason is that the role of accounting conservatism in improving information transparency and quality is insufficient. The second heterogeneity analysis concerned the nature of different property rights. The nature of property rights is an eternal topic in the study of China. Based on NCSP, the results showed that the shareholding preference of northbound capital in the sample listed companies payed little attention to the nature of property rights. Based on stock mispricing, the results proved that the impact of ESG ratings on stock mispricing was better in SOE firms than in non-SOE firms. Based on stock price crash risk, the results showed that the stock price crash risk in the sample listed companies was not based on the nature of property rights. The third heterogeneity analysis focused on the COVID-19 period. Based on NCSP, the results indicated that there was no differential impact of ESG ratings on NCSP before and after the COVID-19 period. Based on stock mispricing, the results indicated that there was a differential impact of ESG ratings on stock mispricing before and after the COVID-19 period. Based on stock crash risk, the results indicated that there was the differential impact of ESG ratings on stock crash risk before and after the COVID-19 period.

Additionally, this dissertation computed TAI to reflect the China' provincial regional innovation. TAI is a metric used to evaluate and rank the technical achievements of regions such as countries, continents, and historical periods. However, the prior literature lacks an assessment of a country's provincial TAI evolution. In China, an emerging country that has prioritized technological achievement in recent years, understanding the development level of technology in its provinces is an important topic. Desai (2002) calculated TAI for 72 countries to measure technology achievement, while Archibugi and Coco (2004) improved the TAI for numerous countries by proposing new indicators. Ali et al. (2014) calculated TAI for 34 Muslim countries in 2012, and Büşra (2022) examined TAI development rankings for more nations from 1990 to 2019. In most literature, four dimensions and eight indicators were utilized to measure TAI. In contrast, this study developed an index to depict the relationship between indicators and created a provincial

145

TAI for China from 2010 to 2021. To the best of our knowledge, this is the first instance of calculating China's provincial TAI.

146

CHAPTER 6

CONCLUSIONS AND FUTURE RESEARCH

6.1 Summary of the Study

This quantitative study was conducted to examine the impact of ESG ratings on information efficiency in the capital market for Chinese listed companies, using the period 2010-2021 as the study sample. The general problem addressed in this dissertation was whether and by what mechanism ESG ratings explain the variation in information efficiency of capital market for Chinese companies. An additional problem answered in this dissertation was how environmental factors affect the relationship between ESG ratings and information efficiency in Chinese capital market. The goal of this dissertation was to draw the attention of the Chinese capital market to ESG ratings, and to inform corporate managers and policy makers to improve the quality of ESG information disclosure, and promote the construction and development of the ESG system. After defining the information efficiency of the capital market as NCSP, stock mispricing and stock price crash risk, this dissertation developed three research questions to answer the above problems and achieve its goal.

Different from the previous literature, this dissertation focused on the mediating role of information asymmetry. At the same time, after establishing the two variables of TAI and dynamic abilities, this dissertation investigated the moderated mediation effect of these two variables on the relationship of ESG ratings and information efficiency of capital market for Chinese listed companies. Regarding the heterogeneity analysis, this dissertation examined the impact of accounting conservatism, the nature of different property rights, and COVID-19 on ESG ratings and information efficiency of capital market for Chinese listed companies. The chapter on literature review provided further confirmation of the importance and need for this dissertation. In terms of ESG-related work, the existing literature has focused on the relationship between ESG and business activities, corporate governance, corporate risk, cost of capital and corporate performance. Most studies have found that ESG practices can improve the efficiency of corporate operations and financial activities, reduce risks and thus access to more financing channels and greater sustainability, and ultimately lead to increased shareholder value. In the context of ESG ratings, the existing literature has focused on the impact of

147

ESG rating differences, the causes and the existence of the ESG rating "washing" phenomenon. In terms of ESG and the capital market, most studies confirmed that ESG is positively correlated with the stock market, bond returns, fund stability and stock returns. Successful ESG practices took into account the interests of stakeholders and sent positive signals that were well received by investors. In terms of ESG and dynamic capabilities, some literature has already found the effect of dynamic capabilities on sustainability performance. In addition, by examining TAI, this dissertation would deepen the understanding of technological innovation. Information asymmetry, TAI and dynamic capabilities will help to better understand the relationship between ESG ratings and information efficiency in the capital market for Chinese listed companies.

The study objectives and directions of this dissertation were discussed in detail in the study design of Data and Methodology. This dissertation described the quantitative methodology for the empirical analysis, the EWM for the TAI and the MBF method for the robustness test, which will be further carried out by other methods. This dissertation also explained the method used to collect the data and the variables to be used. Based on the research literature, the definition of the variables was explained and their selection was justified. Finally, this dissertation formulated the hypotheses of the questions and developed empirical models.

The results of the first research question revealed that ESG ratings had a significant positive impact on NCSP in the Chinese capital market. Specifically, the findings showed that corporate ESG ratings had a significantly positively impact on NCSP after controlled other variables, year and industry effect, which was significant at 1% level. The results remained unchanged after using the MBF, instrumental variable estimation, Heckman two-step method, lagging the independent variable by One year, and using Logit model. The results indicated that one level increasing in ESG ratings can lead to 12.8% increase in NCSP. It suggested that the higher the ESG ratings, the higher the NCSP. The results also proved that information asymmetry played a mediating effect between the ESG ratings of companies and the NCSP, which was significant at 1% level. This also showed that enterprises with good ESG performance have low information asymmetry, which can better convey business information to investors and enhance NCSP. The test results proved that TAI played a moderating role, which was significant at 10% level, such that relationship was stronger for regions with high-as opposed to low-levels of TAI. The test

148

results proved that dynamic capabilities launched the moderator from ESG ratings to information asymmetry, which was significant at 5%, such that relationship was stronger for companies with high-as opposed to low-levels of dynamic capabilities. Further study results showed that the learning and absorption capabilities played the most important effect, which was significant at 1% level.

The findings of the second question were different to the first question. From the perspective of ESG ratings and stock mispricing, this dissertation found that ESG ratings had a significant negative impact on stock mispricing in the Chinese capital market. In detail, the results showed that there was a significantly negative relationship between ESG ratings and stock mispricing, which was significant at 1% level. After a series of robustness test, including the MBF, instrumental variable estimation, Heckman two-step method, lagging the independent variable by One year, and using fixed effect model, the results remained unchanged. As for economic significance, the results indicated that one level increasing in ESG ratings can lead to 7.0% decrease in stock mispricing. It suggested that the higher the ESG ratings, the lower the stock mispricing. The results also showed that information asymmetry played a mediating effect between the ESG ratings of companies and the stock mispricing, which was significant at 1% level. That meant corporate ESG ratings can reduce stock mispricing by alleviating information asymmetry. The interaction term between ESG ratings and TAI was negatively and significantly related to information asymmetry at 1% level, that proved TAI play a moderating role, such that relationship was stronger for regions with high-as opposed to low-levels of TAI. The findings also showed that the interaction term between ESG ratings and dynamic capabilities was negatively and significantly related to information asymmetry at 5% level, that proved that dynamic capabilities have moderating effect from ESG ratings to information asymmetry, such that relationship was stronger for companies with high-as opposed to low-levels of dynamic capabilities. Further study results showed that the learning and absorption capabilities played the most important effect, which was significant at 1% level.

The findings of the third question were similar to the second question, with the exception of individual differences. From the point of view of ESG ratings and the risk of a stock price crash, this dissertation found that ESG ratings had a significant negative impact on stock price crash risk in the Chinese capital market. Concretely, the regression coefficient

149

of ESG ratings on the stock price crash risk was significantly negative at the 1% level of significance. The results remained unchanged after the use of the MBF, the estimation of instrumental variables, the Heckman two-step method, the lagging of the independent variable by one year and the change of the dependent variable. The results proved that the ESG performance of the companies reduced the risk of stock price crash, indicating that the better performance of the ESG responsibilities of the companies would help to reduce the risk of stock price crash and promote the stability of the Chinese capital market. The results of the study indicate that the relationship between ESG ratings and stock price crash risk is mediated by information asymmetries. Specifically, the study found that higher ESG performance mitigates stock price crash risk by reducing information asymmetry to a certain extent, suggesting that information asymmetry plays a significant role in this relationship. Additionally, the study found that the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry is moderated by TAI. The relationship is stronger for regions with high TAI levels compared to those with low TAI levels. Regarding dynamic capabilities, the results showed that dynamic capabilities moderated the strength of the mediated relationship between ESG ratings and stock price crash risk via information asymmetry, which was significant at the 10% level. The further results showed that the learning and absorptive capabilities and the coordination and integration capabilities had the most important effect, which were significant at the 1% and 10% levels, respectively.

As heterogeneity analysis based on Accounting Conservatism, this dissertation selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of accounting conservatism on the relationship between ESG ratings and information efficiency for Chinese listed companies. The results were as followed. Based on NCSP, the coefficient of correlation between ESG ratings and accounting conservatism was significant at the 1% level, which showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the NCSP of the capital market. Based on stock mispricing, the coefficient of correlation between ESG ratings and accounting conservatism was also significant at the 1% level. This showed that the ESG performance of companies with higher accounting conservatism played a stronger role in stabilizing the stock mispricing of the capital market. Based on stock price crash risk, the coefficient of correlation between ESG ratings and accounting

150

conservatism was no significant at any level. This showed that accounting conservatism did not have a moderating effect on the relationship between ESG ratings and capital market information efficiency for China. This interesting finding showed that the effect of accounting conservatism on ESG performance and information efficiency was different in the Chinese capital market. The possible reason is that the role of accounting conservatism in improving information transparency and quality is insufficient.

As heterogeneity analysis based on the nature of different property rights, this dissertation selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of the nature of different property rights on the relationship between ESG ratings and information efficiency. The results were as followed. Based on NCSP, the coefficient of the correlation between ESG ratings and state was no significant at any confidence level, which showed that the shareholding preference of northbound capital in sample listed companies paid little attention on the nature of property rights. Based on stock mispricing, the coefficient of the correlation between ESG ratings and state was significant at 1% confidence level, which proved that the impact of ESG ratings to stock mispricing in SOE companies are better than that in non-SOE companies. Based on stock price crash risk, the coefficient of the correlation between ESG ratings and state was no significant at any confidence level, which showed that the stock price crash risk in sample listed companies were not based on the nature of property rights.

As heterogeneity analysis around the COVID-19 period, this dissertation selected NCSP, stock mispricing and stock price crash risk as proxy variables to explore the impact of the COVID-19 on the relationship between ESG ratings and information efficiency. The results were as followed. Based on NCSP, the coefficient of the correlation between ESG ratings and NCSP was no significant at any confidence level, which indicated that there was no differential impact of ESG ratings on NCSP before and after the COVID-19 period. Based on stock mispricing, the coefficient of the correlation between ESG ratings and stock mispricing was significant at 1% confidence level, which indicated that there was the differential impact of ESG ratings on stock mispricing before and after the COVID-19 period. Based on the stock price crash risk, the coefficient of the correlation between ESG ratings and stock price crash risk was significant at 1% confidence level, which indicated that there was the differential impact of ESG ratings on stock price crash risk before and after the COVID-19 period.

151

The remaining sections of this chapter include the implication of this dissertation for the practical realm and academic researchers, the future direction on ESG rating study, and the limitations of this dissertation.

6.2 Implications

Based on the above conclusions, this dissertation proposes the following implications.

For listed companies, the advantages of ESG ratings provide them with long-term capital value, high social reputation and investment attractiveness especially northbound capital shareholding preference, reduce the information asymmetry of enterprises, reduce the mispricing and stock price crash risk, and can be recognized and trusted by the capital market. Therefore, listed companies should implement the ESG concept in the operation and management process, increase investment in the ESG field, continuously improve the ESG performance of enterprises, and improve the ESG ratings of enterprises. Listed companies should strengthen their business performance with the ESG concept, transform their own resource system and competitiveness, and ultimately achieve high-quality sustainable development of enterprises. At the same time, the dynamic capacities of enterprises, especially the learning and absorptive capacities, should be improved, which is conducive to reducing the information asymmetry and promoting the positive impact of ESG ratings on the information efficiency of the Chinese capital market. As better ESG performance can achieve better capital market performance, this coincides with the increasing attention of institutional investors to the ESG performance of listed companies. Listed companies should be more aware of their responsibilities and strengthen their mission and commitment. Under the background of China's carbon-neutral environmental protection policy, companies can achieve better performance in the capital market by better fulfilling their environmental responsibilities, which is a positive incentive for listed companies to better implement the carbon-neutral aims for China.

For government departments, they should continue to improve the corporate ESG performance evaluation system and information disclosure system, and implement rewards and punishments for corporate ESG performance. The government can give certain policy preferences to enterprises with good ESG performance, such as financing support, tax incentives and employment support, and increase the punishment for enterprises with poor ESG performance, increase the cost of violating laws and

152

regulations through administrative punishment, draw up negative lists, increase credit restrictions, etc., so as to guide enterprises to actively participate in ESG activities, strive to improve ESG performance, consciously disclose ESG information and improve the quality of ESG rating. The government should improve the ESG support system and measures of listed companies, strengthen the supervision of information disclosure in the capital market, encourage listed companies to better implement ESG practices, and provide institutional guarantee for achieving the "double carbon" goal and preventing and resolving financial market risks. Additionally, the government should study and build China's ESG standard system as soon as possible, integrate with international ESG disclosure standards and rating standards, strengthen data sharing among government departments, capital markets and third-party rating agencies, provide timely and accurate reference data for information users' decision-making, and improve the information efficiency of Chinese capital market. As pointed out in this dissertation, the ESG ratings of regions with higher TAI has a better impact on the capital market. Therefore, it is necessary to create an innovative atmosphere in the economic field and improve regional technological achievements, which is conducive to improving the information efficiency of the capital market and better promoting the positive impact of ESG ratings on the capital market. Furthermore, it is recommended that the government enhance the ESG information disclosure mechanism of enterprises by incentivizing them to improve their ESG performance and consciously disclose reliable and accurate ESG information to facilitate effective decision-making by stakeholders. Such efforts would improve the ESG disclosure mechanism and contribute to a complete logical chain of "ESG regulation and standards - sustainable investment driven by capital markets - sustainable operation of listed companies - high-quality development of economy and society".

For investors, strengthen the guidance, training and education of investors, improve their professional competence and information acquisition abilities, enable investors to form an investment concept based on enterprise value, avoid herd behaviour and speculative psychology, calm investor sentiment, and reduce the risk of stock mispricing and stock price crash risk. Since ESG ratings can effectively improve the market information environment and encourage management to reduce the implementation of earnings management, it has a certain reference value for investors' investment behaviour and pricing decisions. At the same time, investors should clarify the relationship between ESG

ratings and the stock market, reasonably use the rating results to make investment decisions, and provide relevant empirical evidence to strengthen the governance and regulation of ESG rating agencies.

For other stakeholders, give full play to the comprehensive role of external supervision factors such as securities analysts, auditors, media and internal governance factors of listed companies, form a joint force of internal and external parties to supervise and govern, curb its negative role, avoid its distortion of reflection information for personal gain, and guide it to play a good role. At the same time, encourage listed companies to actively and uniformly communicate ESG information, improve the ESG information disclosure environment of the whole capital market, so as to reduce market irrational factors, improve the corporate information environment and enhance the information efficiency of the capital market for China.

6.3 Future Research

Based on this study, this thesis presents three types of ESG research trends.

Firstly, research on the drivers and economic impact of ESG rating in the context of emerging markets. Compared to developed capital markets, the political system, economic environment, legal framework and cultural background of emerging markets are different from those of developed capital markets, which may affect the economic impact of ESG practices. Currently, there is little research on the impact of ESG practices on companies in emerging markets. Future research can examine the drivers and economic consequences of ESG rating in combination with the cultural background, economic environment and political system of emerging markets. For example, as an emerging market, China's unique corporate culture and traditional ideological culture provide a unique cultural background for ESG research in China. Whether the policy effect of promoting ESG rating in China has promoted the development of corporate ESG needs to be examined.

Secondly, further research on ESG disclosure and ESG ratings. In terms of ESG disclosure and ESG ratings, most studies have demonstrated the positive effect of ESG disclosure and discussed its influencing factors. The influence of ESG rating divergence, its causes and the "cleaning" phenomenon of ESG ratings are the current research hotspots that deserve further discussion. In addition, from the perspective of ESG rating

154

agencies, different countries should combine their own reality and establish a scientific and effective ESG rating standard system. In ESG rating, we should pay special attention to the quality of information disclosure and the real issues of ESG, and discuss how to avoid the "green-washing" behaviour of companies. In the era of big data, we can try to combine machine learning, artificial intelligence and other methods and technologies to develop quantitative tools for ESG rating.

Thirdly, Analyse by refining the research direction of ESG ratings. Different industries pay different attention to ESG ratings, and different forms of pollution and different ESG policies will have different impacts. In studying the influencing factors and economic consequences of China's ESG ratings, the future research can test which ESG policies are adopted in different industries, different regions and different life cycle stages, and which forms of pollution can be addressed to bring about the common improvement of economic and social benefits. Clean energy, low-carbon transport, green manufacturing, agricultural science and technology and other industries have become the main direction of ESG investment, so they are the key areas for future research. In addition, existing research has found that companies with higher ESG ratings have higher stock prices, but whether this means there will always be better returns in the long term needs more observation and future research.

6.4 Limitations

Firstly, this study uses the ESG rating introduced by China Huazheng ESG rating to measure the ESG performance of companies. However, as there is currently no unified and standardised ESG rating system in China, different rating agencies have not reached a consensus on the evaluation factors and standards of the same issue, so it remains to be seen whether the rating indicators selected in this study can be widely recognized.

Secondly, due to the availability of data, this study could not separate the data of the three dimensions of E, S and G to explore the impact of each dimensional rating on the information efficiency of the capital market. I hope that in the future, when the data is available, we will further explore whether the performance of ESG in all dimensions has a different impact on the information efficiency of China's capital market.

Thirdly, at present, research on ESG in China is still in its infancy, and there is little literature exploring the relationship between ESG rating and the capital market. Whether

155

the conclusions of this study are applicable to developed countries remains to be discussed in future literature.

156

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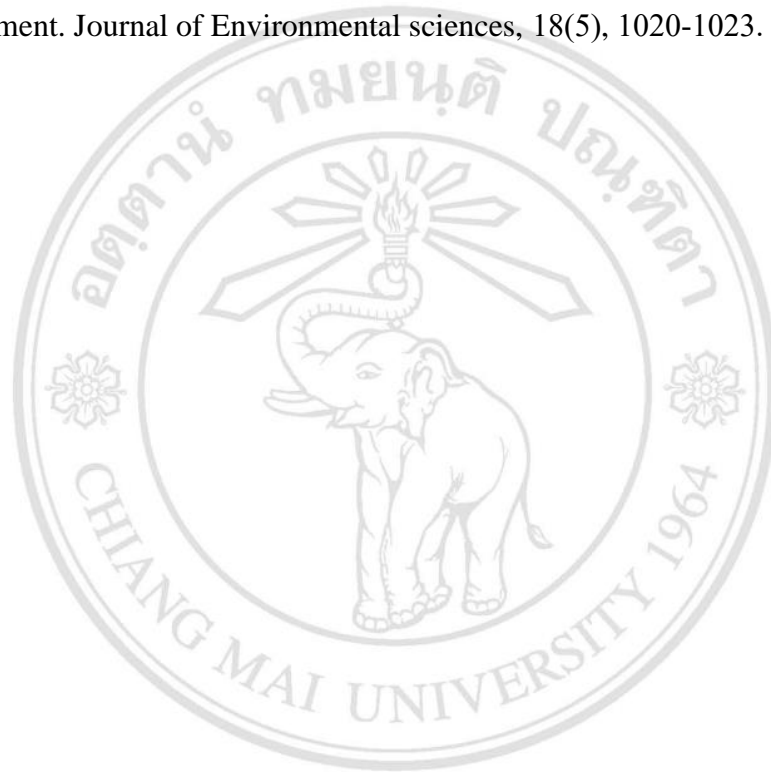
183

APPENDIX A

31 Provincial TAI for China from 2010 to 2021

Province	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Beijing	0.994	0.987	0.957	0.966	0.953	0.950	0.972	0.985	0.987	0.978	0.965	0.963
Shanghai	0.600	0.556	0.532	0.501	0.480	0.471	0.494	0.502	0.525	0.512	0.507	0.510
Zhejiang	0.346	0.354	0.309	0.336	0.326	0.365	0.367	0.416	0.447	0.463	0.458	0.484
Tianjin	0.421	0.456	0.439	0.415	0.423	0.430	0.432	0.431	0.436	0.420	0.439	0.441
Jiangsu	0.338	0.344	0.324	0.339	0.325	0.343	0.355	0.391	0.386	0.387	0.396	0.407
Guangdong	0.330	0.315	0.275	0.290	0.265	0.268	0.279	0.308	0.360	0.361	0.353	0.376
Fujian	0.216	0.235	0.227	0.227	0.216	0.213	0.205	0.227	0.230	0.217	0.228	0.234
Tibet	0.061	0.059	0.101	0.075	0.094	0.112	0.116	0.155	0.166	0.171	0.198	0.228
Shaanxi	0.212	0.215	0.220	0.216	0.213	0.206	0.207	0.207	0.201	0.210	0.223	0.227
Ningxia	0.134	0.180	0.167	0.154	0.153	0.150	0.164	0.183	0.197	0.180	0.195	0.204
Shandong	0.159	0.177	0.159	0.166	0.161	0.172	0.169	0.181	0.177	0.168	0.190	0.197
Chongqing	0.144	0.136	0.125	0.136	0.150	0.157	0.166	0.194	0.205	0.194	0.186	0.192
Jiangxi	0.034	0.055	0.061	0.044	0.048	0.060	0.061	0.075	0.095	0.119	0.149	0.186
Inner Mongolia	0.177	0.203	0.192	0.205	0.172	0.165	0.165	0.171	0.166	0.165	0.179	0.182
Hubei	0.130	0.143	0.147	0.135	0.138	0.148	0.148	0.157	0.158	0.156	0.173	0.181
Anhui	0.062	0.114	0.090	0.103	0.103	0.113	0.106	0.118	0.119	0.117	0.153	0.168
Sichuan	0.086	0.083	0.079	0.094	0.091	0.090	0.089	0.104	0.124	0.122	0.140	0.157
Jilin	0.136	0.141	0.140	0.126	0.161	0.160	0.177	0.170	0.140	0.134	0.159	0.156
Liaoning	0.224	0.222	0.201	0.205	0.198	0.182	0.177	0.181	0.159	0.150	0.158	0.154
Qinghai	0.144	0.170	0.203	0.139	0.158	0.153	0.156	0.170	0.191	0.167	0.150	0.150
Xinjiang	0.112	0.117	0.133	0.129	0.122	0.123	0.128	0.118	0.133	0.129	0.144	0.149
Gansu	0.071	0.088	0.076	0.083	0.079	0.091	0.087	0.135	0.124	0.125	0.130	0.147
Hebei	0.096	0.108	0.094	0.093	0.087	0.085	0.092	0.105	0.100	0.106	0.118	0.126
Hainan	0.114	0.120	0.111	0.115	0.108	0.123	0.131	0.124	0.137	0.146	0.124	0.123
Shanxi	0.135	0.147	0.130	0.161	0.133	0.118	0.101	0.123	0.119	0.121	0.117	0.122
Heilongjiang	0.113	0.110	0.107	0.096	0.106	0.105	0.106	0.121	0.098	0.088	0.108	0.110
Hunan	0.069	0.094	0.079	0.078	0.078	0.093	0.077	0.104	0.079	0.073	0.093	0.100
Guizhou	0.037	0.062	0.054	0.046	0.059	0.054	0.058	0.083	0.086	0.089	0.074	0.080
Guangxi	0.038	0.040	0.030	0.019	0.041	0.041	0.040	0.042	0.049	0.053	0.062	0.069
Henan	0.065	0.074	0.058	0.077	0.079	0.072	0.066	0.075	0.072	0.068	0.063	0.063
Yunnan	0.027	0.030	0.031	0.035	0.034	0.039	0.039	0.037	0.037	0.033	0.040	0.041

184

APPENDIX B

The topics in my dissertation are published as the followings:

Journal papers:

1) Wan, G., & Dawod, A. Y. (2022). ESG Rating and Northbound Capital Shareholding Preferences: Evidence from China. *Sustainability*, 14(15), 9152. (Published) (SCOPUS Q1)

2) Wan, G., Dawod, A. Y., & Nopasit, C. (2023). A Bibliometric and Visual Analysis in the Field of Environment, Social and Governance (ESG) Between 2004 and 2021. International Journal of Information Science and Management (IJISM), 21(2), 103-125. (Published) (SCOPUS Q3)

3) Wan, G., Dawod, A. Y., Chanaim, S., & Ramasamy, S. S. (2023). Hotspots and trends of environmental, social and governance (ESG) research: A bibliometric analysis. Data Science and Management. (Published) (SCOPUS Q2)

International conference papers:

1) Wan, G., Dawod, A. Y., & Chanaim, S. (2022, October). Dynamic Evolution of Technical Achievement in China's Provinces. *In 2022 International Conference on Engineering and Emerging Technologies (ICEET)* (pp. 1-6). IEEE. (Published and Presentation)

2) Wan, G., Dawod, A. Y., & Chanaim, S. (2023). Environmental, social, and governance (ESG) Ratings and Stock Mispricing: a Moderated Mediation Model. *The International Conference of the Thailand Econometric Society (TES2023)*. Springer International Publishing. (Acceptance for publication and Presentation)

3) Wan, G., Dawod, A. Y., Chanaim, S., & Ramasamy S.S. (2023). ESG Performance and Stock Excess Returns: Evidence from China. *7th Thailand International College Consortium International Conference 2023*. (Acceptance and Presentation)

185

APPENDIX C

Journal paper 1

ESG Rating and Northbound Capital Shareholding Preferences:

Evidence from China

Guochao Wan, Ahmad Yahya Dawod

The original article was published in Sustainability (Scopus Q1).

Wan, G., & Dawod, A. Y. (2022). ESG Rating and Northbound Capital Shareholding Preferences: Evidence from China. Sustainability, 14(15), 9152.

Journal paper 2

A Bibliometric and Visual Analysis in the Field of Environment, Social and Governance (ESG) Between 2004 and 2021

Guochao Wan, Yahya Dawod Ahmad, Chakpitak Nopasit

The original article was published in International Journal of Information Science and Management (Scopus Q3).

A Bibliometric and Visual Analysis in the Field of Environment, Social and Governance (ESG) Between 2004 and 2021

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A Bibliometric and Visual Analysis in the Field of Environment, Social and Governance (ESG) Between 2004 and 2021

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🌐 https://doi.org/10.22034/ijism.2023.1977765.0

Abstract
Environment, Social and Governance (ESG) has attracted increasing research interest for sustainable management and decision-making in recent years. In order to further understand the research status and trend, the purpose of this study is to adopt bibliometric and visual methods to analyze the knowledge structure and the evolution path in the research field of ESG. Based on 1735 papers on ESG in the Web of Science Collection database from 2004 to 2021, this study uses CiteSpace and VOSviewer to present a bibliometric overview of publications, citation structure, authors, universities, countries/regions, journals, and keywords that work on this Topic. Results indicate that scholars are increasingly regarding ESG as an integrated sustainability analysis framework and paying more attention to the connection among its different dimensions. According to the growth trend, ESG may remain a hot research topic for the next few years. The USA is the most productive country followed by England and China. Journals on ESG research with higher effective factors have higher co-citation frequency and higher publications. Sustainable development, corporate governance, corporate social responsibility, ESG, and ESG ratings as the research hotspots are presented. Additionally, this study provides an overview of the ESG research trends for future researchers. This may aid researchers in understanding current patterns and future study paths, allowing future authors to perform their studies more successfully.

Keywords
ESG   Bibliometric   Visual analysis   Research trends   Citespace   VOSviewer

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Journal paper 3

Hotspots and Trends of Environmental, Social and Governance (ESG) Research: A Bibliometric Analysis

Guochao Wan, Ahmad Yahya Dawod, Somsak Chanaim, Siva Shankar Ramasamy

The original article was published in Data Science and Management (Scopus Q2).

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Hotspots and Trends of Environmental, Social and Governance (ESG) Research: A Bibliometric Analysis

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Guochao Wan, Ahmad Yahya Dawod, Somsak Chanaim

The original article was published in in 2022 International Conference on Engineering and Emerging Technologies (ICEET). IEEE.

International conference paper 2

Environmental, social, and governance (ESG) Ratings and Stock Mispricing: A Moderated Mediation Model

Guochao Wan, Ahmad Yahya Dawod, Somsak Chanaim

The original article was accepted for publication in The International Conference of the Thailand Econometric Society (TES2023). Springer International Publishing.

International conference paper 3

ESG Performance and Stock Excess Returns: Evidence from China

Guochao Wan, Ahmad Yahya Dawod, Somsak Chanaim and Siva Shankar

Ramasamy

The original article was accepted for publication in *7th Thailand International College Consortium International Conference* 2023.

The 7th TICC International Conference: Conference Schedule

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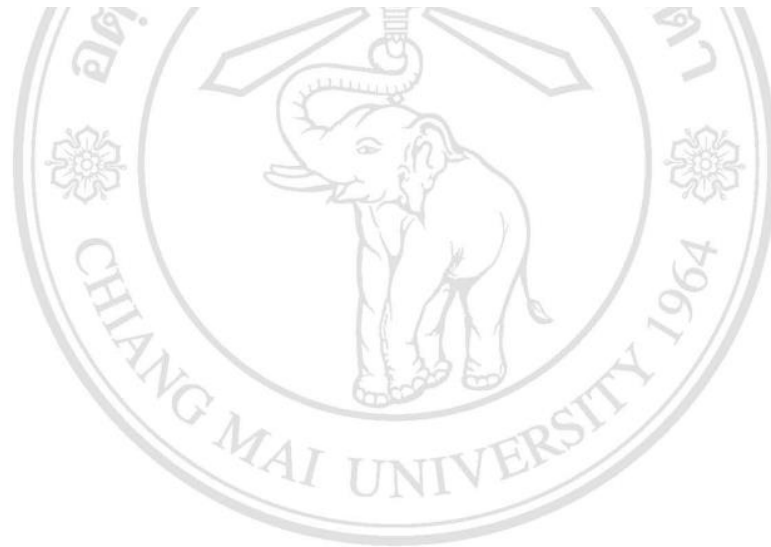周一 2023/1/30 17:52

📄 TICC7 Schedule.pdf ⌄

Dear **Guochao Wan**,

We would like to express our appreciation as well as our gratitude to all of you who support us. Congratulations to the authors who have had their manuscripts accepted for publication.

Kindly find the program schedule and the list of presenters as an attachment. Generally, the program for Contributed Talks will be divided into three sessions within two days of the conference (4-5 February 2023). Each presenter will have **20 minutes** to present the work (15 minutes for the presentation and 5 minutes for Q&A). The date, time slot, and room number of all presenters are presented in the attached file.

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194

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