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**THREE STUDIES IN FIRM ENVIRONMENTAL
INITIATIVES: STAKEHOLDER ANTECEDENTS AND
PERFORMANCE OUTCOMES**

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PhD

The Hong Kong Polytechnic University

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**Three Studies in Firm Environmental Initiatives:
Stakeholder Antecedents and Performance Outcomes**

Yuxiao Ye

**A thesis submitted in partial fulfillment of the requirements for the
degree of Doctor of Philosophy**

October 2019

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Abstract

In the past few decades, China has experienced prospering economic growth. However, the aggressive progress of industrialization and urbanization causes severe environmental problems in the nation. Environmental pollution induces widespread reflections: Is it possible for firms to reduce harm to the environment and the public as much as possible while sustaining strong economic growth? As the Chinese government is enforcing environmental regulations tightly, and the public is appealing to environmental protection, an increasing number of firms has involved in proactive environmental initiatives. While environmental initiatives cover a broad scope of practices, two types of environmental initiatives are identified to uncover the antecedent and outcomes of environmental initiatives. Environmental strategy is regarded as an upper-level decision, and its formation is dependent on the perception and orientation of managers. Thus, I unpack how environmental strategy is formulated from the managerial cognition perspective. On the other hand, ISO 14001 certification is a process-based standard at the operational level. As the implementation of ISO 14001 requires substantial inputs, it is of particular importance to consider the performance outcomes of ISO 14001. I now examine how ISO 14001 implementation influences operational risk, financial risk, and sales growth.

Study 1 investigates the impact of ISO 14001 adoption on operational risks, proxied by regulatory violations and casualties, and the moderating roles of government monitor and slack resources. Existing OM literature mainly evaluates the outcomes of environmental initiatives from an efficiency perspective. Nevertheless, it is less understood how environmental initiative could contribute to the well-being of people. The purpose of the study is to unveil whether saving the environment is a means of saving lives. The researcher collects data from multiple sources and uses propensity score matching and difference-in-difference analysis to draw the causal influence of ISO 14001 on operational risks. As such, I estimate the quantitative impact of ISO 14001 adoption on operational risks, while controlling for selection bias and

endogeneity. I also conduct the triple-difference model to examine the moderating impacts of government monitor and slack resources. Finally, a series of robustness tests and extension analysis is conducted to ensure that the results are reliable. This study shows that ISO 14001 adoption significantly decreases operational risks. For firms that receive government monitor, the impact of ISO 14001 adoption on casualties is strengthened. For firms with more slack resources, the impact of ISO 14001 adoption on regulatory violations is weakened.

Study 2 examines the impact of ISO 14001 adoption on financial risks and sales growth, and the moderating effects of certification time and industrial pollution level. Low financial risk and high sales growth are indicators for a firm's resilience performance. Following the signalling theory, I propose that ISO 14001 adoption demonstrates a firm's credibility and capability to its shareholders and customers, thus mitigating financial risk and enhancing sales growth. I employ propensity score matching and difference-in-difference models to test the hypotheses and then conduct robustness tests. The findings suggest that ISO 14001 adoption leads to paradoxical outcomes: it decreases financial risks and attenuates market growth simultaneously. Early certification exacerbates the paradox by reducing more financial risk and diminishing more market growth. Adoption of firms in high-polluting industries alleviates the paradoxical outcome by decreasing more financial risk and harming less market growth.

Study 3 investigates the impact of perceived stakeholder pressures on firm environmental strategy and the moderating effect of managerial value orientations. In this study, I focus on the antecedent of environmental initiative from the managerial cognition perspective. The finding shows that perceived competitive pressure is positively related to environmental strategy, while perceived social pressure does not affect. Managerial legal orientation is positively related to environmental strategy, while economic orientation does not show an effect. For the moderating effects, economic orientation positively moderates the impact of competitive and social

pressure on environmental strategy, while legal orientation negatively moderates the impact of competitive and social pressure on environmental strategy.

Keywords: Environmental initiatives; ISO 14001 adoption; Operational risk; Financial risk; Sales growth; Environmental strategy; Stakeholder pressure; Value orientation

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1 Introduction

1.1 Research background

1.1.1 Practical background

Over the past decades, we have witnessed the accelerated development of China with the Open Reform Policy and the rapid growth of the population. As the world factory, China is responsible for most production tasks in global value chains. According to the statistics in 2014, Chinese firms manufactured over 300 million items of personal computers, 100 million sets of air conditioners, and 800 million tons of crude steel, accounting for over half of the world total volume. Despite the enormous contribution of industrialization, it also gives rise to severe environmental problems that impose both immediate and chronic catastrophic consequences on the well-being of people.

Because many heavily polluting firms locate their plants in densely populated areas, environmental accidents take place in China occasionally. According to Greenpeace East Asia, there are on average 29 environmental accidents in China every month, leading to one casualty every 10 hours. Approximately 1,400 chemical leakage cases have occurred from 2006 to 2011, among which 19% resulted in death, and 30% caused injuries (Li *et al.*, 2014). Over 600 surface water accidents have taken place from 1985 to 2012, among which over 30% damaging human lives (Yao *et al.*, 2016). More recently, the massive chemical explosion in Tianjin led to about 1,000 casualties,

Taking a more chronic perspective, we have noticed that air, soil, and water pollution are the most significant problems in China. Among the most polluted cities in the world, half of them are located in China. A recent study by Berkeley Earth reveals that air pollution in China leads to 1.6 million premature deaths each year, and water pollution leads to many serious diseases as well. On the report of the statistics from the Institute of Public & Environmental Affairs (IPE), of all the 15,746 listed firms in China, 2,729 have committed to environmental violations, including 1,139 manufacturing firms. Furthermore, when the Chinese government initiated environmental inspections

across 28 northern cities in 2017, over 70% of the firms failed to comply with the environmental regulations.

The urgent environmental problems engender profound reflections: Can firms mitigate adverse influence on human well-being as much as possible while maintaining economic growth? Faced with increasing pressure from external stakeholders, firms are gradually aware of environmental protection and take initiatives in environmental management beyond regulatory requirements, such as obtaining ISO 14001 certifications, establishing environmental strategy, using recyclable energies, and conducting supply chain environmental management (Berrone and Gomez-Mejia, 2009; Christmann and Taylor, 2001; Darnall *et al.*, 2010; Liu *et al.*, 2015; Zhu *et al.*, 2007). Proactive environmental initiatives are voluntary, such that they bear few public monitoring costs (Liu *et al.*, 2010; Zhang *et al.*, 2008). Lenovo Corporate, for instance, enacts a policy to take action against climate change, including green procurement and green customer selection¹. Hair Corporate integrates environmental management in every stage of product life cycles and has continued to publish sustainability reports for over ten years². The number of Chinese firms obtaining ISO 14001 certifications ranks top in the world, and the increasing speed is second to none (Corbett and Castka, 2015).

While firms are actively engaging in environmental management, the expected outcomes are not well understood. Some studies suggest that corporate environmental initiatives do not improve performance. Two possible explanations are proposed. First, some firms may only reveal the bright aspect of environmental practices and spread propaganda about their proactive environmental initiatives, but the actual outcome of environmental initiatives does not exhibit (Boiral, 2007; Du, 2013). Second, the substantial efforts devoted to environmental initiatives may not lead to financial benefits in the short term, as a result of this suppressing firms' enthusiasm for environmental protection (Molina-Azorín *et al.*, 2009).

In summary, it is necessary to explore if environmental initiatives can mitigate harm

¹ Please refer to <https://www.lenovo.com/us/en/about/sustainability>

² Please refer to http://www.haier.net/en/social_Responsibility/

to human lives while sustaining economic prosperity. Moreover, understanding the motivations for firms to engage in environmental practice is essential to promote more involvement. I propose three questions about firm environmental initiatives that call for further investigation. The first question is whether corporate environmental initiatives are effective in minimizing adverse impacts on human life and health. The second question is whether corporate environmental initiatives are beneficial for reducing financial risk while boosting sales growth. The third one is what drives the adoption of corporate environmental initiatives. Perceived stakeholder pressure and managerial value orientations may impact the decision to establish an environmental strategy.

1.1.2 Theoretical background

In answering the research question of whether environmental initiatives are efficacious, previous literature has examined the relationship between environmental practices and environmental performance (e.g., pollution emission and regulatory compliance records). Most found a positive impact of environmental practices on environmental performance. Firms that adopt proactive environmental initiatives have a clear goal of environmental protection, commit to improving processes continuously, and emphasize firmwide involvement, thus enhancing environmental performance (Adebanjo *et al.*, 2016; Boiral and Henri, 2012; Gimenez *et al.*, 2012; Liang and Liu, 2017; Melnyk *et al.*, 2003; Potoski and Prakash, 2005a; Zhu *et al.*, 2007).

On the other side, some studies indicate that corporate environmental initiatives are not effective in improving environmental performance. A plausible reason is that firms adopt environmental initiatives merely to symbolic comply with stakeholder pressure, while the actual implementation is decoupled from substantial efforts. For example, Boiral (2007) suggested that obtaining ISO 14001 certifications is a myth given that firms pursue it for symbolic meaning and decouple from substantial implementation, and thus the relationship between environmental practices and environmental performance is not clear. Gomez and Rodriguez (2011) found that ISO 14001

certifications do not reduce pollutant emissions and exert minimal impact on environmental performance. Aravind and Christmann (2011) further distinguished between low- and high-quality of ISO 14001 implementation and found that low-quality implementation does not contribute to environmental performance.

Except for environmental performance, few studies focus on operational risk as the outcomes of corporate environmental initiatives. In the OM field, diagnosing and minimizing risk is critical (Hora and Klassen, 2013). Firms need to pay extra efforts to minimize operational risk since it is closely related to public health and safety (Zou *et al.*, 2015). Nevertheless, only in the field of quality and safety management can some related studies be found. As an example, Levine and Toffel (2010) found that ISO 9001 certifications can reduce safety accidents. Lo *et al.* (2014) also indicated that OHS 18001 certifications decrease safety accidents risk.

By investigating the relationship between ISO 14001 adoption and operational risk, the research provides compelling empirical evidence to answer whether ISO 14001 adoption, a particular form of environmental initiative, is valid. Besides, an important question is under what circumstances will ISO 14001 adoption be more effective (Boiral *et al.*, 2018; Endrikat, 2015; Sartor *et al.*, 2019)? This thesis attempts to narrow this gap by examining the moderating factors.

Research gap 1: The existing studies have not reached a consensus about whether ISO 14001 adoption is effective. As operational risk is closely related to public health and safety, it is essential to understand how ISO 14001 adoption is related to operational risk and under what conditions the relationship will be reinforced.

In answering the question of whether it pays to adopt corporate environmental initiatives, previous studies have employed survey, event study, or secondary panel data to examine the relationship between corporate environmental initiatives and financial performance, such as ROA, ROE, profit, Tobin's Q, and access to capital. Existing studies empirically support the positive effect of corporate environmental initiatives on financial performance (Brulhart *et al.*, 2017; Christmann, 2000; Darnall *et al.*, 2008a;

Eng Ann *et al.*, 2006; Feng *et al.*, 2010; Judge and Douglas, 1998; Ortiz-de-Mandojana and Bansal, 2016; Prajogo *et al.*, 2012; Sharfman and Fernando, 2008; Wahba, 2008; Zhu *et al.*, 2007).

However, some studies suggest that corporate environmental initiatives have a marginal impact on financial or market performance, or even produce antagonistic effects. An event study based on the U.S. listed firms found that announcements related to environmental practices receive adverse stock market reaction (Gilley *et al.*, 2000). Lam *et al.* (2016) conducted a similar event study in China and found that environmental initiatives result in negative stock returns. An explanation for the negative consequences could be that stakeholders deem environmental practices as a long-term and high-risk investment that could lead to short-term financial loss. Firms must devote substantial resources for upgrading green equipment and establishing environmental processes, with this significantly raising production costs. Accordingly, environmental initiatives are not favored by the market in this regard.

While the focus of existing studies has been on short-term financial performance, ISO 14001 adoption, a particular type of environmental initiative, may lead to potential and long-term financial benefits, such as decreased financial risk and market growth opportunities (Sharfman and Fernando, 2008). Ortiz-de-Mandojana and Bansal (2016) proposed that low financial risk and high market growth signal a firm's potential to prosper in the long run, namely achieving resilience. Together with answering the question of whether it pays to adopt environmental initiatives, another puzzle is when it pays to be green (Dixon-Fowler *et al.*, 2013; Riillo, 2017). At this moment, the research aims to understand the moderating factors in the relationship between ISO 14001 adoption and financial performance (Boiral *et al.*, 2018; Endrikat, 2015; Sartor *et al.*, 2019).

Research gap 2: Since there is no consensus about whether it pays to adopt ISO 14001, more empirical studies are encouraged to investigate the issue. Financial risk and market growth indicate firms' potential to develop in the long term, but the

understanding of how ISO 14001 adoption influences them is still lacking.

In exploring the antecedents of corporate environmental initiatives, previous studies have identified internal and external factors (Boiral *et al.*, 2018; Engert *et al.*, 2016; Gonzalez-Benito and Gonzalez-Benito, 2006; Heras-Saizarbitoria *et al.*, 2011; Lee *et al.*, 2018; Liu *et al.*, 2015). In regard with external factors, stakeholder or institutional pressure is most extensively studied (Berrone *et al.*, 2013; Boiral and Henri, 2012; Buysse and Verbeke, 2003; Clemens and Douglas, 2006; Darnall *et al.*, 2010; Yang *et al.*, 2018; Yu and Ramanathan, 2015; Zhu *et al.*, 2013). When faced with external pressure, firms need to implement environmental initiatives to gain legitimacy, retain customers, and promote market image (Darnall *et al.*, 2010; Henriques and Sadorsky, 1999). The internal factors include different motives, value orientations, capabilities, resources, and experiences (Aragon-Correa *et al.*, 2008; Bansal and Roth, 2000; Fryxell and Lo, 2003; Li *et al.*, 2016; Luan *et al.*, 2016; Zhu *et al.*, 2008). For example, Bansal and Roth (2000) proposed three main motives for adopting corporate environmental initiatives, namely winning competitive advantages, gaining legitimacy, and taking over social responsibility.

A few studies investigate and compare the effects of internal and external antecedents. Darnall *et al.* (2008a) found that both internal organizational capabilities and external institutional pressure are positively related to the adoption of environmental management systems. Qi *et al.* (2012) explored the impacts of a variety of internal capabilities and external motives on the substantial implementation of ISO 14001 certifications and indicated that only internal factors have significant effects. Besides, some studies probe into the interactive effects of internal and external antecedents (Berrone *et al.*, 2013; Darnall *et al.*, 2010; González-Benito and González-Benito, 2006; Kang and He, 2018). Berrone *et al.* (2013) indicated that regulatory and normative pressure influences the level of environmental innovation, and slack resources and specific assets moderate the relationship. Kang and He (2018) found that environmental orientation and innovation capabilities strengthen the impact of

institutional pressure on environmental strategy.

To summarize, existing studies have focused on institutional pressure, organizational capabilities, and value orientations at the firm-level. Typically, the adoption of environmental initiatives depends on the decisions of managers, who perceive external pressure and refer to their cognitive values. Nevertheless, except for Yang *et al.* (2018), González-Benito and González-Benito (2006), and Garcés-Ayerbe *et al.* (2012), few examine the role of managers in adopting environmental initiatives. Therefore, it remains necessary to investigate the drivers for environmental strategy from the perspective of managers.

Research gap 3: The existing studies have revolved around antecedents to the adoption of environmental strategy, such as institutional pressure, organizational capabilities, and corporate values, but only a few examines how external pressure and internal value orientation interact to influence environmental strategy. Even fewer literature considers the factors from the perception of managers.

1.2 Research objectives

To fill existing research gaps, the thesis attempts to investigate three research questions as described below. The first research question is to explore whether and when ISO 14001 adoption is effective in mitigating the harm to people. Specifically, I explore whether ISO 14001 adopters can effectively reduce operational risk. Since the substantial implementation of ISO 14001 certifications depends on external visibility and internal support, I consider government monitor and slack resources from the perspectives of the institutional theory and resource-based view, respectively. Besides, I collect archival data from multiple sources and use a rigorous econometric method to examine the hypothesized relationships.

The second research question is to understand whether and when ISO 14001 adoption is worthwhile concerning reducing financial risk and promoting sales growth. Explicitly, I draw from the signalling theory and examine the impact of ISO 14001

accreditations on long-term financial risk and sales growth. Obtaining an ISO 14001 certification sends a positive signal to investors, customers, governments, NGO, and the public that a firm is environmentally friendly, capable, and healthy, altering their perceptions and appraisals towards the firm (Berrone *et al.*, 2017; Su *et al.*, 2014; Toffel, 2005). Moreover, I explore certification time and industrial pollution levels as moderators that could affect the effectiveness of the signal. Similarly, data from multiple sources are collected, and econometric methods are used to examine the relationships.

The third research question is to investigate the antecedents to environmental strategy from the perspective of managers. I examine the impact of perceived stakeholder pressure and managerial value orientations on environmental strategy and explore the interactive effects. More specifically, two types of stakeholder pressure (i.e., competitive and social pressure) and two types of value orientations (i.e., economic and legal orientation) are identified. Managers would perceive different stakeholder pressure and make decisions on establishing environmental strategy following their value orientations.

Figure 1 summarizes the overall framework of the thesis, which is comprised of three inter-related studies. The purpose is to examine how firms formulate the decision to develop environmental strategy and how the actual implementation of ISO 14001 certification leads to operational and economic outcomes. In study 1 and study 2, I examine ISO 14001 adoption, as a type of environmental initiatives at the firm operational level, and its relationship with operational risks and economic outcomes. In study 3, I investigate the antecedent of environmental strategy, as another type of environmental initiatives at the decision-making level, from the managerial cognition perspective.

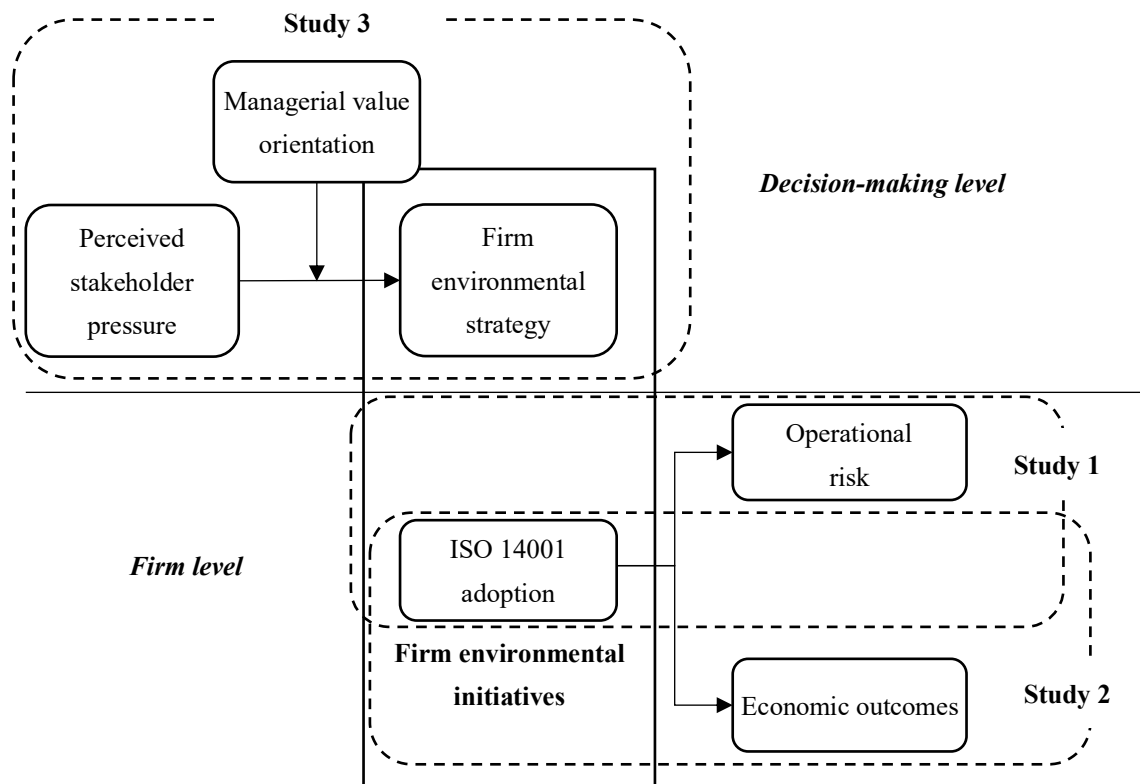


Figure 1 Overall framework

1.3 Significance of the thesis

The significance of the thesis resides in the contributions to the stakeholder antecedents and performance outcomes of firm environmental initiatives. First, the research provides a novel perspective and offers substantial empirical evidence to the question of whether environmental initiatives are effective. OM scholars tend to focus on efficiency and economic benefits, but hidden behind these visible measures are the burdens to the environment and human beings (Pagell *et al.*, 2015). Study 1 examines the relationship between ISO 14001 adoption and operational risk, bringing considerations for people’s well-being into sharp focus.

Second, the research adds empirical evidence for whether it pays to adopt corporate environmental initiatives. Based on the signalling theory, study 2 resolves a puzzle about the impact of ISO 14001 accreditations on financial risk and sales growth. Financial risk refers to the idiosyncratic volatility of stock returns. The higher the

financial risk, the more uncertain shareholders perceive about a firm's future financial stability (Bansal and Clelland, 2004; Lam, 2018; Luo and Bhattacharya, 2009). Sales growth, on the other hand, stands for a firm's potential to grow and prosper, indicating its full exploitation of existing resources and abundant opportunities (Mishina *et al.*, 2004). Low financial risk and high sales growth signify a firm's long-term and stable development. Investigating this relationship helps understand the potential and long-term influence of ISO 14001 adoption.

Third, the research brings in the managerial cognitive perspective, enriching the knowledge about the antecedents of corporate environmental initiatives. Little is known about how managers perceive external pressure and are influenced by their value orientations in pursuing an environmental strategy. Study 3 links the stakeholder theory to the managerial cognition perspective, contributing to the literature on corporate environmental initiatives.

Fourth, the research links corporate environmental initiatives to risk outcomes, including financial and operational risk, bridging the gap between environmental and risk management. Risk management has been a popular topic in recent years (Lewis, 2003). A high level of operational risk incurs tremendous financial loss, damages firm reputation, and requires substantial costs to recover (Hora and Klassen, 2013; Kleindorfer and Saad, 2005). Similarly, a high level of financial risk impairs a firm's stability of cash flow and weakens the anticipation of future development (Bansal and Clelland, 2004). By scrutinizing the relationship between ISO 14001 adoption and risk, the research contributes to the literature in risk management.

Last but not least, the research enriches empirical studies about Chinese firms' environmental initiatives. Due to the lack of existing database about environmental management, there is a scarcity of research using secondary data. Most studies using surveys suffer from common method bias and endogeneity concerns. Moreover, cross-sectional data are not applicable to examine causal relationships. In this thesis, I collected data from multiple sources and formed a unique secondary database, which

could be used to establish causal relationships.

1.4 Thesis structure

The thesis consists of six chapters. Chapter 1 introduces the research background from theoretical and practical aspects, summarizes existing research gaps, and raises research questions.

Chapter 2 is comprehensive literature about firm environmental initiatives and theories used in relevant studies. This chapter provides a foundation for the following three studies.

Chapter 3 is a study about the impact of ISO 14001 adoption on operational risk and the moderating effects of government monitor and slack resources. The purpose of this study is to explore whether and when corporate environmental initiatives are effective in saving lives.

Chapter 4 is a study about the impact of ISO 14001 adoption on long-term financial risk and sales growth and the moderating roles of certification time and industrial pollution levels. The objective of this study is to answer whether and when it pays to adopt environmental initiatives. More specifically, this study probes into whether environmental initiatives can maintain stability and boost growth simultaneously.

Chapter 5 is a study about the impact of perceived stakeholder pressure on environmental strategy and the moderating effect of managerial value orientations. This study aims to understand the antecedents of environmental initiatives from the perspective of managers.

Chapter 6 summarizes the general conclusion, elaborates on the theoretical contributions and managerial implications, discusses the limitations and areas of future studies.

2 Literature review

2.1 The concept of firm environmental initiatives

The firm environmental initiative is defined as the practice to minimize negative environmental impact and maximize positive environmental benefits (Gilley *et al.*, 2000; Jacobs *et al.*, 2010; Lam *et al.*, 2016). According to the literature on environmental initiatives, there are three categories: systematic and organizational practices, operational practices, and communication practices (Aragon-Correa, 1998; Buysse and Verbeke, 2003; Gonzalez-Benito and Gonzalez-Benito, 2006; Hart, 1995; Henriques and Sadosky, 1999; Sharma *et al.*, 1999).

The first type is formulating a firm-wide environmental strategy and communicating environmental management situation to stakeholders, including employees, supply chain partners, consumers, NGOs, governments, and the public (Buysse and Verbeke, 2003; Liu and Anbumozhi, 2009; Waddock *et al.*, 2002). These practices include having a proactive environmental strategy, disclosing voluntary environmental information, and cooperating with external stakeholders to promote environmental management.

The first type indicates that firms have adopted a systematic management approach, such as adopting voluntary environmental management system (EMS) or an ISO 14001 certification accredited by a third party (Christmann, 2000; Darnall *et al.*, 2008a; Potoski and Prakash, 2005a; Yin and Schmeidler, 2009). The commonality is that environmental management has become a systematic approach, including formulating environmental management policies, setting environmental protection goals, optimizing process practices, assessing environmental impact, and conducting employee training (Khanna & Anton, 2002; Kolk & Mauser, 2002; Prajogo *et al.*, 2014).

The third type represents environmental production and operational initiatives (Adebanjo *et al.*, 2016; Christmann, 2000; Handfield *et al.*, 2001; Klassen and McLaughlin, 1996; Lee *et al.*, 2018; Sarkis and Cordeiro, 2001; Singh *et al.*, 2014). These initiatives can be classified according to product-related and process-related

(Aragón-Correa and Sharma, 2003; Gilley *et al.*, 2000; Klassen and McLaughlin, 1996). Product-related practices refer to designing new environmentally friendly products or applying improved technologies to transform existing products. Process-related practices refer to adopting new production or distribution processes and carrying out reverse logistics (product recovery) to form a closed loop, such that waste pollutants are reduced during the process.

In this thesis, I focused on two particular types of environmental initiatives. The first one is proactive environmental strategy. The formation of environmental strategy is primarily based on the decision-making process of managers (Buysse and Verbeke, 2003; Darnall *et al.*, 2010). Managerial perceptions of external stakeholder pressure and internal value orientations would have a substantial impact on firm environmental strategy. The second one is ISO 14001 adoption, a systematic environmental management system. ISO 14001 certification is an internationally acknowledged process standard, and the implementation would lead to an overall improvement in operational processes and attract external recognition (Boiral *et al.*, 2018).

2.2 Firm environmental strategy

With more and more firms involving in environmental management, researchers have proposed different typologies of environmental strategy. At first, some scholars referred to corporate social responsibility (Carroll, 1979) and classified four types of environmental strategy: reactive, defensive, accommodative, and proactive. For example, Hunt and Auster (1990) proposed a five-phase environmental development path based on the degree of firms' initiative in environmental management: from the "beginner" who performs only the most basic environmental practices in the first phase to the "proactivist" that minimizes risk at the best effort in the fifth phase. Roome (1992) proposed five classifications, ranging from "non-compliance" with no concern for environmental management to "leading edge" that proactively becomes the industry standard. These classifications are based on a rough and broad understanding of

environmental strategy.

Further, researchers have adopted a taxonomy approach. That is, based on their understanding of environmental strategy, they used actual data for classification. For example, Aragon-Correa (1998) adopted a cluster analysis method and distinguished five types of environmental strategies based on Roome's (1992) topology classification. Buysse and Verbeke (2003) identified three types of environmental strategies: response strategies, pollution prevention, and environmental leaders. Su and Rhee (2007) provided four classifications: reactive, focused, opportunistic, and proactive strategy. Table 1 lists some of the main classifications for environmental strategies.

Table 1 Classification of environmental strategies

Author	Classification	Method
Hunt and Auster (1990)	Beginners, firefighters, concerned citizens, pragmatists, proactivist	Typology
Roome (1992)	Non-compliance, compliance, beyond compliance, commercial and environmental excellence, leading-edge	Typology
Berry and Rondinelli (1998)	Non-compliance, compliance with regulations, beyond compliance	Typology
Aragon-Correa (1998)	Non-compliance, compliance, compliance plus, environmental excellence, leading-edge	Taxonomy
Buysse and Verbeke (2003)	Reactive strategy, pollution prevention, environmental leadership	Taxonomy
Henriques and Sadorsky (1999)	Reactive, defensive, accommodative, proactive	Taxonomy
Su and Rhee (2007)	Reactive, focused, opportunistic, proactive	Taxonomy
Murillo-Luna <i>et al.</i> (2008)	Passive, attention to legislation, attention to stakeholders, total environmental quality	Taxonomy

According to researchers' classification, environmental strategy can be described as a continuum, with one end being reactive and the other end being proactive (Aragón-Correa and Sharma, 2003; Sharma and Vredenburg, 1998; Vastag *et al.*, 1996). Reactive environmental strategy refers to passively complying with legal requirements or dealing with environmental issues that have arisen. For such firms, environmental management is not included in the strategy, and environmental training for all

employees is not necessary. End of pipe solution can suffice the legal requirements (Sharma, 2000; Sharma and Vredenburg, 1998). In contrast, firms adopt proactive environmental practices to achieve a competitive advantage. For such firms, environmental management is a proactive strategic act that goes beyond legal requirements. Firms regard environmental protection as part of their overall strategy and formulate policies that change the organization's environmental management beyond the requirements of regulations, markets, and society to improve environmental performance (Aragon-Correa, 1998; Aragón-Correa and A. Rubio-López, 2007; Buysse and Verbeke, 2003; Sharma *et al.*, 1999).

2.3 ISO 14001 certification

ISO 14001 certification is an environmental management system based on internationally accepted standards, aiming to provide firms with a practical framework for establishing environmental management systems (Aragón-Correa and A. Rubio-López, 2007; Darnall, 2003; Gonzalez-Benito and Gonzalez-Benito, 2006). Since its establishment in 1996, ISO 14001 certification has been developed for more than 20 years and is the most widely adopted certification worldwide. Table 2 shows that the number of ISO 14001 certifications has shown a rapid growth trend in various countries, especially in China. The growth rate is very significant, highlighting the importance of investigating the role of ISO 14001 certification in China.

Table 2 Number of ISO 14001 adoption in the world

Country	1999	2001	2008	2015	Percentage in 2015	Percentage in 2015 scaled by GDP
China	222	1085	39195	114303	36.13%	2.37
USA	636	1645	4974	6067	1.92%	0.08
EU	7253	17941	78118	119754	37.5%	1.30
Japan	3015	8123	35573	26069	8.24%	1.36
World	13994	36464	188574	319324	100	1

Source: Heras-Saizarbitoria *et al.* (2018)

There are seven basic requirements for obtaining ISO 14001 certification: (1) formulate policies for environmental protection and obtain high-level support; (2) set targets in line with environmental protection policies; (3) conduct operational practices following the targets, and conduct employee training; (4) supervise the effectiveness of the practices; (5) conduct self-audits to correct problems found; (6) regularly review the entire management system; (7) continuously improve the effectiveness of the system to enhance environmental performance. These requirements are based on the best practices of the environmental management system, such that a closed-loop (plan-do-check-act circle) is established for planning, operation, inspection, and perfection processes (Toffel, 2005). ISO 14001 certification sets two goals for the firms: the promise to abide by environmental regulations and continuous improvement. The certification does not set an environmental performance goal that must be achieved by the adopted firm. Instead, it focuses on process improvement and setting flexible and achievable environmental targets (Melnik *et al.*, 2003; Potoski and Prakash, 2005b).

Firms need to invest considerable costs to obtain ISO 14001 certification (Bansal and Hunter, 2003; Potoski and Prakash, 2005b). According to an estimate, the cost of a third-party audit in the certification progress can exceed \$ 100,000, and other costs may be around \$ 250,000 to \$ 1 million (Bansal and Hunter, 2003). In practice, the costs include process transformation, staff training, and recruitment of external experts. In other words, to get ISO 14001 certification, firms need to invest a lot of visible and invisible sunk costs. Therefore, analyzing the performance outcomes of ISO 14001 certification is vital for firms.

2.4 Theories related to firm environmental initiatives

As more and more research pays attention to firm environmental initiatives, they adopt different theories to understand the antecedents and outcomes. In this section, I review the relevant theories involved in the literature of firm environmental initiatives, including the resource-based view (natural resource-based view), institutional theory, stakeholder theory, signalling theory, and other theories.

2.4.1 The resource-based view (Natural resource-based view)

The resource-based view (RBV) originates from Barney (1991). The theory proposes that resources follow two underlying assumptions: resources in the same industry may be heterogeneous; resources do not ultimately flow between firms. When a firm has valuable, rare, imperfect imitation, and hardly substitutable resources, it can gain a sustainable competitive advantage. In other words, the competitive advantage of a firm depends on its resources and capabilities (Wernerfelt, 1984). These resources and capabilities may be tangible, such as information technology, capital, equipment, or intangible, such as knowledge, intellectual capital, and commitment. Extending from the basic resource-based view, strategy theories such as knowledge-based view, relational view, and dynamic capability theory have emerged (Eisenhardt and Martin, 2000; Makadok, 2001). These theories further illustrate resources that can help firms gain a competitive advantage, including knowledge, strategic relationships between companies, and organizational capabilities. In particular, dynamic capability reflects the ability of a firm to continuously exploit existing resources, absorb new resources, allocate resources, and create competitive advantages in a dynamically changing environment (Eisenhardt and Martin, 2000). Therefore, the competitive advantage of a firm lies in its ability to develop, integrate, and coordinate different resources and capabilities.

RBV discusses the basis for establishing a competitive advantage from a general perspective. In the field of environmental management, Hart (1995) constructed a natural-resource-based view (NRBV), proposing that firms should gain a competitive advantage from their interactions with the natural environment. Although RBV suggests that the deployment of resources and capabilities can achieve a competitive advantage, the constraints of the natural environment may become an obstacle (Hart and Dowell, 2011). NRBV indicates three core strategies for firms to gain a competitive advantage: pollution prevention, product stewardship, and sustainable development. Pollution avoidance strategy has the characteristics of causally ambiguous. It

emphasizes that firms must continue to improve through approaches like total quality management to control pollution within the scope permitted by law, thereby establishing a cost-leading competitive advantage. The product stewardship strategy is socially complex, emphasizing reducing environmental pollution throughout the entire product life cycle (from raw material selection, production, distribution, packaging, consumption, to recycling), thus developing a product leading competitive advantage. The sustainable development strategy is a rare resource. It means the development of clean technologies and the establishment of a long-term vision with stakeholders in operational processes, thereby minimizing the burden on the environment. The three strategies represent three different phases, and each phase is interrelated, reflecting the characteristics of path dependence.

RBV and NRBV are one of the most widely applied theories in the research of firm environmental initiative. The literature using RBV and NRBV can be roughly divided into three categories. The first type of research considers environmental initiative as a critical resource or capability that can be a source of competitive advantage (Baek, 2017; Delmas and Montes-Sancho, 2009; Sharma and Vredenburg, 1998; Walls *et al.*, 2011). For example, Sharma and Vredenburg (1998) found that firms implementing a proactive environmental strategy have sturdy organizational capabilities, including stakeholder management, learning, and continuous innovation, such that they can operate at low costs, enhance reputation, maintain cohesive relationships with stakeholders, and gain a competitive advantage. Baek (2017) noted that obtaining ISO 14001 certification is beneficial for firms to improve operational efficiency, reduce production costs, and enhance customer satisfaction, thus gaining a competitive advantage.

The second type explores the complementary resources that can reinforce the implementation of environmental initiatives, such as top management support, managerial values, employee participation, supply chain coordination, and environmental munificence, that enable firms to implement environmental practices

better, leading to superior performance (Chen *et al.*, 2018; Christmann, 2000; Lucas and Noordewier, 2016). For instance, Christmann (2000) found that process and product innovation capabilities are complementary resources that moderate the relationship between best environmental management practice and cost advantage.

The third type of research explores the role of resources and capabilities in the development of environmental initiatives (Aragon-Correa *et al.*, 2008; Darnall, 2003; Darnall *et al.*, 2008b; Delmas and Montes-Sancho, 2011; Menguc *et al.*, 2010; Prajogo *et al.*, 2012; Sarkis *et al.*, 2010). As an example, Darnall and Edwards (2006) state that a firm's existing management system and practical experience (quality management systems, pollution reduction practices) and support from external stakeholders (from the parent company, government, third-party experts) are an essential foundation for the establishment of environmental management systems. Zhu *et al.* (2008) indicate that firm size represents the capacity of the resource pool, and large-scale firms have more financial resources and capabilities to implement environmental management. To sum up, RBV and NRBV are useful lenses to understand how firms build the foundation of environmental initiatives and how to gain a competitive advantage from these initiatives.

2.4.2 Institutional theory

The core notion of institutional theory is that in the same institutional field, firms maintain or obtain legitimacy by obeying the expectations of the institution (DiMaggio and Powell, 1983). An institutional field refers to the institutional ecosystem in which the focal firm, its suppliers, customers, regulators, and other similar organizations reside in (DiMaggio and Powell, 1983). Firms in the same institutional field are affected by institutional pressures consisting of similar values and norms, including coercive, imitative, and normative pressures, resulting in similar organizational structures and practices (DiMaggio and Powell, 1983). Among them, coercive pressure comes from formal and informal rules, which prompt firms to adopt relevant practices through coercion, punishment, and sanctions. The pressure of imitation is due to the uncertainty

of the environment. Firms follow the practices of other similar firms to meet the system requirements. Normative pressure comes from professional organizations or educational institutions. Managers are educated by these institutions to adopt socially recognized values and norms to change the structure and behavior of the organization (Baek, 2017; DiMaggio and Powell, 1983). Institutional theory points out that firms not only pursue economic interests as the priority but also recognize that social legitimacy is an essential source of long-term survival and competitive advantage for them (Berrone *et al.*, 2013; Suchman, 1995).

Institutional theory is one of the earliest theories applied to the studies of environmental initiatives (Bansal and Clelland, 2004; Delmas and Toffel, 2010). With environmental protection becoming a value and norm, firms in similar institutional environments can gain legitimacy by showing outstanding environmental performance (Bansal, 2005; Berrone and Gomez-Mejia, 2009). Based on this argument, a wealth of research topics are developed, such as the diffusion of environmental initiatives, the impact of environmental initiatives on performance, as well as the decoupling phenomenon.

First, in understanding why firms carry out environmental initiatives, the institutional theory holds that different institutional pressures can affect environmental practices (Boiral and Henri, 2012; Delmas and Montes-Sancho, 2011; Kang and He, 2018; Phan and Baird, 2015; Zhu *et al.*, 2013). For example, Boiral and Henri (2012) found that the adoption of ISO 14001 certification and the integration between environmental management and firm strategy are affected by institutional pressures. Zhu *et al.* (2013) investigated Chinese manufacturing firms and found that three types of institutional pressures drive firms to perform green supply chain management, thereby achieving triple-bottom-line performance.

Second, in light of the theoretical view that environmental legitimacy can bring value to firms, a series of studies have focused on the impact of environmental initiatives on different types of performances, especially financial performance. Many

firms gain legitimacy by adopting environmental initiatives and thus improving financial performance. Such findings answer the frequently asked question “answering the question "Does it pay to be green?". For example, Bansal and Clelland (2004) indicated that environmental management practices bring legitimacy and raise investors’ expectations for long-term and stable development, thereby reducing financial risks. Buysse and Verbeke (2003) suggested that proactive environmental strategy enables firms to integrate their stakeholders to gain a competitive advantage. Meng *et al.* (2012) conducted an event study and found that the market reaction to environmental information disclosure is positive, indicating that firms have obtained market legitimacy by publishing environmental information.

Finally, although firms can obtain legitimacy by complying with institutional pressures, such compliance does not represent a firm's actual practice (Meyer and Rowan, 1977). Decoupling refers to the fact that although a firm has abided by pressure on the surface and gained symbolic value, it has refrained from substantive investments in actual implementation (Aravind and Christmann, 2011; Christmann and Taylor, 2006). A series of studies have explored whether firm environmental initiatives are symbolic (Boiral, 2007; Montiel *et al.*, 2012). For example, Aravind and Christmann (2011) found that the implementation quality of ISO 14001 certification will affect the environmental performance of firms. For firms with lower implementation quality, ISO 14001 does not have any substantial help for environmental performance. Further, researchers investigate the circumstances under which environmental initiatives are genuinely useful. For example, Delmas and Montes-Sancho (2009) suggested that firms that joined environmental management agreement earlier are subject to higher political pressure and rely more on local governments, so they could conduct environmental practices with higher quality and reduce more pollution.

2.4.3 Stakeholder theory

A stakeholder is broadly defined as an individual or organization that affects or is affected by the firm (Freeman and Boeker, 1984). The core notion of the theory is that

corporate management should take into account the interests of all stakeholders, not just shareholders (Laplume *et al.*, 2008). Stakeholders influence the strategic choices and actual operations of a firm directly or indirectly (Henriques and Sadorsky, 1999). Regulatory stakeholders, including governments and trade organizations, can formulate regulations and sign trade agreements. Competitors can take the lead in developing new technologies and adopt new standards that affect the entire industry. Consumers have different preferences and expressions, and their intentions can be affected by opinion leaders. Consumers can even lead to protests and boycotts because of dissatisfaction with the firm. Employees are the foundation of all business activities, and they can form labor unions to express opinions and fight for their rights. The media can disseminate information and can significantly affect the firm's public image. Sharma and Henriques (2005) categorized stakeholders according to the level of dependence between firms and stakeholders.

Managers play an essential role in stakeholder management (Husted, 1998; Sharma and Henriques, 2005). Managers can directly perceive the needs of different stakeholders and make corresponding feedback based on their cognition (Henriques and Sadorsky, 1999; Mitchell *et al.*, 1997). Agle *et al.* (2006) proposed that managers judge the importance of stakeholders based on their perception of the power, legitimacy, and urgency of their stakeholders, and make decisions based on their value orientation.

The application of stakeholder theory to environmental initiative research falls into two categories. The first category focuses on the impact of different stakeholder pressures on environmental management practices (Garcés-Ayerbe *et al.*, 2012; Testa *et al.*, 2015; Wing-Hung Lo *et al.*, 2010; Yang *et al.*, 2018). Unlike institutional theory's classification of institutional pressure (coercive, normative, and imitative pressure), stakeholder theory distinguishes sources of pressure based on different stakeholder groups. For example, Wing-Hung Lo *et al.* (2010) studied the impact of government, industry, and community pressure on firms' tendency to participate in environmental management systems. Yang *et al.* (2018) investigated the impact of managerial

perceived business and social pressure on the adoption of proactive environmental strategy.

The second type of research revolves around how firms integrate with stakeholders in carrying out environmental initiatives (Buysse and Verbeke, 2003; Darnall *et al.*, 2010; Delgado-Ceballos *et al.*, 2011; Rueda-Manzanares *et al.*, 2008; Zhu *et al.*, 2007). For example, when firms face stakeholders of different importance levels, their environmental management practices may shift from simple pollution control to business process redesign (Buysse and Verbeke, 2003; Sharma and Henriques, 2005). Firms can further improve environmental performance by integrating environmental management with suppliers and customers in the supply chain (Zhu *et al.*, 2007).

2.4.4 Signalling theory

Signalling theory explains how firms may display their unobservable characteristics and capabilities to overcome information asymmetry (Connelly *et al.*, 2011). Signalling theory is derived from market signalling research by Spence (1974). Spence pointed out that there is a high degree of information asymmetry between candidates and recruiting companies in the talent market, but candidates can prove their ability through identifiable information such as university diplomas and competency certificates. Obtaining a college diploma requires substantive efforts, with this indicating that the candidate is diligent and intelligent. For a subject to be a reliable signal, it needs to meet two requirements: first, obtaining the subject requires considerable effort and money, and second, the benefits brought about by this subject should offset the costs of the investment.

Firms can demonstrate their environmental management level to external stakeholders by obtaining ISO 14001 certification, disclosing environmental information, and publishing corporate social responsibility reports. For example, ISO 14001 certification can be a signal for firms to demonstrate excellent environmental performance given that obtaining ISO 14001 certification requires considerable investment and that firms with excellent environmental performance can obtain

certification at relatively low cost (King *et al.*, 2005). In light of the rationale, some studies explore the selection effect of ISO 14001 adoption. For example, Bansal and Hunter (2003), Toffel (2005), and Heras-Saizarbitoria *et al.* (2011) found that firms with outstanding environmental performance and strong environmental orientation are more likely to obtain ISO 14001 certification. Mahoney *et al.* (2013) indicated that firms that publish CSR reports usually achieve better environmental performance. It can be concluded that through the signal function of environmental initiatives, stakeholders can distinguish firms with better environmental performance.

Another stream of research adopts the signalling theory to investigate the outcomes of environmental initiatives. Lam *et al.* (2016) focused on the reaction of stock investors to environmental initiatives of Chinese firms. Using signalling theory, Lam explained that investors have a more positive response to product-based, privately-held, and third-party certified environmental initiatives. Lam (2018) found that firms' sustainable practices in the supply chain can serve as a signal to reduce financial risk.

2.4.5 Other theories

Above, I review the main theories applied to studies about environmental initiatives, including the resource-based view, institutional theory, stakeholder theory, and signalling theory. Also, other theories have been applied at relatively low frequency.

Transaction cost theory attaches importance to the reduction of transaction costs in organizational relationships (Williamson, 1981). The source of transaction costs is bounded rationality and exchange partners' behavioral uncertainty. To reduce such uncertainty, firms have to invest in information search, contract formulation, supervision, and enforcement (Dyer, 1997). As firms must ensure that raw materials from their suppliers are environmentally friendly to meet customers' environmental needs, they need to pay for the cost of information search, contract development, and follow-up supervision of contract execution (Delmas and Montiel, 2009). By engaging in environmental initiatives, such as obtaining ISO 14001 certification, firms can reduce transaction costs and increase transaction efficiency (Tate *et al.*, 2011). Similarly,

King (2007) pointed out that firms having excellent environmental performance can reduce transaction costs and establish win-win cooperative relationships with stakeholders. Delmas and Montiel (2009) found that suppliers are more likely to obtain ISO 14001 certification when they are in a transaction with high asset specificity.

The managerial cognition theory holds that managers' observations and interpretations of the internal and external environments determine their strategic decisions (Gavetti and Levinthal, 2000; Kaplan, 2011). For environmental management, managers make decisions based on their values and perceived external pressures. For example, Yang *et al.* (2018) argued that managers determine the focus on environmental strategy based on their perceived institutional pressure. Schaltenbrand *et al.* (2018) found that when facing environmental pressure from consumers and communities, managers will decide their environmental investment strategy based on their perceived firm financial and market performance, as well as their working tenure. Table 3 summarizes the theories and their arguments on firm environmental initiatives.

Table 3 Theories on environmental initiatives

Theory	Arguments	Representative studies
Resource-based view	<p>Environmental initiative is a valuable resource and capability, which can bring a competitive advantage to a firm.</p> <p>The successful implementation of environmental initiatives requires the synergistic support of both internal and external resources.</p> <p>Firms need to acquire specific resources and capabilities as a basis to develop environmental management practices.</p>	<p>(Baek, 2017; Delmas and Montes-Sancho, 2009; Sharma and Vredenburg, 1998; Walls <i>et al.</i>, 2011)</p> <p>(Chen <i>et al.</i>, 2018; Christmann, 2000; Lucas and Noordewier, 2016)</p> <p>(Darnall, 2003; Darnall <i>et al.</i>, 2008b; Delmas and Montes-Sancho, 2011; Menguc <i>et al.</i>, 2010; Sarkis <i>et al.</i>, 2010)</p>
Institutional theory	<p>Firms are under the influence of coercive, imitative, and normative institutional pressures to adopt environmental initiatives.</p> <p>Through adopting environmental initiatives, firms gain environmental legitimacy and performance.</p> <p>Because external factors drive institutional pressure, firms may symbolically carry out environmental practices in order to obtain legitimacy, but decouple from actual practices.</p>	<p>(Baek, 2017; Berrone <i>et al.</i>, 2013; Delmas and Montes-Sancho, 2011; Heras-Saizarbitoria <i>et al.</i>, 2011; King <i>et al.</i>, 2005; Sarkis <i>et al.</i>, 2010)</p> <p>(Bansal and Clelland, 2004; Buysse and Verbeke, 2003; Meng <i>et al.</i>, 2012)</p> <p>(Aravind and Christmann, 2011; Boiral, 2007; Christmann and Taylor, 2006; Montiel <i>et al.</i>, 2012)</p>
Stakeholder theory	<p>Firms are under pressure from different stakeholders to implement environmental initiatives.</p> <p>Firms may integrate with stakeholders in developing environmental initiatives.</p>	<p>(Garcés-Ayerbe <i>et al.</i>, 2012; Testa <i>et al.</i>, 2015; Wing-Hung Lo <i>et al.</i>, 2010; Yang <i>et al.</i>, 2018)</p> <p>(Buysse and Verbeke, 2003; Darnall <i>et al.</i>, 2010; Delgado-Ceballos <i>et al.</i>, 2011; Rueda-Manzanares <i>et al.</i>, 2008; Zhu <i>et al.</i>, 2007)</p>
Signalling theory	<p>Firms show their environmental performance through visible environmental initiatives, thereby eliminating uncertainty and affecting stakeholder perceptions</p> <p>The adoption of environmental initiatives has a selection effect, which can distinguish</p>	<p>(Lam, 2018; Lam <i>et al.</i>, 2016)</p> <p>(Bansal and Hunter, 2003; Toffel, 2005) (Heras-</p>

	high-performance firms.	Saizarbitoria <i>et al.</i> , 2011; Johnstone and Labonne, 2009; Mahoney <i>et al.</i> , 2013)
Transaction cost theory	Conducting environmental initiatives can reduce transaction costs for exchange parties.	(Delmas and Montiel, 2009; King, 2007; Tate <i>et al.</i> , 2011)
Managerial cognition theory	Managers make strategic decisions based on their values and perceived external pressure.	(Schaltenbrand <i>et al.</i> , 2018; Yang <i>et al.</i> , 2018)

Based on Sartor *et al.* (2019)

3 Study 1: Saving the environment, saving lives: The impact of ISO 14001 adoption on operational risk

3.1 Introduction

Environmental protection has become a prominent issue around the world in the past few decades. Faced with increasing pressure from stakeholders, increased companies are voluntarily adopting environmental initiatives (e.g., ISO 14001 certification) for better environmental management. For example, IBM is pushing factories around the world to adopt ISO 14001 certification (Morrow and Rondinelli, 2002). ISO 14001 is the most widely used environmental management system accredited by an independent third party, and it requires firms to identify, measure, and control their environmental impact (Bansal and Hunter, 2003). By the year 2016, more than 360,000 companies worldwide have obtained ISO 14001 certification. Among them, more than 160,000 Chinese companies have obtained ISO 14001 certification, accounting for half of the world's total number.

Acquiring ISO 14001 certification requires firms to invest significant resources in improving operational processes in all aspects and making an active commitment to environmental management (Boiral *et al.*, 2018). According to a survey in the United States, if a firm that owns ten factories adopts ISO 14001, the initial cost sums up to \$0.25 to \$1 million. The following maintenance costs are also substantial, including time devotion, money investment, external experts hiring, and the continuation fees (Potoski and Prakash, 2005b). In this sense, it is curious why many firms adopt ISO 14001 certification. The critical point is that a firm's environmental management is unobservable to the outside world. Obtaining ISO 14001 certification enables a firm to demonstrate a sound level of environmental management to stakeholders, and may gain more favor than the uncertified firms (Toffel, 2005). ISO 14001 is a critical way for stakeholders to distinguish whether a firm is environmentally friendly or heavily polluting. Therefore, it is vital to study whether ISO 14001 is useful as a signal to external stakeholders.

Previous studies have extensively investigated the relationship between ISO 14001 certification and performance (Boiral *et al.*, 2018; Potoski and Prakash, 2005b; Qi *et al.*, 2012; Toffel, 2005; Yu and Ramanathan, 2015). Current research mainly focuses on the impact of ISO 14001 on environmental performance (Aravind and Christmann, 2011; Potoski and Prakash, 2005b; Yu and Ramanathan, 2015) and financial performance (Heras-Saizarbitoria *et al.*, 2011; Paulraj and de Jong, 2011). Few studies pay attention to operational risk, which I define as the risk that imposes potential or actual harm on human-beings due to misconduct or accidents in operational activities. In the field of operations management, it is crucial to study how to diagnose and reduce risks (Hora and Klassen, 2013). Operational risk has important implications for firm competitiveness, brand reputation, and financial performance (Kleindorfer and Saad, 2005; Maruchek *et al.*, 2011). In particular, as risk is closely related to public health and safety, firms need to pay more attention to reducing risk (Zou *et al.*, 2015). However, only in the area of quality and safety management emerges several articles exploring how firms can reduce operational risk. For example, Levine and Toffel (2010) found that ISO 9001 certification reduces the risk of injury and death of employees; Lo *et al.* (2014) indicated that OHS 18001 certification reduces the risk of safety incidents.

This study centers on two types of operational risks, namely regulatory violations and environmental casualties. I employ the two proxies as they represent two facets of operational risk. While regulatory violations represent the potential hazards that could have a long-term threat to human lives, environmental casualties are actual hazards that demonstrate severe and immediate harm to human lives. The risk of regulatory violations is subject to the violation of environmental regulations in operational activities (Dobler *et al.*, 2015). Firms that have violated environmental regulations may face punishment that takes forms of fines, suspension of production, and even the lawsuits according to the level of severity. At the same time, having regulatory violations implies that the firms have potential or chronic threats to the environment in their operational processes, such as emitting waste and not passing the environmental

evaluation. The risk of environmental casualties, on the other hand, is the threat and harm to the well-being of employees or the public caused by accidents in firms' operations. The accidents here cover environmental accidents and other safety incidents. The risk of regulatory violations and environmental casualties can lead to production inefficiencies, operational disruptions, stock price damage, government penalties, consumer boycott, and other consequences that significantly harm a firm's interests (Dobler *et al.*, 2014; Lo *et al.*, 2018; Toffel, 2005). More importantly, considering the social consequences, the risk of regulatory violations and environmental casualties may induce significant harm to the ecological environment and impose a long-term adverse impact on public health. Therefore, reducing operational risk not only enables firms to maintain a stable daily operational activity but also reduces harm to people.

The critical research question of this study is whether ISO 14001 certification can effectively reduce operational risk compared to firms without ISO 14001 certification. I adopt the lens of institutional theory and the resource-based view and propose that firms have both legitimacy and efficiency requirements. Specifically, I explored two moderating factors in the relationship between ISO 14001 and operational risk, namely government monitor and slack resources. From the perspective of institutional theory, the more supervision and control a firm receives, the more likely it will substantively implement environmental management practices (Marquis and Qian, 2014). From the perspective of the resource-based view, slack resources provide firms with substantial financial support for environmental initiatives (Darnall and Edwards, 2006). By comparing the roles of government monitor and slack resources, I further understand the contingency factors in the relationship between ISO 14001 and operational risk, as well as enhancing the understanding of two critical theories.

This study has an essential contribution to the literature. First, this study enriches the understanding of performance indicators, emphasizing the priority of people in operations management. Traditionally, in the field of operations management, scholars pay more attention to economic benefits and risks. However, there are many costs

hidden behind economic and efficiency-based benefits, which are less noticed in previous studies (Pagell *et al.*, 2015). In this study, these costs refer to the damage to health and the loss of lives. While the impact of ISO 14001 on financial performance is immediate and observable, its impact on operational risk is potential and underlying (Guerrero-Baena *et al.*, 2015). Second, this study enriches the contextual factors around the effectiveness of ISO 14001 adoption. By examining the moderating roles of government monitor and slack resources, I further understand under what circumstances will ISO 14001 adoption be more effective in reducing operational risk. Also, most existing studies so far have adopted a survey (Christmann and Taylor, 2006), and few employed objective data to test the outcomes of ISO 14001 certification. It is thus necessary to use archival data to assess the effectiveness of the certification better.

The main objective of this study is to test whether a voluntary environmental management system, namely ISO 14001 certification in Chinese firms, can effectively reduce operational risks. I adopt two different measures for operational risk: regulatory violations and environmental casualties. I collect secondary data from multiple sources, including firm certification, environmental violation, and news and announcements data, and employ rigorous econometric methods to test the hypotheses. First, I conduct a selection effect analysis to compare the pre-period differences in operational risks between firms that will obtain ISO 14001 certification and those that will not. Then, using the propensity score matching and the difference-in-difference methods, I construct a matched sample and examine the treatment effect to identify the actual impact of ISO 14001 on operational risk. Subsequently, a difference-in-difference model is used to test the moderating effects of government monitor and slack resources. Finally, I employ a series of tests, including the event study method, to verify the robustness of the results.

3.2 Theory and hypotheses development

ISO 14001 is a voluntary environmental management system. The intention of implementing ISO 14001 is to improve firms' environmental performance (Aravind and Christmann, 2011; Potoski and Prakash, 2005a; Yu and Ramanathan, 2015). To obtain ISO 14001 certification, a firm must follow a well-designed guideline and meet a set of requirements in operational processes (Aravind and Christmann, 2011; Bansal and Hunter, 2003; Boiral, 2007). First, the firm needs to thoroughly review its operational processes and identify possible negative impacts on the environment. Second, it should accordingly formulate an environmental management plan, determine the corresponding goals, and ensure its managers' full commitment to it. Third, it should implement designed policies by the specified plans and objectives. During the implementation stage, it is critical to communicate with employees, provide them with sufficient training and empowerment, and maintain clear records. Fourth, it needs to conduct environmental audits regularly to correct deviations in advance and ensure the achievement of established goals. Finally, it should review the entire system and continuously improve the level of environmental management. The whole process in obtaining ISO 14001 follows a plan-do-check-act (PDCA) circle (Moen and Norman, 2006), which is a continuous improvement process in terms of the system, the structure, the policy, and the goal.

It is worth noticing that ISO 14001 certification does not set a specific goal of environmental performance for a firm (Melnyk *et al.*, 2003). Instead, the certification helps firms to carry out a series of process improvement activities to minimize adverse impacts on the environment. During the processes, firms can have an in-depth understanding of their operational processes and the external impacts of the processes, pay more attention to top management commitment to the environment and emphasize the close involvement of employees, and also attach great importance to the audit, review, and continuous improvement of the system (Bansal and Hunter, 2003; King *et al.*, 2005; Prakash and Potoski, 2011).

3.2.1 The impact of ISO 14001 on operational risk

For a long time in the past, academics have been arguing whether environmental management practices can improve environmental performance and reduce operational risk (Aravind and Christmann, 2011; Boiral, 2007; Eccles *et al.*, 2014; Link and Naveh, 2006; Melnyk *et al.*, 2003; Nishitani *et al.*, 2012; Potoski and Prakash, 2005a; Qi *et al.*, 2012). In discussing whether ISO 14001 certification is valid, I employ two theories as complementary perspectives. The institutional theory holds that firms adopt ISO 14001 out of legitimacy purposes (Meyer and Rowan, 1977). Legitimacy is the core concept in the institutional theory, which means that the behavior of a firm should conform to the norms, values, beliefs, and definitions in the social system (Suchman, 1995). In implementing ISO 14001, firms should make sure they meet the requirements of stakeholders, including customers, governments, competitors, and NGOs (Bansal and Clelland, 2004; Li *et al.*, 2017b) and tend to seek risk-averse behavior (Bansal and Clelland, 2004; Berrone *et al.*, 2013). Operational risk entails high externalities, which threaten firms' legitimacy status. For example, the government may punish a firm with regulatory violations, and the public would blame for environmental casualties. Furthermore, adopting ISO 14001 helps firms to establish a positive image of excellent environmental management. To maintain this image, firms ought to adhere to stakeholder requirements and reduce operational risk (Lii and Lee, 2012). According to the rationale, I argue that firms that adopt ISO 14001 are driven by external pressure to maintain legitimacy, thereby reducing operational risk (He *et al.*, 2016).

While the institutional theory emphasizes the role of external pressure in shaping firms' behavior, the resource-based view stresses the significance of firms' capabilities and resources (Berrone *et al.*, 2013; Yin and Schmeidler, 2009). According to the resource-based view, adopting ISO 14001 is a way for firms to gain competitive advantages (Barney, 1991; Hart, 1995). ISO 14001 certification enables firms to acquire a range of sophisticated resources and capabilities to improve operational performance (Aragon-Correa *et al.*, 2008; Aragón-Correa and Sharma, 2003; Baek,

2017; Su *et al.*, 2015). These valuable resources and capabilities involve a mindset that puts people and the environment in the first place, a systematic management approach, a continuous improvement capability, and high-involvement human capital (Paiva *et al.*, 2008), which substantially help firms to reduce operational risk. Combining the institutional theory and resource-based view, I argue that ISO 14001 adoption reduces operational risk due to both legitimacy and efficiency reasons (Ataseven *et al.*, 2014; Christmann and Taylor, 2006). I further explain the mechanism as follows.

Adopting ISO 14001 certification is regarded as a means of obtaining legitimacy for firms, who may receive increasing attention from stakeholders. Meanwhile, firms with ISO 14001 certification have higher external visibility due to the involvement of external experts and audits by certifying organizations (Eccles *et al.*, 2014; Simpson and Samson, 2008). Once a firm commits an environmental violation or causes casualties, these records may be exposed to third parties and induce risk to the firm (Toffel, 2005). Due to the risk of information leakage and the motivation to maintain a positive image, firms tend to comply with requirements to reduce operational risk.

ISO 14001 certifications help firms to develop a mindset that puts human beings as a priority, a systematic management perspective, continuous improvement capabilities, and high-involvement human resources. First, ISO 14001 adoption changes firms' mindsets in operations management (Aravind and Christmann, 2011; Kitazawa and Sarkis, 2000). ISO 14001 requires firms to establish environmental goals, consider environmental impacts in every process, provide training for employees, and underscore environmental protection values in top management (Link and Naveh, 2006). Caring for the environment and people becomes one of the priorities for ISO 14001 certified firms, and such a value is deeply embedded in daily operational activities as well as in the minds of employees and managers, thereby driving firms to reduce violations and accidents. At the same time, ISO certification emphasizes a precautionary approach in designing and improving manufacturing processes (Levine and Toffel, 2010), thereby reducing accidents due to complex processes and tight

coupling (Perrow, 1984).

Second, ISO 14001 adoption enables firms to develop a systematic management approach, which can improve business processes in multiple ways (Delmas and Montes-Sancho, 2011). The implementation of ISO 14001 leads to a comprehensive improvement of organizational structures, processes, and knowledge base. During the period, firms can gain a deeper understanding of their operations and correct those unreasonable, irregular, and unsafe processes as early as possible, thus reducing operational risks (Kitazawa and Sarkis, 2000). At the same time, the certification calls for high involvement from different levels of employees and functional departments (Bansal and Hunter, 2003; Kitazawa and Sarkis, 2000). For example, the procurement department needs to work with the production department to understand the relationship between raw materials and pollution in production. The production department also needs to collaborate with the sales department to make sure the firm can satisfy the environmental needs of the customer. With systematic internal collaboration, firms reduce the risk of non-compliance and casualties.

Third, ISO 14001 enhances firms' capabilities to improve and learn continuously. Continuous improvement capabilities mean that firms are continually detecting and correcting problems. In the implementation of ISO 14001, firms would form an audit team to regularly assess conformity with certification requirements and identify deviations from the established goals. Specifically, the team needs to evaluate performance data, check equipment, and talk to the frontline workers about the actual implementation. If problems are identified, the team will take improvement measures to solve the problem fundamentally. This continuous improvement will fundamentally reduce the likelihood of regulatory violations and casualties. At the same time, ISO 14001 implementation requires external experts to provide guidelines (Prakash, 1999). Firms may absorb new knowledge and learn new technologies (Yang *et al.*, 2018). Also, certified firms could leverage support by foreign firms, governments, and NGOs as they reach a high level of their environmental standards, thus reducing risk (Rondinelli and

London, 2003; Yang *et al.*, 2018).

Fourth, ISO 14001 adoption enhances the quality of human capital (Brandon-Jones *et al.*, 2014). As employees are trained and empowered for better capabilities in environmental management, they can better adhere to regulations and protect themselves from accidents (Guerrero-Baena *et al.*, 2015). Meanwhile, employees are motivated and encouraged to demonstrate a strong commitment to environmental protection, and have a sense of identity with the organization (De Roeck and Delobbe, 2012; Morrow and Rondinelli, 2002). Based on the above arguments, I propose the following hypotheses:

H2a: ISO 14001 leads to lower operational risks in terms of regulatory violations

H2b: ISO 14001 leads to lower operational risks in terms of environmental casualties

3.2.2 The moderating effects of government monitor and slack resources

Firms may implement ISO 14001 certification substantively or symbolically (Boiral, 2007; Christmann and Taylor, 2006; Delmas and Montes-Sancho, 2009; Marquis and Qian, 2014). The effectiveness of ISO 14001 certification depends on a range of contextual factors. Researchers often use institutional theory and resource-based theory to explain the relationship between environmental management practices and performance (Berrone *et al.*, 2013; Boiral, 2007; Darnall *et al.*, 2008a; Hofer *et al.*, 2012; Sarkis, 2012). The institutional theory emphasizes that companies face external pressure, and the resource-based view highlights the internal resources that companies have, both of which may affect the relationship between ISO 14001 adoption and operational risk.

On the one hand, firms may sustain legitimacy by conforming to the requirements of external pressure. On the other hand, firms need to obtain competitive advantages by taking advantage of the resources they have. Legitimacy and resource abundance are two pillars for companies to survive and develop. Therefore, investigating the moderating effects of external pressure and internal resources deepens the

understanding of the role of ISO 14001 adoption. Existing studies have also explored the influence of pressure and resources in environmental management practices (Berrone *et al.*, 2013; Chen *et al.*, 2018; Li *et al.*, 2017a), yet they reached inconsistent conclusions. In this study, I rigorously examine the moderating impacts of government monitor and slack resources, enriching the empirical evidence in the literature.

The moderating effect of government monitor

According to the institutional theory, firms may adopt ISO 14001 certification to obtaining legitimacy by adhering to stakeholder pressure. Stakeholder pressure may stem from the government, the public, NGOs, and consumers, in which government monitor may be the overwhelming source of pressure (Marquis and Qian, 2014; Meng *et al.*, 2012; Zhu and Sarkis, 2007). Most previous studies examined the role of government monitor in the Western context (Wang *et al.*, 2018), while the understanding in emerging economies, especially China, is still insufficient (Marquis and Raynard, 2015). Moreover, the effectiveness of government monitor in China has been subject to many questions (Kang and He, 2018).

On the one hand, some scholars believe that China's institutional environment is not yet mature, the legal provisions are vague, and the government's enforcement of environmental regulations is low (Connelly *et al.*, 2011; Wei *et al.*, 2017; Yee *et al.*, 2014). Even worse, the local government sometimes turns into a "protective umbrella" that allows firms to violate regulations for economic benefits. Under such circumstances, the government monitor may not impose substantial pressure on firms. Instead, firms may assume that the government would allow violations of economic benefits because they are on the regulatory list.

On the other hand, some scholars suggest that institutional pressure, including regulatory pressure, is an essential factor driving environmental initiatives (Perez-Batres *et al.*, 2012; Zeng *et al.*, 2012; Zhu and Sarkis, 2007). With increasing emphasis on environmental protection by the Chinese Communist Party and the continuous

improvement of the environmental regulation system, the significance of regulatory pressure has been strengthened. At the same time, the Chinese government has been characterized by high coercive power and strong executive force, especially when the country puts environmental protection as a priority (Shu *et al.*, 2016; Wang *et al.*, 2018).

When a firm is on the monitor list, the government will pay closer attention to whether the firm complies with environmental regulations, such as environmental impact assessment, environmental protection inspections, and using of environmental protection equipment. The emissions of pollutants are also under a more intensive monitor. Under this pressure, firms will implement ISO 14001 more substantively in order to meet the government's requirements. Second, the government is the most important source of firm legitimacy. Especially in China, the political capital and political relations of firms are the critical ways to obtain critical resources (Li and Liang, 2015; Sheng *et al.*, 2011). If a firm does not satisfy the government's requirements, the government may use administrative means to punish the firm, including fines, rectification, and shutdown. Especially when there is a risk of regulatory violations or casualties in the firm, the government usually imposes severe penalties on it because of the strong externalities (Li *et al.*, 2017a). As a result, firms need to be more careful to maintain the legitimacy of ISO 14001 certification and try to reduce operational risk (Leonidou *et al.*, 2013). Finally, for firms under government monitor, its visibility in the eyes of the government is not only reflected in environmental violations or pollutant emissions, but also in their efforts to protect the environment. Firms may receive additional appreciation and encouragement from the government when they are ISO 14001 certified (Shu *et al.*, 2016). These incentives include access to scarce resources and specialized treatments such as tax cuts, environmental subsidies, special programs, and preferential policies (Sheng *et al.*, 2011). Therefore, government monitor will significantly enhance the enthusiasm of firms to carry out ISO 14001 certification substantively (Berrone *et al.*, 2013). Based on the above arguments, I conclude that government monitor can significantly enhance the effectiveness of implementing ISO

14001 certification. I propose the following assumptions:

H3a: The impact of ISO 14001 in reducing operational risks in terms of regulatory violations is reinforced when firms simultaneously receive government monitor

H3b: The impact of ISO 14001 in reducing operational risks in terms of environmental casualties is reinforced when firms simultaneously receive government monitor

The moderating effect of slack resources

Slack resources are additional resources available to firms (Cyert and March, 1963). Bourgeois III (1981) vividly described slack resources as a water-filled resource sponge. Firms can squeeze out additional resources to deal with threats or seize opportunities. Slack resources can often be classified into absorbed and unabsorbed slack resources, where unabsorbed slack resources are reconfigurable and mobile, which is more critical to the immediate needs of firms (Bourgeois III, 1981; Daniel *et al.*, 2004; Peng *et al.*, 2009). The main focus of this study is on unabsorbed slack resources. Based on the resource-based view, slack resources can support firms to innovate, promote strategic behavior, and improve performance (Su *et al.*, 2009). Having abundant slack resources means that the firm has sufficient resources to be deployed according to the needs of the environment and can even invest them in some risky projects. In other words, firms with sufficient slack resources can more efficiently respond to challenges and more fully seize opportunities without having to calculate the benefits and costs. For example, Fauzi and Idris (2009) found that slack resources can promote financial gains from CSR. Hendricks *et al.* (2009) found that slack resources will weaken the negative impact of supply chain disruption on stock prices. Bansal *et al.* (2015) indicated that firms with slack resources are still able to conduct substantive CSR during periods of economic depression.

According to the resource-based view, slack resources are a crucial source for companies to carry out a series of advanced activities, such as production process transformation, technology upgrades, and employee training following the

requirements of ISO 14001 certification. In order to meet the requirements of ISO 14001 certification, firms must continue investing without knowing whether these considerable investments will improve financial performance. Thus only firms with sufficient slack resources can continue to invest without worrying about short-term cost-benefit balance (Welch *et al.*, 2002). For many firms, achieving environmental and financial improvement are two conflicting goals (Endrikat *et al.*, 2014; Wright and Ferris, 1997). When resources are limited, firms tend to emphasize short-term financial performance while undermining expectations for environmental improvement. However, slack resources can alleviate goal conflicts and help firms pursue different goals at the same time (Daniel *et al.*, 2004; Su *et al.*, 2009; Xiao *et al.*, 2018). As a result, slack resources enable firms to concern less about the uncertain financial outcomes from ISO 14001 adoption and substantively implement ISO 14001 certification (Perez-Batres *et al.*, 2012; Surroca *et al.*, 2010). Firms with slack resources will increase their investment in R&D and high-risk innovation activities (Surroca *et al.*, 2010) and facilitate better implementation of environmental process innovation and technological innovation along with the ISO 14001 requirements (Christmann, 2000), thereby reducing operational risk. Besides, firms with high slack resources can provide employees with more dividends, training, and protection, cultivating employees who are highly committed to the requirements of ISO 14001 certification. These committed employees may also better understand the organization's goals and environmental requirements, thus reducing errors in the work and decreasing operational risks.

To conclude, ISO 14001 adoption can reduce operational risks more effectively when firms have more slack resources. I propose the following assumptions:

H4a: The impact of ISO 14001 in reducing operational risks in terms of regulatory violations is reinforced when firms simultaneously improve slack resources

H4b: The impact of ISO 14001 in reducing operational risks in terms of environmental casualties is reinforced when firms simultaneously improve slack resources

3.3 Methodology

3.3.1 Data collection

In order to test the hypothesis proposed in this study, I select the manufacturing firms (industry code: C13-C43) listed in China's Shanghai and Shenzhen stock markets from 2004 to 2016 as the sample pool. I choose Chinese manufacturing firms as the sample frame for several reasons: (1) environmental risks is a severe issue for Chinese firms; (2) relevant variables of operational risks are available: regulatory violations can be well tracked through an NGO named IPE; accidents and casualties can be obtained through government websites and news; (3) Chinese listed firms have relatively complete financial and operational data; (4) secondary data research on voluntary environmental management has been scarce.

This study focuses on manufacturing firms because they are an essential source of environmental pollution. By the year 2016, there are 2,100 listed manufacturing firms in China with a total of 27,300 firm-year observations. During 2004 and 2016, 1,318 firms obtained ISO 14001 certification and 782 companies that are never certified. I record each firm's stock codes, full name, and abbreviated name as a clue to matching across different databases. Appendix 1 summarizes the descriptive statistics of samples in terms of industries, regions, and adoption status.

The panel data are derived from multiple databases. The independent variable (ISO 14001 adoption) is obtained from the national certification and accreditation information public service platform³, which provides official inquiry service. By querying a firm's name, I record whether the firm obtains ISO 14001 certification and the earliest time of certification. At the same time, I also record information about the firm's access to other ISO certifications, such as ISO 9001, OHS 18001 certification. I gather 1,318 ISO 14001 certified companies and 782 uncertified companies between 2004 and 2016. I subsequently build a matched sample based on this data set.

Regulatory violations are from a public database collected by a non-profit

³ Please refer to <http://cx.cnca.cn/CertECloud/result/skipResultList>

organization named the Institute of Public and Environmental Affairs (IPE). In China, governments publish environmental violations online, but these announcements are scattered on the websites of all levels of government. Therefore, it has been a great challenge for researchers to collect scattered information from different sources. The emergence of IPE has changed all of this. As stated in the NGO's website, IPE is committed to collecting and analyzing open environmental information, integrating environmental data services for environmental procurement, environmental finance, and government environmental decision making. Through the joint efforts of firms, governments, non-profit organizations, research institutions, a large number of firms are encouraged to achieve environmental protection transformation and promote the improvement of environmental information disclosure and environmental governance mechanisms. Specifically, IPE collects regulatory violations announced by different levels of government in different regions and verify through other media sources (such as news and online reports) and corporate social responsibility reports. The data collected by IPE has been used in various papers, such as Wang *et al.* (2018) in the Strategic Management Journal, Lo *et al.* (2018) in Manufacturing & Service Operations Management, Xu *et al.* (2014) in Journal of Business Ethics. Therefore, I consider that obtaining regulatory violations through IPE is a reliable method. Using the firm name and stock code as keywords, I employ a web crawler to obtain violation data from IPE. I obtain a total of 5,580 environmental violations committed by 962 companies. I compile violations by the same firm in one year, yielding a total of 2090 firm-year observations.

The data of casualties are from news reports. I obtain accident data from the Wisenews database, which is the world's largest Chinese news database, with more than 1,900 Chinese newspapers and magazines. In previous studies, the database has been widely used (e.g., Lo *et al.*, 2018; Wiengarten *et al.*, 2020). I conduct a news search at Wisenews following the procedures in Appendix 2. After screening, the study obtains a total of 251 accident news records, of which 161 include casualty records.

The financial data of the sample firms are from the CSMAR database, which is the most widely used in China. CSMAR database is similar to CRSP, Compustat, Thomson, and other international well-known databases. CSMAR is the most comprehensive and accurate database of Chinese listed firms, including stocks, funds, bonds, financial derivatives, economics, industry, and other database products.

After the compilation of the dataset, I clean the data. As I will perform the propensity score matching method (PSM) and the Difference-in-Difference (DID), I need one year before and after the certification of ISO 14001. Thus, I exclude the sample firms which lack the required data. Table 4 shows how the data is developed.

Table 4 Dataset development

Steps	Description
1	Select the manufacturing firms (industry code: C13-C43) listed in China's Shanghai and Shenzhen stock markets from 2004 to 2016 as the sample pool
2	Identify firms that adopt ISO 14001 from the national certification and accreditation information public service platform
3	Identify firms that have regulatory violations from IPE
4	Identify firms that have casualties from Wisenews
5	Collect financial data and other control variables from CSMAR
6	Keep sample firms that have one year before and after the certification of ISO 14001

3.3.2 Variable measurement

Dependent variables

For operational risk, this study uses two sets of proxies. Regulatory violations come from the IPE website, which including air pollution, water pollution, government inadequate evaluations (such as being registered as a red environment by companies), and other violations (such as illegal emissions of harmful substances). According to previous studies, I consider all violations to be equally important (Lo *et al.*, 2014). Because the number of environmental violations has a strong relationship with the size of the company and the annual production volume of the company, I divide the number of regulatory violations per year by the company's sales (per million dollars) as a measure. Environmental casualties are from a news search at Wisenews. For each news

item that meets the criteria, I count the number of people affected in the accident. Similar to regulatory violations, the larger the firm or, the higher the production volume, the more accidents may occur, and the higher the possibility of environmental casualties. Thus, I divide the total number of casualties per year in the firm by the total sales of the company (per million dollars) as a measure of the environmental casualties.

Independent variable

I identify firms that receive ISO 14001 certification and record the year in which the firm is certified while verifying and supplementing the data through firm annual reports. ISO 14001 is measured by a dummy variable, coded as 1 if the firm has adopted ISO 14001 and 0 if not.

PSM matching variables

I review relevant literature and identify a series of variables that may affect the likelihood of ISO 14001 adoption. First, ISO 14001 adoption may be due to managers' tendency to operate in a highly institutionalized and structured manner (Toffel, 2005). The likelihood will also increase if the firm has acquired a series of capabilities to meet the requirements of ISO certification. Hence, firms that have obtained other certifications of management systems, such as *ISO 9001* (Quality Management System Certification) and *OHS 18001* (Safety Management System Certification), will increase the tendency to obtain ISO 14001 certification. I identify the firms' ISO 9001 or OHS 18001 certification status from the National Certification and Accreditation Information Public Service Platform, which is coded as one in the years of adoption.

Cross-listing of firms in the oversea stock market can affect the likelihood of ISO 14001 certification (Baek, 2017; King *et al.*, 2005; Peng *et al.*, 2014). On the one hand, compared with domestic investors, overseas investors may have higher requirements for environmental management. On the other hand, since there is more severe information asymmetry between firms and overseas investors, ISO 14001 certification

can serve to eliminate such asymmetry. I use a dummy variable coded as 1 for firms listed on the Hong Kong stock market or the U.S. stock market at the same time, and 0 for firms that are not cross-listed.

The resources owned by the firm may have an impact on certification adoption. Firms with better financial performance can allocate more funds to environmental management (Baek, 2017; Heras-Saizarbitoria *et al.*, 2011; Li *et al.*, 2017b). Therefore, I use return on assets (*ROA*) and *fixed asset turnover* as matching variables.

Financial leverage can affect a firm's ability to obtain certification (Baek, 2017; Przychodzen and Przychodzen, 2015). When investors evaluate the financial risks of firms, they pay increasing attention to the environmental performance of firms and whether they have an environmental management system. The more a firm is dependent on debt, the more efforts it needs to improve environmental management. At the same time, firms with sound environmental management practices have lower financing costs and can reduce costs by increasing debt (Sharfman and Fernando, 2008).

Firm age may affect whether the company is certified (Baek, 2017; Hudson and Orviska, 2013). There is no consistent answer to whether the relationship between firm age and certification is positive or negative. On the one hand, the older a firm is, the higher the pressure on the firm and the more resources it owns to adopt environmental certification. On the other hand, the younger the age, the more urgency the firm needs to obtain environmental certification to obtain legitimacy. This study uses the natural logarithm of the year minus the year of establishment of the firm to measure firm age.

Firm size may also be an essential factor (Darnall *et al.*, 2010; Simpson *et al.*, 2012; Zhu *et al.*, 2008). This study employs the *total assets* of a firm and the *number of employees* in natural logarithm as matching variables. Also, I add *lagged dependent variables* for a more accurate match. I adopt the mean of the outcome variables that are lagged for one and two years. *Years*, *industries*, and *regions* are also included as dummies.

Moderating variables

Slack resources indicate the availability of additional resources, which can be divided into unabsorbed and absorbed slack (Daniel *et al.*, 2004; Stan *et al.*, 2014). *Unabsorbed slack resources* are unutilized resources that are available (Bourgeois III and Singh, 1983), indicating that firms have resources to meet new needs and opportunities in the short term (Finkelstein and Hambrick, 1990). Cash flow is a type of unabsorbed slack resources. Having absorbed slack resources suggest that the expenditure of a firm is higher than actual needs. While the resources have been absorbed by the firm but can be restored when needed. For example, inventories represent a type of absorbed slack.

In comparison, unabsorbed slack is less expensive to use and is quickly available, while already absorbed slack has higher asset specificity and is difficult to be immediately redeployed by a firm (Tan and Peng, 2003). This study focuses on resources that are ready at any time, so I adopt unabsorbed slack resources that are measured by the ratio of current equities to total assets (Peng *et al.*, 2009). A high ratio indicates that a firm has abundant unabsorbed slack resources. That is, the firm can quickly extract resources from existing liquid assets to meet current demands.

Government monitor is measured by whether a firm is in the annual list of monitored firms announced by the Ministry of Environmental Protection⁴. The screening criteria for the list are based on a firm's discharge of wastewater, waste gas, and heavy metal pollutants in the previous year. The firms in the monitor list will be closely watched regarding pollution emission, and the information is revealed to the public regularly. Government monitor is a dummy variable with a value of 0 or 1. The summary of the statistics of the variables is in Table 5. Table 6 shows the correlation table.

⁴ Please refer to <http://www.mee.gov.cn>

Table 5 Summary statistics

Variable	Measures	Mean	s.d.	Min	Max
Regulatory violations	Number of regulatory violations/sales per million dollars	0.002	0.0221	0	1.456
Environmental casualties	Number of casualties / sales per million dollars	0.001	0.0114	0	0.515
Adopt ISO 14001 this year	Dummy coded as 1 if the firm adopted ISO 14001 in this year	0.062	0.2412	0	1
Has adopted ISO 9001	Dummy coded as 1 if the firm has adopted ISO 9001	0.295	0.4562	0	1
Has adopted OHS 18001	Dummy coded as 1 if the firm has adopted OHS 18001	0.019	0.1380	0	1
Cross-listing	Dummy coded as 1 if the firm is listed in Hong Kong or the U.S. stock market	0.027	0.1625	0	1
ROA	Profit / Total Asset	0.022	0.6008	-48.316	10.401
Total asset turnover	Sales income / total asset	6.903	126.8248	0.003	10485.580
Financial leverage	Debt / Total Asset	0.536	1.7763	0	96.959
Firm age	This year – established year	2.429	0.5061	0	3.555
Number of employees	Number of employees (log)	7.530	1.2072	0	12.140
Total assets	Total assets (log)	21.405	1.1728	16.508	26.961

The number of observations is 7514; The sample includes adopters before and in their adoption year and all years for nonadopters; Missing values are excluded.

Table 6 Correlations matrix

Variable names	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Adopt ISO 14001 this year	1.000											
(2) Regulatory violations	-0.016	1.000										
(3) Environmental casualties	0.004	0.005	1.000									
(4) Has adopted ISO 9001	0.128*	-0.024*	0.011	1.000								
(5) Has adopted OHS 18001	0.067*	-0.003	-0.005	0.076*	1.000							
(6) Cross-listing	-0.016*	-0.007	-0.007	-0.014	-0.009	1.000						
(7) ROA	0.009	-0.005	0.001	0.016	0.002	0.001	1.000					
(8) Total asset turnover	-0.006	-0.001	-0.002	-0.007	-0.002	-0.005	0.018	1.000				
(9) Financial leverage	-0.021	0.004	-0.002	-0.031*	-0.008	-0.003	-0.427*	-0.001	1.000			
(10) Firm age	-0.142*	0.038*	0.000	-0.032*	0.025*	0.055*	-0.012	0.024*	0.041*	1.000		
(11) Number of employees	0.030*	-0.088*	-0.014	-0.035*	0.019	0.207*	0.041*	-0.020	-0.127*	0.015	1.000	
(12) Total assets	-0.004	-0.095*	-0.010	-0.009	0.049*	0.205*	0.049*	-0.003	-0.135*	0.093*	0.714*	1.000

* p<0.1; The number of observations is 7514; The sample includes adopters before and in their adoption year and all years for nonadopters; Missing values are excluded.

3.3.3 Propensity score matching (PSM) and Difference-in-Difference (DID)

Treatment effects are the effects of a project or policy implementation. In examining treatment effects, the real question is: is ISO 14001 adoption leads to lower operational risk than the hypothesized operational risk if the firm had not adopted ISO 14001. To answer this question, I first adopt propensity score matching (PSM) to construct a set of matched samples and then use difference-in-difference (DID) to test the treatment effects. The combination of PSM and DID is a commonly used technique that can control observed and non-observed variables and eliminate the impact of endogeneity (Qian, 2007).

Propensity score matching

PSM is a method of matching to construct treatment and control groups. By matching, a set of quasi-control groups with similar characteristics to the treatment group can be obtained. After matching the propensity scores, confounding variables are controlled, and net effects are obtained between variables (Rosenbaum and Rubin, 1983). The probability of being ISO 14001 certified depends only on a series of pre-period covariates, and other inter-group variations are randomly distributed.

The successful use of PSM relies on several premises (Levine and Toffel, 2010; Toffel, 2005). First, the source of certified and uncertified firm data is the same, satisfying the “overlapping assumption”; second, the selection of covariates that affect ISO 14001 adoption is based on a comprehensive literature review, which satisfies the “non-confounding assumption.” Third, nearest-neighbor matching within a caliper is used to find the nearest neighbor within a specific range, which satisfies the requirements that the control and the treatment groups are similar.

The first step in PSM is to calculate the propensity score. I employ the probit model to predict the probability of a firm acquiring ISO 14001 certification. In the model, several PSM matching variables (lagged for one year) are added, including ISO 9001, OHS 18001, cross-listing, ROA, total asset turnover, financial leverage, firm age, number of employees, and total assets. To ensure that the level of operational risk before certification is similar across two groups, I add lagged dependent variables (Barbara & Lyons, 1996; Eichler & Lechner, 2002). Besides, dummy variables for years, industries, and regions are added.

In the second step, after obtaining the propensity scores, I employ the `psmatch2` command in the STATA program and match each adopter to a non-adopter in the year

of certification. I implemented the nearest-neighbor matching within 0.02 caliper without replacement to construct a 1:1 matched sample.

In the third step, it is necessary to check whether propensity scores are similar across the treatment and the control group (Smith and Todd, 2005). This procedure, known as the balancing test is to ensure no significant difference between the two groups in the pre-period. There are several ways for the balancing test: 1) I compare the changes in pseudo R2 before and after matching. The pseudo R2 represents the explanatory power of regressors on the dependent variable. After matching, pseudo R2 of the probit model significantly drops; 2) I conduct a t-test to compare means of the covariates in the treatment group and the control group. After matching, the significance of the mean difference decreases dramatically; 3) I check changes in the standardized bias of covariates, which is the percentage of the difference between group means divided by the square root of the mean variances across the groups. After matching, the standardized bias is reduced significantly. 4) I perform temporal trend analyses for the treatment and the control group to check whether the selection effect still exists after matching. I find no significant pre-period trend after matching.

Difference in difference

This study uses DID to examine the impact of ISO 14001 adoption on operational risk. DID would employ the operational risk of the control group as a counterfactual effect of the treatment group if it were not treated. Explicitly, DID takes the double difference between *ex-post and ex-ante* operational risk in treated and control groups, thus isolating the causal effect of ISO 14001 adoption. Following the classic DID model (Wooldridge, 2010), the estimated model is as follows:

$$y_{it} = \alpha_i + \beta_1 \text{Treat}_i + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot \text{Treat}_i \cdot \text{Post}_t + \gamma \cdot X_{it} + \delta_t \cdot \text{year}_t + \varepsilon_{it}$$

where y_{it} refers to regulatory violations or environmental casualties; α_i is the intercept for each firm; *Treat* is a dummy variable, coded as 1 for the treatment group, and 0 for the control group; *Post* is also a dummy variable, coded as one after the treatment and 0 before the treatment. β_3 estimates the interaction between *Treat* and *Post*, which represents the impact of ISO 14001 on the outcomes; year_t represent year dummies. The model is based on ordinary least square with firm fixed effects.

3.3.4 Test of moderating effects

Based on the treatment and control group generated by PSM, I add a triple interaction term in the DID model to test the moderating effects; the model is also known as the difference-in-difference-difference (DDD) model.

$$\begin{aligned}
y_{it} = & \alpha_i + \beta_1 \text{Treat}_i + \beta_2 \text{Post}_t + \beta_3 \text{Treat}_i \cdot \text{Post}_t \\
& + \beta_4 \text{Moderator}_{i(t)} + \beta_5 \text{Treat}_i \cdot \text{Moderator}_{i(t)} + \beta_6 \text{Post}_t \cdot \text{Moderator}_{i(t)} \\
& + \beta_7 \text{Treat}_i \cdot \text{Post}_t \cdot \text{Moderator}_{i(t)} + \gamma X_{it} + \delta_t \text{year}_t + \varepsilon_{it}
\end{aligned}$$

where y_{it} refers to regulatory violations or environmental casualties; α_i is the intercept for each firm; Treat is a dummy variable, coded as one for the treatment group, and 0 for the control group; Post is also a dummy variable, coded as one after the treatment and 0 before the treatment. β_7 estimates the triple interaction between Treat , Post , and Moderator , which represents the moderating effect; year_t represent year dummies. The model is based on ordinary least square with firm fixed effects.

3.4 Results

3.4.1 Propensity score matching

A probit model is used to calculate the propensity score in Table 7. The probit coefficients obtained by the model are regarded as the estimated probability of being ISO 14001 certified. Marginal effects indicate that each change in the independent variable affects the change in the probability of the dependent variable. As a result, firms are more likely to obtain ISO 14001 when they have a lower risk of regulatory violations, have obtained ISO 9001, OHS 18001, have lower financial leverage, a younger firm age, and a more significant number of employees.

Table 7 Probit model for estimating propensity scores

	Probit coefficient	Marginal effect
Dependent Variable: adopt ISO14001 this year		
Average regulatory violations (t-1)&(t-2)	-13.438* [7.80583]	-1.428406
Average environmental casualties (t-1)&(t-2)	-1.369 [1.3403]	-0.1455507
Has adopted ISO 9001	0.404* [0.0580]	0.0429119
Has adopted OHS 18001	0.753* [0.1508]	0.0800351
Cross-listing	-0.090 [0.1751]	-0.0095138
ROA	0.210 [0.2204]	0.0223179
Total asset turnover	-0.003 [0.0034]	-0.0002785
Financial leverage	-0.434* [0.1375]	-0.0461395
Firm age	-0.235* [0.0527]	-0.0249981
Number of employees	0.060* [0.0353]	0.0063587
Total assets	0.046 [0.0385]	0.0048522
Number of firms	1105	
Observations (firm-year)	7514	
Pseudo-R2	0.14	
Wald2	3398.50	

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies. The sample includes adopters before and in their adoption year and all years for nonadopters.

According to the coefficients obtained by the probit model, I perform one-to-one matching in the same year and obtain 440 pairs of treatment and control sample firms. The probability distributions of the two groups before the matching show significant differences, while the distributions after the matching become very close. The pseudo R2 before matching is 0.212, and the value after matching is 0.036, indicating that the matching covariates lose their predictive power on ISO 14001 adoption. The balancing test indicates that the mean differences after matching become very small. At the same time, standardized bias has also dropped significantly. The mean (median) decreases from 9.7% (7.0) before matching to 3.1% (2.6%) after matching. These results demonstrate that the matching results from PSM are reliable. Finally, the temporal trend analysis after matching suggests that the trends of operational risk in the treatment and the control group are not significant, further supporting the results of PSM.

3.4.2 DID and DDD

Table 8 is the result of DID examining the impact of ISO 14001 adoption on operational risk. Since the model uses an individual fixed-effects model, the treatment variable is omitted since its value is time-invariant. I find that ISO 14001 adoption significantly reduces the risk of regulatory violations by 1%. Considering the average sales of sample firms is \$687.3 million, I suggest that certified firms can reduce the number of regulatory violations by 0.68.

Similarly, ISO 14001 significantly reduces the risk of environmental casualties. Compared to firms that are not certified, certified companies reduce casualties by 2%. Given the average sales of the sample firms, certified companies can reduce 1.1 casualties. These results support H2a and H2b.

Table 8 DID results

	H1: regulatory violations	H2: environmental casualties
Treat	omitted	omitted
Post	0.0001 [0.00067]	0.0011 [0.00067]
Treat*Post	-0.0010* [0.00062]	-0.0016* [0.00079]
Regulatory violations	-	0.0087 [0.00622]
Environmental casualties	0.0044** [0.00220]	-
Constant	0.0002 [0.00036]	0.0007* [0.00039]
Number of firms	880	880
Observations	9551	9551
R2	0.011	0.002

***p<0.01, **p<0.05, *p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies.

After using the DID model to examine the treatment effects, I further adopt the DDD model for the moderating effects. The triple interaction term in the model represents the effect of the moderators. Table 9 shows the results of the moderating effect. I find that the impact of ISO 14001 adoption on the risk of environmental casualties is strengthened when firms receive government monitor ($p < 0.1$). Government monitor helps firms with certification to further reduce the risk of environmental casualties by 0.7%, supporting H3b. However, government monitor has no significant moderating effect on the relationship between ISO 14001 adoption and the risk of regulatory violations, rejecting H3a. On the other hand, for firms having slack resources, the effect of ISO 14001 adoption on the risk of regulatory violations is weakened ($p < 0.05$). Slack resources have no significant moderating effect on the relationship between ISO 14001 certification and the risk of environmental casualties, rejecting H4b.

Table 9 DDD results

	H3a Regulatory violations	H3b Environmental casualties	H4a Regulatory violations	H4b Environmental casualties
Treat	omitted	omitted	omitted	omitted
Post	-0.0001 [0.00053]	0.0008 [0.00075]	0.0031*** [0.00118]	0.0017 [0.00167]
Treat*Post	-0.0014** [0.00060]	-0.0012 [0.00085]	-0.0040** [0.00157]	0.0008 [0.00221]
Regulatory violations	-	0.0093 [0.0151]	-	0.0008 [0.01512]
Environmental casualties	0.0047 [0.00765]	-	0.00441 [0.00764]	-
Government monitor	-0.0018 [0.00214]	-0.0020 [0.00356]	-0.0004 [0.00059]	0.0009 [0.00083]
Slack resources	-0.0009 [0.00089]	-0.0006 [0.00126]	-0.0011 [0.00124]	-0.0014 [0.00175]
Treat * government	-0.0011 [0.00253]	0.0038 [0.00356]		-
Post * government	0.0008 [0.00225]	0.0050 [0.00317]	-	-
Treat * post * government	0.002839 [0.00270]	-0.0070* [0.00379]	-	-
Treat * slack	-	-	0.0028 [0.00223]	0.0062* [0.00314]
Post * slack	-	-	-0.0052*** [0.00183]	-0.0009 [0.00257]
Treat * post * slack	-	-	0.0054** [0.00260]	-0.0045 [0.00366]
Constant	0.0007 [0.00076]	0.0011 [0.00107]	0.0001 [0.00084]	-0.0001 [0.00119]
Number of firms	880	880	880	880
Observations	9550	9550	9550	9550
R2	0.01	0.003	0.01	0.003

***p<0.01, **p<0.05, *p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies.

3.4.3 Robustness tests

I adopt a variety of methods to examine the robustness of the results. Since I calculated the risk of regulatory violations and environmental casualties as the number divided by sales per million dollars, I use the direct number in a long-horizon event study as an additional test. The event study method is often used to examine the impact of an event on firm performance (Lo *et al.*, 2014; Lo *et al.*, 2013; Lo *et al.*, 2009). Through an event study, I can intuitively examine whether ISO 14001 adoption affects the number of violations and casualties.

I set the year of obtaining ISO 14001 certification as $t=0$ and use $t=-1$ as the base year to construct control firms. Since the number of violations and casualties is a count variable and is often zero in many years, I set a long event period, from $t=-1$ (base year) to the next five years ($t=0, t=1, t=2, t=3, t=4$).

Following the recommendations of Barber and Lyon (1997), I construct a matched sample and examine the effect of ISO 14001 adoption by estimating abnormal performance. Barber and Lyon (1997) suggest that the treatment and the control group should be constructed based on three criteria: pre-event performance, industry, and firm size. I match the certified firms with non-certified firms in $t=-1$ following three steps:

- (1) In $t=-1$, I match certified to non-certified firms in the same industry, with ROA ranging from 90% to 110%.
- (2) For certified firms not being matched in step 1, I remove the industry restrictions and match according to 90% to 110% of the ROA.
- (3) For certified firms not being matched in step 2, I match them to firms with the closest ROA level.

Since the event window is from $t=-1$ to $t=4$, only firms in 2005-2011 are retained. After excluding firms with missing data in the window period, there are 1043 firms left, among which 261 firms obtain ISO 14001 certification, and 782 do not. The matching procedures yield 254 certified and 1,941 control firms.

To calculate abnormal performance, I first estimate the expected performance of the treatment group, that is, the number of regulatory violations and environmental casualties should the firm not obtain ISO 14001 certification. The expected performance is calculated by the performance of the base year plus the change in the median performance of the control group over time. Abnormal performance is actual performance minus expected performance. I conduct a series of tests, including t-tests and sign tests, to examine the significance of the abnormal performance. Table 10 and

11 show the abnormal performance of each period and cumulative abnormal performance from $t=-1$ to $t=4$. The results show that ISO 14001 adoption reduces regulatory violations and environmental casualties. During the event period, ISO 14001 adoption reduces 0.17 violations and 0.07 casualties. The results of the event study increase the robustness of the study.

Table 10 Event study: regulatory violations

Abnormal performance of regulatory violations						
Period	Number of certified firms	Mean	Percentage Positive	of	T-test	Sign test
-1, 0	254	-0.01	51.5%		-0.149	0.246
0, +1	254	0.03	52.9%		0.439	0.686
+1, +2	254	-0.18	46.3%		-2.160**	-0.1
+2, +3	254	-0.02	41.1%		-0.13	-2.34**
+3,+4	254	-0.17	42.9%		-0.97	-1.99**
-1,+4	254	-0.17	43.1%		-2.53***	-1.39

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 11 Event study: casualties

Abnormal performance of casualties						
Period	Number of certified firms	Mean	Percentage Positive	of	T-test	Sign test
-1, 0	254	0.11	40%		-0.05	-0.632
0, +1	254	0	36.4%		0	-1.28
+1, +2	254	-0.17	28.6%		-0.78	-1.96**
+2, +3	254	-0.14	21.1%		-0.74	-2.52***
+3, +4	254	-0.23	27.7%		-1.42	-1.89*
-1, +4	254	-0.07	37.5%		-1.51*	-0.71

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Second, I adjust the sample data as the values of regulatory violations, and environmental casualties contain many zero values, which may interfere with the results. I keep firms that have at least one violation or one casualty during the sample period and re-run the DID test. The result is not changed.

Finally, I use unabsorbed slack as a measure of slack resources, which is calculated as the operating cost (SGA) divided by sales (Bourgeois III, 1981). I rerun the DDD model and find similar results. Absorbed slack resources also weaken the impact of ISO 14001 adoption on the risk of regulatory violations, indicating that the results are robust.

3.4.4 Extension

While the combination of PSM and DID can effectively determine the causal relationship between ISO 14001 adoption and operational risk, I examine the selection effect for additional knowledge. The selection effect means that if a firm has outstanding performance, it is more likely to obtain certain practices. In other words, ISO 14001 adoption may not lead to a reduction in operational risk, but firms with lower operational risk tend to adopt ISO 14001 certification.

Following the rationale of Bansal and Hunter (2003), Toffel (2005) and Heras-Saizarbitoria *et al.* (2011), which indicate that firms with excellent environmental or financial performance have a greater tendency to adoption ISO 14001, I argue that firms with lower operational risks could be more likely to obtain ISO 14001 certification. First, ISO 14001 certification places strict demands on operational processes. Firms with a lower risk of regulatory violations are more environmentally-friendly and develop more efficient processes; firms with a lower risk of environmental casualties have more standardized and well-designed processes. These firms are more convenient to accommodate existing processes to ISO 14001 requirements and thus have a better foundation for adopting ISO 14001. Meanwhile, the cost of additional investments for process improvement will be reduced (Clemens and Douglas, 2006). Second, firms with lower operational risks and may face higher regulatory pressure and are more likely to comply with institutionalized standards, environmental laws, and regulations, (Fryxell and Szeto, 2002). These companies are more willing to adopt the institutionalized ISO 14001 certification to address pressure from stakeholders (Welch *et al.*, 2002). Third, according to the signal theory, ISO 14001 can a signal to demonstrate sound environmental practices (Johnstone and Labonne, 2009), and the credibility of the signal is ensured when there is a high threshold for ISO 14001 certification (Spence, 1974; Toffel, 2005). To obtain ISO 14001 certification, firms need to invest much money in preparing and training employees (Russo and Fouts, 1997; Sarkis *et al.*, 2010). Therefore, firms with lower operational risk may adopt ISO 14001 at a lower cost, while those with high operational risk need to invest more, but may not be worthwhile (Dobler *et al.*, 2015).

To examine the selection effect, I employ *adoptISO14001thisyear* as the dependent variable and use lagged *regulatory violations* and *environmental casualties* as the independent variable in a probit model. Dummy variables of year, industry, and region are added as control variables.

$$ISO14001thisyear_{it} = F(Y_{it-1\&t-2}, year_t, industry_t, region_t, u_{it})$$

where *adoptISO14001thisyear* is coded as one if a firm adopts ISO 14001 in a particular year; u_{it} stands for randomly distributed residuals. The sample includes firms that never adopt ISO 14001. For firms that adopt ISO 14001, the sample includes the adoption year and years before adoption. In order to control for heteroscedasticity and the interdependence within firms in different years, I reported robust standard errors clustered by firms.

In addition to the probit analysis, I compared the trends of regulatory violations and environmental casualties in the pre-adoption period between firms that will adopt ISO 14001 and firms that never adopt ISO 14001. I estimated the following model for firm *i* in year *t*:

$$y_{it} = \alpha_i + \beta_{li} \cdot t + \varepsilon_{it}$$

where *y* is regulatory violations or environmental casualties; β_{li} is the time trend for each firm. To mitigate the confounding of ISO 14001 certification, I excluded adopters from two years prior to adoptions. After estimating the model, I obtained trend β_{li} of each firm for each dependent variable. I then conducted an independent t-test to examine the difference in the trends of the adopters and non-adopters.

Tables 12 and 13 show the results of the selection effect. I find that firms with a higher risk of regulatory violations are less likely to obtain ISO 14001 certification (Table 12, column 2). There are significant upward trends in the risk of regulatory violations in both certified and non-certified firms (Table 13, column 2, column 3). However, there is no significant difference in the trends between the two groups (Table 13, column 4).

In terms of the risk of environmental casualties, I find that the risk of environmental casualties has no significant effect on whether the firm would obtain ISO 14001 (Table 12, column 2). There is no significant change in the trend of environmental casualties in both groups (Table 12, column 2, column 3). However, the difference between the two groups is significant ($p < 0.1$). I suggest that firms not certified have a trend of increased risk compared to those that will be certified (Table 13, column 4). The results support H1a and H1b.

Table 12 Probit model for selection analysis

	Probit coefficient	Marginal effect
Dependent Variable: adopt ISO14001 this year		
Average regulatory violations (t-1)&(t-2)	-18.19* [7.580]	-2.02
Average environmental casualties (t-1)&(t-2)	-0.79 [1.357]	-0.09
Observations (firm-year)	7617	
Number of firms	1112	
Pseudo-R2	0.094	
Wald2	31134.37	

Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies. Adopters are excluded from the sample after the year of certification.

Table 13 Temporal trend analysis

	Firms that will adopt ISO 14001	Firms that will not adopt ISO 14001	Difference between groups
Regulatory violations	0.00037* [0.00029]	0.00024* [0.00010]	0.00013 [0.000236]
Environmental casualties	-0.00097 [0.00095]	0.00006 [-0.00971]	0.00104* [0.000602]

Robust standard errors are clustered by firms in brackets; The number of firms that will and will not adopt ISO 14001 is 240 and 638, respectively.

3.5 Discussion

This study indicates that ISO 14001 adoption can effectively reduce the risk of regulatory violations and environmental casualties. The finding suggests that the effect of ISO 14001 adoption is substantial. On the one hand, previous studies on ISO 14001 certification focus on its impact on financial and environmental performance (Aravind and Christmann, 2011; de Jong *et al.*, 2013; He *et al.*, 2015; Paulraj and de Jong, 2011). Few look at the role of ISO 14001 from the perspective of risk. The research finding confirms that ISO 14001 adoption brings substantive process improvement to firms and reduces operational risk.

On the other hand, only a few studies on ISO 9001 and OHS 18001 certifications examine the impact on people (Brandon-Jones *et al.*, 2014; Levine and Toffel, 2010). This study is the first to examine the impact of ISO 14001 adoption on the risk of regulatory violations and environmental casualties and considers its impact on people, including not only the employees but also residents in the neighborhoods. ISO 14001 reduces the risk of regulatory violations, thus reducing the actual or potential health effects of environmental violations on employees and the surrounding public. ISO

ISO 14001 also reduces the risk of environmental casualties, thus actually minimizing injuries or death caused by accidents. In other words, the risk of regulatory violations represents the potential impact on the ecological environment and people, and the risk of environmental casualties represents direct harm to people. The finding suggests that ISO 14001 adoption saves people's lives, implying that ISO 14001 may have not only financial and operational benefits for the business but also social benefits, namely reducing the harm to people.

In investigating the moderating effects, the study indicates that for firms receiving government monitor, the impact ISO 14001 adoption on the risk of environmental casualties is strengthened, while its impact on the risk of regulatory violations is not affected. The findings strongly support the institutional theory, which stresses the importance of government role in ISO 14001 implementation. This finding is consistent with studies of Li *et al.* (2017a), Berrone *et al.* (2013), and Zhu and Sarkis (2007). While there have been controversies about the role of the Chinese government in environmental protection in the past, such as ambiguous legal provisions, low executive power, collusion between the government and firms, and overly economic orientations (Marks, 2010), this study indicates that government monitor can promote firms to substantively implement ISO 14001, thereby reducing the risk of environmental casualties. On the other hand, I find that government monitor does not promote the impact of ISO 14001 certification on the risk of regulatory violations. One possible reason is that the externality of the risk of regulatory violations is relatively weak compared to the risk of environmental casualties. Many times, regulatory violations do not directly harm public health. For example, wastewater discharge exceeding the standard or facilities failing to pass the environmental impact assessment are only potential threats to public health, and such violations usually do not cause strong public concern.

For this reason, the government attaches less importance to environmental violations, which thereby cause less damage to the legitimacy status of firms. Another reason may be that the emergence of environmental casualties indicates a significant flaw in a firm's strategies or processes. Firms monitored by the government may be more likely to detect significant problems and improve in ISO 14001 implementation. Regulatory violations, however, reflect more subtle problems in specific and detailed processes. It is difficult for the government to help firms fix such issues, and thus government monitor does not improve the effect of ISO 14001 certification on reducing

the risk of regulatory violations. In summary, government monitor can promote firms to fully use ISO 14001 certification to reduce the risk of severe environmental casualties, but it does not help in addressing the risk of fewer serious regulatory violations.

The study has a surprising finding that slack resources weaken the effect of ISO 14001 adoption. For firms with high slack resources, ISO 14001 certification has a less negative impact on the risk of regulatory violations. Contrary to the hypothesis, slack resources weaken the role of ISO 14001 certification, making it more symbolic. The dark side of slack resources has been explored previously (Leyva-de la Hiz *et al.*, 2018; Shahzad *et al.*, 2016; Tan and Peng, 2003). The first possible explanation is based on the agency theory, meaning that the inconsistency between managers and firm owners causes the negative impacts of slack resources (Daniel *et al.*, 2004; Li *et al.*, 2017a). As managers are often in control of those slack resources, they are likely to deploy the resources to enhance the image to gain personal interests, instead of satisfying stakeholders' requirements (Yeung *et al.*, 2011). In other words, the availability of abundant slack resources amplifies managers' moral hazard and increases the conflicts between owners and agents.

In the context of ISO 14001 adoption, firms with more slacks may nurse managers pursuing self-interests, who may take advantage of the symbolic side of ISO 14001 certification for external promotion, and decouple from the actual implementation of ISO 14001. Moreover, managers with a higher power are more likely to abusively use the resources that are supposed to support the implementation of ISO 14001, hereby weakening its effect on regulatory violations.

Nevertheless, environmental casualties have a massive impact on the image and reputation of managers and may even bring jail to them. Therefore, managers will not reduce the impact of ISO 14001 certification on casualties due to the abusive use of slack resources. The second possible explanation is that firms with slack resources may prefer to use them to cover economic penalties out of regulatory violations. Paying fines in China can sustain the symbolic meaning of ISO 14001 certification and avoid committing to substantive process improvement. Having slack resources induces firms to solve problems with money and refuse substantive devotion (Berrone *et al.*, 2013). However, due to the severity of casualties, firms may be condemned by the government and the public for environmental casualties. It is difficult for firms to use economic resources to cope with them. Therefore, slack resources have no significant impact on the relationship between ISO 14001 and the risk of environmental casualties.

Besides, this study indicates a selection effect for ISO 14001 adoption. If a firm has a low risk of regulatory violation and a decreasing trend of environmental casualties in the pre-period, it will be more willing and able to adopt ISO 14001 certification. The finding is consistent with the results of Heras-Saizarbitoria *et al.* (2011), Toffel (2005), and Levine and Toffel (2010). ISO 14001 certification can serve as a signal to stakeholders to demonstrate the level of environmental management (Johnstone and Labonne, 2009; King *et al.*, 2005; Potoski and Prakash, 2005b). Also, firms with low operational risk can obtain certification at a lower cost and thus are more likely to be certified.

3.6 Conclusions and contributions

Based on a unique panel data collected from multiple sources, this study adopts rigorous econometric methods to empirically examine the impact of ISO 14001 adoption on operational risk. Specifically, it examines the causal impact of ISO 14001 adoption on operational risk and the moderating effects of government monitor and slack resources. The findings indicate that ISO 14001 adoption significantly reduces the risk of regulatory violations and environmental violations. While government monitor significantly enhances the negative impact of ISO 14001 on the risk of environmental casualties, slack resources significantly weaken the negative impact of ISO 14001 certification on the risk of regulatory violations.

This study has significant contributions to the literature. First, this study unveils a previously unnoticed outcome of environmental initiatives. Previous research has indicated that ISO 14001 adoption can improve environmental and financial performance, but there has been little research focusing on operational risk. This study considers the risk of regulatory violations and environmental casualties as two proxies of operational risks and demonstrates that saving the environment can save lives. The people-oriented mindset stresses on identifying the external social impact of firm practices. I suggest that in future operations management research, more attention should be paid to hidden costs (i.e., impact on people, environment, and society) beyond economics and efficiency considerations.

Second, this study provides valuable empirical evidence for the debate about the effectiveness of ISO 14001 certification (Boiral, 2007; Heras-Saizarbitoria *et al.*, 2011; Iatridis and Kesidou, 2016; Link and Naveh, 2006). This study discusses the role of

ISO 14001 certification for operational risk from the institutional theory (legitimacy perspective) and resource-based theory (efficiency perspective) (Baek, 2017; Boiral, 2007; Potoski and Prakash, 2005b). More importantly, this study proposes two types of moderating variables, government monitor and slack resources, from two theoretical perspectives, further enhancing the understanding of theories.

This study also provides several practical implications. First, due to unprotective legal systems and weak regulatory enforcement in China, it is of practical significance to study whether ISO 14001 can play a useful role (Kang and He, 2018; Zhou and Poppo, 2010). By implementing ISO 14001, firms can mitigate operational disruptions caused by environmental violations and casualties, minimize the negative impact on employees and surrounding residents, and enhance the reputation and social performance overall. Firms should actively implement ISO 14001 certification, especially for those at considerable risk due to obsolescent technologies and complex processes.

Second, as the adoption of ISO 14001 certification shows both selection and treatment effects, firms may well utilize ISO 14001 certification to identify reliable suppliers and customers with low operational risks, thereby reducing supply chain disruption due to high operational disruptions (Chopra and Sodhi, 2014; Kleindorfer and Saad, 2005). Hence, firms can make pure judgments on the operations of other firms according to ISO 14001 certification.

Finally, the effectiveness of ISO 14001 certification can be improved with stringent government monitor and scarce slack resources. Firms shall simultaneously concern about external pressure and internal resources when implementing ISO 14001 certification. On the one hand, when a firm is on the government's monitor list, it should substantively implement ISO 14001 certification following given requirements, and reduce the chance of having casualties. On the other hand, firms should take a cautious view on the role of slack resources. If managers as agents of firms only pay attention to self-interest, slack resources will likely be abused and damage the vital interests of firms. In implementing ISO 14001, firms should control the number of slack resources or more strictly monitor the use of slack resources. Firms can also design a flexible compensation system for managers and reduce the inconsistency of interests caused by agency behavior.

Moreover, the study has essential merits for policymakers. Since policymakers are concerned about the social impact of a firm, it is beneficial to encourage firms to implement voluntary environmental management systems actively. At the same time,

policymakers can refer to ISO 14001 certification to supervise firms and develop regulations that encourage firms to implement ISO 14001 certification. Besides, government monitor is a means of urging firms to implement certification substantially. Policymakers can impose necessary measures at appropriate times to motivate firms to implement environmental management practices with sufficient efforts.

4 Study 2: Maintaining stability or boosting growth: The impact of environmental accreditations on long-term financial risk and sales growth

4.1 Introduction

Firms nowadays are facing increasing pressure from stakeholders to behave in an environmental-friendly manner. For instance, many firms adopt environmental management accreditations, such as ISO 14001 certifications, to identify, measure, and control factors in operational processes that may harm the natural environment (Bansal and Hunter, 2003). To obtain an ISO 14001 certification, one firm must invest a great deal of time and money and improve underlying processes systematically (King *et al.*, 2005; Potoski and Prakash, 2005b).

Existing studies have focused on short-term financial outcomes of ISO 14001 adoption, such as stock market reaction (Cañón-de-Francia and Garcés-Ayerbe, 2009; Jacobs *et al.*, 2010; Paulraj and de Jong, 2011), immediate return on asset, return on sales, sales volume, and profitability (de Jong *et al.*, 2013; Lucas and Noordewier, 2016; Su *et al.*, 2015; Wang *et al.*, 2015). A common issue in previous studies is that they focus on ISO 14001 adoption's direct and immediate impact on financial outcomes. Less is known about whether ISO 14001 adoption can lead to underlying and long-term outcomes, such as reduced financial volatility and improved sales growth as time goes by (Sharfman and Fernando, 2008). According to Ortiz-de-Mandojana and Bansal (2016), low financial volatility and reliable sales growth rates in the long-term are implications for organizational resilience. In other words, firms can mitigate shocks and seize the opportunity to maintain stability and boost growth. Financial risk refers to the idiosyncratic volatility of stock prices. A high level of financial risk indicates that investors are uncertain about a firm's future performance (Bansal and Clelland, 2004; Lam, 2018; Luo and Bhattacharya, 2009), while low financial risk predicts easy access to finance and steady cash flows (Shin and Stulz, 2000). Sales growth refers to the future potential for a firm to expand and grow (Mishina *et al.*, 2004). A high sales growth rate reveals that a firm can take full advantage of its existing resources and opportunities to enlarge its size (Eshima and Anderson, 2017).

To summarize, low financial risk and high sales growth are indicators for a firm's long-term and stable development. However, empirical evidence suggests a trade-off relationship between risk and return (Amit and Wernerfelt, 1990). Firms pursuing rapid

growth may take a highly risky approach, since maintaining a stable financial flow is at the expense of losing the market expansion opportunity (Fitzsimmons *et al.*, 2005; Singh and Mitchell, 2005). This conflict leads to a curious question: how is receiving environmental accreditations related to long-term financial risk and sales growth?

In this study, I employ a perspective from the signalling theory to understand the impact of ISO 14001 adoption on a firm's long-term financial risk and sales growth. Signalling theory probes into how firms reveal their underlying, intangible, and unobservable features to their stakeholders, to reduce the information asymmetry (Connelly *et al.*, 2010; Spence, 2002). It is difficult for firms to explicitly show their commitment to environmental management to the external stakeholders in a credible way. The cost of issuing an announcement is too minimal to convince the audience that a firm has an outstanding environmental performance. Obtaining an ISO 14001 certification, however, requires substantial investments, overall improvement in processes, and auditing from an independent third-party, making the certification a reliable signal as a manifestation of being green (Berrone *et al.*, 2017; Su *et al.*, 2014; Toffel, 2005). When a signal is well received by stakeholders, such as the investors, customers, consumers, regulators, and NGOs, their positive perceptions towards the firm would improve, subsequently impacting a firm's performance (Johnstone and Labonne, 2009). For example, having an ISO 14001 certification in the eyes of investors may symbolize low environmental and operational risks or less adverse impact from such incidents (Lam, 2018). These investors may thus feel less uncertain about the firm's future development and secure their investment in the firm.

Meanwhile, an ISO 14001 certification as a positive signal may also impact a firm's downstream customers (including end consumers) (Johnstone and Labonne, 2009). As the public realizes the importance of environmental protection, customers who are sensitive to environmental issues may be attracted to firms with ISO 14001 certifications (Delmas and Toffel, 2004). Briefly, this study investigates how ISO 14001 certifications as a signal may be perceived by the investors and customers, which in turn affects financial risk and sales growth.

Existing studies have drawn inconsistent conclusions regarding the relationship between firm environmental practices and long-term resilience performance. It is thus more prominent to investigate the contingent factors in the relationship between ISO 14001 adoption and financial risk and sales growth of firms in the long-run (Cañón-de-Francia and Garcés-Ayerbe, 2009; Lucas and Noordewier, 2016; Su *et al.*, 2015).

Following the signalling theory, this study suggests that the effectiveness of a signal depends on the time to signal and the environment a signal is sent (Cañón-de-Francia and Garcés-Ayerbe, 2009; Lucas and Noordewier, 2016; Su *et al.*, 2015). For instance, early, firms might face higher uncertainty and more significant learning costs, thus making the signal of ISO 14001 adoption more critical and reliable. On the other hand, firms in a high-polluting industry might be more concerned with environmental pollution, making ISO 14001 certifications a more valuable signal.

I leverage data from Chinese listed manufacturing firms to examine the hypotheses due to the importance of the Chinese context of this study. First, China, as the world factory, undertakes substantial production tasks around the world. The rapid industrialization and economic development results in severe environmental pollution problems. However, according to the ISO survey⁵, the number of Chinese firms adopting ISO 14001 is increasing dramatically, and it reaches over 1.7 million in 2018, accounting for over half of the total number of adoptions worldwide. In this sense, understanding whether it pays to implement ISO 14001 is critical. Second, there is a stereotype about Chinese manufacturers that they are narrow-minded and lagged in operational processes. The contrary opinion puts Chinese manufacturers at additional risks and constrains their growth potential. Understanding how ISO 14001 certifications may provide firms with stability and growth opportunity has strategic merits for Chinese firms. Third, previous studies about ISO 14001 and financial performance are mainly based on the western context, and the few studies in the Chinese setting mainly use surveys based on the perceptions of respondents, which can be biased (Feng and Wang, 2014; He *et al.*, 2015). This study fills the gap by using archival data and rigorous econometric methodology.

In conclusion, this study focuses on three primary research questions. 1) Does ISO 14001 adoption reduce financial risk? 2) Does ISO 14001 adoption improve sales growth? 3) Would time to certificate and industrial pollution level moderate the relationship? I first adopt propensity score matching to form treatment and control groups, and then use a difference-in-difference model to test the main and the moderating effects. Several robustness tests are conducted afterward.

⁵ <https://www.iso.org/the-iso-survey.html>

4.2 Literature review and hypotheses development

4.2.1 The impact of ISO 14001 on long-term financial risk

Risk stems from uncertainty, denoting that the outcome of a situation is not predictable (Miller and Bromiley, 1990; Sitkin and Pablo, 1992). Financial risk is assessed through volatility or disturbance in stock prices, which indicates the degree to which investors are indeterminate about a firm's future cash holdings (Bouchaud and Potters, 2000; Luo, 2007). Firms with minimal financial risk are competitive because they have more flexible strategic options (Chatterjee *et al.*, 1999), easy access to capital (Shin and Stulz, 2000), and sound future expectations (Bansal and Clelland, 2004).

Financial risk can be classified into two types. One is systematic risk, and the other is unsystematic or idiosyncratic risk (Ang *et al.*, 2006; Bansal and Clelland, 2004; Luo, 2007). Systematic risk refers to the volatility in stock prices due to fundamental changes in the market, such as risk rate adjustment and currency inflation (Bansal and Clelland, 2004). Systematic risk exerts symmetric influence on all firms in the market. On the other hand, unsystematic risk refers to stock price volatility caused by firm-specific incidents (Bansal and Clelland, 2004), such as supply chain disruptions (Hendricks *et al.*, 2009) and product recall announcements (Zhao *et al.*, 2013). It is widely acknowledged that managers should be more concerned about unsystematic risk because it accounts for a higher proportion of overall volatility in stock prices (over 80%) and entails a more significant impact on a firm's financial health (Bansal and Clelland, 2004). In this study, I focus on unsystematic risk due to its overwhelming impact.

Financial risk stems from investors' uncertainty towards a firm. The nature of uncertainty is information asymmetry. According to the signalling theory, ISO 14001 certifications stand for a high level of environmental management, thus eliminating shareholders' uncertainty towards the firm (King *et al.*, 2005; Orlitzky, 2013). Especially in China, as the enforcement of environmental regulation is lax, and only a few firms are mandated to disclose environmental information, investors hold limited information about firms' environmental management (Prakash and Potoski, 2011; Su *et al.*, 2014). In this situation, an ISO 14001 certification as an international standard granted by an independent third-party, sets up high credibility. Obtaining certifications from an ISO organization requires a firm's extensive involvement and an overall improvement in operational processes (Darnall and Edwards, 2006). Existing studies

have also investigated the signalling roles of certifications, such as ISO 9001 (Terlaak *et al.*, 2006), labor codes (Jayasinghe, 2016), and scientific and regulatory certifications (Polidoro, 2013). Accordingly, ISO 14001 certifications may also demonstrate signalling effects (Connelly *et al.*, 2011; Toffel, 2005).

From the signalling perspective, having an ISO 14001 certification sends a credible signal to investors that a firm has low risks due to a high level of environmental management (Lam, 2018; Potoski and Prakash, 2005b). For example, ISO 14001 certified firms are less likely involved in environmental accidents, thus reducing the odds of internal operational disruptions, punishments due to regulatory violations, and boycotts from customers. Hence, investors expect firms with ISO 14001 certifications to relieve from environmental risks and maintain stable operations. Second, firms adopting ISO 14001 certifications are perceived as being ethical and thus gain a higher level of legitimacy (Nga, 2009). Even if an accident takes place, investors tend to take it as an exception and predict temporal and subtle impacts from this accident. Compared with firms without ISO 14001 certifications, certified firms obtain insurance-like moral capital, which mitigates the negative consequences of environmental accidents (Flammer, 2013; Godfrey *et al.*, 2009). Third, investors may perceive certified firms as having more robust capabilities. In a weak regulatory environment where the approach to disclose environmental information is limited, firms have to pay extra efforts to signal excellent environmental management (Montiel *et al.*, 2012). Adopting ISO 14001 certifications thus indicates a firm's proactive initiatives to fill in institutional voids and show superior capabilities in environmental management.

Moreover, I argue that ISO 14001 adoption endows firms with resources and capabilities to extenuate financial risk. ISO 14001 certified firms tend to have a proactive mindset to prevent accidents *ad hoc*, and a capability to correct for deviations and improve processes continuously. Consequently, firms can reduce casualties of harmful incidents and avoid high stock volatility (Ortiz-de-Mandojana and Bansal, 2016). Certified firms also cultivate high-involvement human capital (Cañón-de-Francia and Garcés-Ayerbe, 2009), who can work in a flexible manner to cope with problems and avoid disruptions. In summary, I propose:

H1: ISO 14001 leads to low financial risk.

4.2.2 The impact of ISO 14001 on sales growth

Following a similar rationale, I indicate that ISO 14001 adoption as a positive

signal to customers may impact sales growth. According to the signalling theory, ISO 14001 certified firms attract customers with similar values and requirements for environmental protection (Wang and Qian, 2011). Many companies, such as Ford and General Electronics, mandate their suppliers to obtain ISO 14001 certifications (Darnall and Edwards, 2006). Thus, suppliers must adopt ISO 14001 to win orders from such companies.

Meanwhile, an increasing number of consumers have realized the significance of environmental protection, which motivates them to purchase products from responsible firms (Flammer, 2013). As a result, ISO 14001 certified firms will have more customers with high environmental awareness, as a result of this expanding market size (Bansal, 2003; Delmas and Montes-Sancho, 2011). Having ISO 14001 certifications additionally symbolizes the legitimacy of a firm in different markets and institutional environments (Aguilera *et al.*, 2007). In other words, ISO 14001 can be an environmental passport for a firm to enter a new market, sign preferential trade agreements, and avoid tariffs (Wang and Qian, 2011). With ISO 14001 certifications, firms can export to a previously inaccessible market and thus improve sales growth (Menguc *et al.*, 2010).

Also, from the resource-based view, firms can build up new technologies, capabilities, and routines in the process of implementing ISO 14001 (Toffel, 2005), so that they are more capable of satisfying different customer needs (Von Krogh and Cusumano, 2001). Firms that adopt ISO 14001 can also cultivate resources that are closely related to their long-term development (Ortiz-de-Mandojana and Bansal, 2016). For instance, firms with well-trained and committed employees, upgraded equipment, and environmental-friendly technologies are more prone to sense and seize opportunities to change and develop. Therefore, I propose:

H2: ISO 14001 leads to high sales growth.

4.2.3 The moderating impact of certification time and industrial pollution level

The effects of ISO 14001 certifications on financial risk and sales growth may depend on contextual factors. Connelly *et al.* (2010) conducted a literature review about the signalling theory and called for more research on the contingencies. Existing studies have investigated the effectiveness of a signal from the sender, receiver, and the signal itself. Fewer studies focus on the context, such as the institutional environment, environmental complexity, and munificence (Lam, 2018; Lester *et al.*, 2006; Terlaak *et al.*, 2006; Zerbini, 2017). Contextual factors affect the level of information asymmetry

between the signal sender and receiver. In this study, I propose two factors that may impact the importance of a signal. The first one is the certification time. Early certification time exists a higher level of information asymmetry since there are fewer accesses to the firm's environmental information. Sending a signal of being environmentally proactive can help firms to gain a first-mover advantage. The second factor is the industrial pollution level. In a high-polluting industry, firms are faced with more stringent requirements, suggesting the significance of sending a signal. Hence, I argue that firms can reap enormous economic benefits from ISO 14001 if the certification time is early, and they are in a high-polluting industry.

Previous studies have explored the influence of certification time and industrial pollution levels on the adoption of initiatives. Most studies found that firms' early initiatives lead to better performance. For example, Klassen and McLaughlin (1996) suggested that winning an environmental award for the first time increases financial performance. Lo *et al.* (2013) found that the earlier a firm obtains ISO 9001 certifications, the better the performance is. Delmas and Montes-Sancho (2009) found that firms that are involved in voluntary environmental agreements late make much less environmental investments than earlier involved firms. Flammer (2013) indicated that the stock market's positive reaction to environmental practices is weakened by time. Su *et al.* (2015) noted that early adoption of ISO 14001 helps a firm to build competitive advantages.

Similarly, many studies focus on the influence of the industrial pollution level. For instance, Lucas and Noordewier (2016) found that firms in a high-polluting industry benefit more from environmental practices than firms in a low-polluting industry. Canon-de-Francia & Garces-Ayerbe (2009) indicated that the market does not favor firms in a low-polluting industry to obtain ISO 14001. However, some studies noted that firms in a high-polluting industry gain fewer advantages from environmental practices. Sadovnikova and Pujari (2016) indicated that inter-firm collaboration in environmental practices is less efficient in high-polluting industries. Klassen and McLaughlin (1996) also discovered that the positive relationship between environmental awards and financial performance is weakened in high-polluting industries. Despite the extensive studies, few researchers focus on financial risk and sales growth as performance indicators, and few employ the signalling theory to understand the moderating effects.

Obtaining a certification early brings first-mover advantages to a firm (Bansal and

Hunter, 2003; Su *et al.*, 2015). First, in the early time when the number of firms that adopt ISO 14001 is scarce, the level of external monitoring is weak, and the rule of environmental information disclosure is underdeveloped, so little information can reveal a firm's level of environmental commitment. An ISO 14001 certification is a valuable signal for stakeholders, including investors, consumers, and customers, to differentiate outstanding from poor environmental performers. On the contrary, late certified firms are in an environment where the environmental regulations are tightened, and they are under greater scrutiny to comply with environmental requirements. With the increasing level of transparency, stakeholders are able to receive munificent information, so the significance of ISO 14001 as a signal is undermined. Second, as earlier certified firms face little institutional pressure, they are more driven by internal motives to obtain ISO 14001 and follow requirements substantively to improve operational processes and enhance environmental performance. In other words, firms are willing to make substantial commitment and investment in the certification, making ISO 14001 a reliable signal. Under more significant external pressure, late certified firms may regard ISO 14001 as a means of obtaining legitimacy and pursuing the symbolic meaning of the certification. In this regard, late certification creates possibilities for free-riding and hence damages the credibility of the signal (Delmas and Montes-Sancho, 2009; Lo *et al.*, 2013; Toffel, 2005). Finally, early certified firms gain heterogeneity in the industry. According to the resource-based view, resource heterogeneity is the key to winning competitive advantages. Compared to peers, firms with early ISO 14001 certifications are distinguishing, so they can take better advantage of resources and capabilities to mitigate risk and seize opportunities. In a word, I argue that early certification time sends a more reliable signal to investors and customers, which symbolizes better environmental management and more substantial capabilities, thus reducing financial risk and improving sales growth. I propose:

H3a: The impact of ISO 14001 in reducing financial risk is reinforced when the certification is obtained early.

H3b: The impact of ISO 14001 in improving sales growth is reinforced when the certification is obtained early.

In a high-polluting industry, adopting ISO 14001 may lead to more significant benefits (Cañón-de-Francia and Garcés-Ayerbe, 2009; Lucas and Noordewier, 2016). High-polluting industries, including textile, chemical, food industries, produce massive

toxic emission and polluted water due to the nature of their products. While high-polluting industries receive close monitoring and strict enforcement (Varadarajan, 2017), firms in these industries have an overall inferior reputation and legitimacy. There might be a halo effect that stakeholders regard the existence of severely polluting and irresponsible firms as a widespread phenomenon in the high-polluting industries. Plus, the negative perceptions of some evident firms may be spilled over to other little-known firms. Due to the halo and spillover effect in these high-polluting industries, stakeholders have limited information to differentiate excellent and poor performers (Barnett and King, 2008). ISO 14001 thus serves as a critical signal. In light industries, however, as the level of pollution is low, the use of ISO 14001 as a signal becomes less necessary. Second, firms in high-polluting industries can reduce more waste and cut down higher costs from ISO 14001 adoption, thus achieving considerable savings (Lucas and Noordewier, 2016). In low-polluting-industries, fewer pollutants are generated such that firms gain fewer benefits from adopting ISO 14001. Similarly, firms in high-polluting industries are more vulnerable to operational and environmental risk. ISO 14001 certifications prepare firms with the capability to foresee risk and cope with existing problems, suggesting an essential role of ISO 14001 certification in high-polluting industries. Furthermore, customers are more willing to purchase from ISO 14001 certified firms in high-polluting industries, since the support demonstrates more exceptional contributions to environmental protection. In summary, having ISO 14001 in high-polluting industries suggests a more reliable and valuable signal to both investors and customers. I propose:

H4a: The impact of ISO 14001 in reducing financial risk is reinforced when the firm is in a high-polluting industry.

H4b: The impact of ISO 14001 in improving sales growth is reinforced when the firm is in a high-polluting industry.

4.3 Methodology

4.3.1 Data collection

In order to examine the hypotheses proposed in this study, I adopted firms in the manufacturing sector (C13-C43), which are listed in Shanghai and Shenzhen A-share stock market. I employ Chinese firms as the research objective for several reasons. In the first place, China meets severe environmental problems owing to industrial

pollution. Second, I have access to the financial and operational database of Chinese listed firms, along with the ISO certification data. Third, the majority of existing studies use survey data to analyze the relationship between environmental practices and performance in China. This study employs archival data, deepening the understanding of the value of ISO 14001 certifications.

This study focuses on firms in the manufacturing sector, which accounts for most sources of pollution. From 2004 to 2016, China has 2100 listed manufacturing firms, namely 27300 firm-year observations. The data of ISO 14001 certification is from the National certification and accreditation information public service platform, which is an official website that records every certification a firm obtains in China. Since one firm may have multiple certified plants or subsidiaries, I recorded the first ISO 14001 certification following previous studies (Corbett *et al.*, 2005; Naveh and Marcus, 2005). I compiled the data with the firms' financial data from The China Stock Market & Accounting Research (CSMAR) database and found that 1318 firms obtained ISO 14001 certifications while 782 never adopted the certification.

I cleaned the data for the following analysis. Since propensity score matching (PSM) requires one year lagged data (t-1), and difference-in-difference (DID) needs one year post (t+1) and one year lagged (t-1) data, I excluded samples which lack one year after or one year before the year of ISO 14001 adoption.

4.3.2 Measures

I provide a specific definition and a proxy for each variable in this study. *Financial risk* refers to the stock volatility of a firm, which is operationalized as idiosyncratic stock risk. Following the procedures of existing studies, I employed Fama-French three-factor model to calculate the idiosyncratic risk (Bansal & Clelland, 2004; Luo, 2007; Lee & Faff, 2009; Luo & Bhattacharya, 2009). Compared to the market model, the three-factor model offers more robust and reliable estimates. Accurately, I estimated the following model for firm i in day t :

$$R_{it} - R_{ft} = \beta_{0i} + \beta_{1i} \cdot (R_{mt} - R_{ft}) + \beta_{2i} \cdot SMB_t + \beta_{3i} \cdot HML_t + \varepsilon_{it}$$

where R_{it} is the actual stock return; R_m is the market portfolio return; R_f is the risk-free return rate; SMB is the small minus big market capitalization, and HML is the high minus low book-to-market ratio. I excluded sample firms that lack 180 days of stock

return data in a year. I estimated the model for each sample firm every year and used the annualized standard deviation of the residual (RMSE) as the measure of idiosyncratic risk. *Sales growth* is measured by the change rate in annual sales compared to the previous year.

ISO 14001 is measured by a dummy variable. I identified ISO 14001 adopters and recorded the year of adoption. I additionally verified the data with firms' annual reports.

Based on the literature review, I employed a series of adoption determinants of ISO 14001, included as matching variables in PSM. Firms with other standard management systems, such as *ISO 9001* (quality management systems) and *OHS 18001* (safety management systems), may be more likely to adopt ISO 14001. The adoption of management systems implies that a firm establishes standardized and structured approaches in operations management and has comprehensive capabilities to meet the requirements of standards (Toffel, 2005). *ISO 9001* and *OHS 18001* are coded 1 in years that firms have obtained these certifications. The data for these management systems are from the same source as ISO 14001.

Whether a firm is *cross-listing* in foreign stock markets will influence the likelihood of obtaining ISO 14001 (Baek, 2017; King *et al.*, 2005; Peng and Su, 2014). Foreign investors might have higher requirements for environmental management, which poses higher pressure for firms to adopt ISO 14001. On the other hand, the level of information asymmetry between firms and oversee investors, and thus, ISO 14001 becomes a valuable tool to mitigate the adverse impacts of information asymmetry. I thus controlled for whether a firm is listed in Hong Kong or the U.S. stock market as a dummy variable.

Empirical studies indicate that firms with abundant *slack* resources are more likely to involve in ISO 14001 certification (Aguilera-Caracuel *et al.*, 2015; Bowen, 2002). As such, I used financial slack, which is calculated as sales volume divided by fixed assets following Hendricks *et al.* (2009). The value of sales volume divided by fixed asset stands for the inverse ratio of financial slack. When the value is high, it indicates that a firm has low financial slack.

Firm age might also impact whether a firm could obtain ISO 14001 certification (Baek, 2017; Hudson and Orviska, 2013). Existing studies indicate inconsistent relationships between firm age and ISO 14001 adoption. Older firms may face more pressure and gain more resources to obtain certification. However, younger firms may need certification to obtain legitimacy. In this study, I used the natural logarithm of the

year minus the firm established year as one matching variable.

The firm's financial performance might have an impact. If a firm has a high level of financial *leverage*, it may have more concern about environmental management to reduce risk (Baek, 2017; Przychodzen and Przychodzen, 2015). Firms with high *ROA* and *ROE* may have more financial resources for obtaining certification (Baek, 2017; Heras-Saizarbitoria *et al.*, 2011; Li *et al.*, 2017b).

Besides, I included *lagged dependent variables* for more precise matching. I added the mean of one year lagged and two year lagged financial risk and sales growth. *Year*, *industry*, and *region* are also added as other controls. Table 10 shows the summary statistics of the variables used for propensity score matching. Table 11 shows the corresponding correlation table.

Table 14 Summary Statistics

Variable	Measures	Mean	s.d.	Min	Max
Average financial risk (t-1)&(t-2)	RMSE from Fama-French model	0.025	0.0172	0.009	0.930
Average sales growth (t-1)&(t-2)	Change in sales volume	0.116	0.3364	-6.953	3.719
Adopt ISO 14001 this year	Dummy coded as 1 if the firm adopted ISO 14001 in this year	0.060	0.2381	0.000	1.000
Has adopted ISO 9001 (t-1)	Dummy coded as 1 if the firm has adopted ISO 9001	0.293	0.4552	0.000	1.000
Has adopted OHS 18001 (t-1)	Dummy coded as 1 if the firm has adopted OHS 18001	0.021	0.1424	0.000	1.000
Cross-listing (t-1)	Dummy coded as 1 if the firm is listed in Hong Kong or the U.S. stock market	0.029	0.1667	0.000	1.000
Slack (t-1)	Sales income / Total asset	6.715	133.906	0.002	10485.58
Firm age (t-1)	This year – established year	2.500	0.4457	0.000	3.555
Leverage (t-1)	Debt / Total Asset	0.529	1.2761	0.000	63.971
ROA (t-1)	Profit / Total Asset	0.019	0.6490	-48.316	10.401
ROE (t-1)	Profit / Equity	0.038	3.4223	-141.763	204.690

6332 firm-year observations. The sample includes firms that never adopted ISO 14001 in all years, and firms that adopted ISO 14001 in and before the adoption year.

Table 15 Correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) Adopt ISO 14001 this year	1.000										
(2) Financial risk (t-1)&(t-2)	0.002*	1.000*									
(3) Sales growth (t-1)&(t-2)	0.017*	0.015*	1.000								
(4) Has adopted ISO 9001 (t-1)	0.099*	-0.007*	-0.002*	1.000							
(5) Has adopted OHS 18001 (t-1)	0.077*	-0.005*	*0.015*	0.089*	1.000						
(6) Cross-listing (t-1)	-0.007*	-0.016*	0.003*	-0.011*	-0.010*	1.000					
(7) Slack (t-1)	-0.005*	0.006*	0.022*	-0.006*	-0.002*	-0.004*	1.000				
(8) Firm age (t-1)	-0.042*	-0.052*	-0.068*	0.011*	0.037*	0.065*	0.023*	1.000			
(9) Financial leverage (t-1)	-0.018*	0.022*	-0.054*	-0.032*	-0.007*	-0.002	0.000	0.047*	1.000		
(10) ROA (t-1)	0.006*	0.002*	0.037*	0.017*	0.003*	0.001	0.018*	-0.014*	-0.426*	1.000	
(11) ROE (t-1)	-0.001*	0.001*	-0.047*	0.002*	-0.001*	-0.001*	0.078*	0.010*	0.002*	0.413*	1.000

6332 firm-year observations. The sample includes firms that never adopted ISO 14001 in all years and firms that adopted ISO 14001 in and before the adoption year.

4.3.3 PSM and DID

Treatment effects refer to the effect after a project or a policy is initiated. In estimating treatment effects, it is essential to isolate selection bias. The research question in this study is whether ISO 14001 leads to better financial performance than non-adopters. To answer this question, I first employed PSM to construct matched treatment and control groups and then used DID to exclude the pre-adoption selection effect and examine the treatment effect. In econometric studies, combining PSM and DID is a common strategy to control non-observed and time-invariant between-group differences and eliminate the impact of endogeneity.

Propensity score matching

PSM is a matching technique to create a quasi-control group with similar adoption covariates to those of the treatment group. In other words, the probability of a firm becoming a treatment group depends on a series of observable covariates in the pre-adoption period, and other between-group differences are randomly distributed (Rosenbaum and Rubin, 1983).

The application of PSM has several assumptions (Levine and Toffel, 2010; Toffel, 2005). First, the data source for the adoption and non-adoption groups should be the same; Second, the covariates used to estimate the propensity score should be comprehensive; Third, the distribution of two groups should be similar. I address these concerns by employing the same data sources for two groups, identifying adoption determinants based on extensive literature review, and using nearest-neighbor matching within caliper for matching.

The first step of PSM is using a probit model to estimate the propensity scores. I included a set of adoption determinants, including ISO 9001, OHS 18001, cross-listing, financial slack, ROA, ROE, financial leverage, firm age. Lagged outcome variables are also included to ensure that both groups have similar pre-period performance (Eichler and Lechner, 2002).

After obtaining the propensity score, I constructed the matched sample using the `psmatch2` command in STATA (Leuven and Sianesi, 2018). I implemented the nearest-neighbor matching within 0.02 caliper without replacement to construct a 1:1 matched sample. Each adopter is matched to a non-adopter, which has the most similar propensity score in the year of certification.

In the third step, I examined the similarity of the treatment and the control group

in terms of the propensity scores (Smith and Todd, 2005). The step is also known as the balancing tests, which aim to ensure that two groups are indistinguishable before treatment. First, the pseudo R square significantly decreased after the matching processes. Second, the difference in the means of covariates between the treatment and the control group became insignificant after matching. Third, the value of standardized bias dropped significantly after matching.

Difference in Difference

I employed DID to examine the impact of ISO 14001 on financial risk and sales growth. The method would use the control group's post-treatment performance as the counterfactual of the treatment group if it did not adopt ISO 14001. I estimate the following model for firm i in year t :

$$y_{it} = \alpha_i + \beta_1 \text{Treat}_i + \beta_2 \cdot \text{Post}_t + \beta_3 \cdot \text{Treat}_i \cdot \text{Post}_t + \gamma \cdot X_{it} + \delta_t \cdot \text{year}_t + \varepsilon_{it}$$

where y_{it} refers to financial risk or sales growth; α_i is the intercept for each firm; Treat is a dummy variable, coded as 1 for the treatment group, and 0 for the control group; Post is also a dummy variable, coded as one after the treatment and 0 before the treatment. β_3 estimates the interaction between Treat and Post , which represents the impact of ISO 14001 on the outcomes; year_t represent year dummies. The model is based on ordinary least square with firm fixed effects.

Besides, I included dummies coded as 1 in $t=0$ to $t=2$, $t=3$ to $t=5$, $t=6$ to $t=8$ in order to investigate the impact of ISO 14001 adoption on financial risk and sales growth in different year periods. In this way, I was able to take a long-term perspective to understand the outcomes of ISO 14001 adoption.

To examine the moderating effects of certification time and industrial pollution level, I adopted multi-group DID. Certification time is measured by the time a firm adopts ISO 14001 compared with its peers in the same industry (Corbett *et al.*, 2005; Su *et al.*, 2015). Specifically, I took the difference between a firm's certification time and the median of certification time of industry. Industrial pollution level is measured according to the industry directory of environmental protection of listed firms issued by the Ministry of Environmental Protection in China ⁶, which classifies 14 industry types as high-polluting industries. After I separated the sample into early and late certified firms, and high- and low-polluting industries and conducted multi-group DID.

⁶ Please refer to http://www.gov.cn/gzdt/2008-07/07/content_1038083.htm

4.4 Results

4.4.1 PSM results

Table 16 presents the results of the probit model for estimating propensity scores, which indicate the probability of adopting ISO 14001 according to the adoption determinants. Each marginal effect shows the change in adoption probability when the independent variable changes for one unit. The results reveal that the likelihood of obtaining ISO 14001 is related to having adopted ISO 9001 or OHS 18001, gaining abundant slacks, having lower financial leverage, being at an early age, and having higher ROA.

Table 16 Probit model for estimating propensity scores

	Probit coefficient	Marginal effect
Dependent Variable: adopt ISO14001 this year		
Average financial risk (t-1)&(t-2)	0.905 [1.1035]	0.093
Average sales growth (t-1)&(t-2)	-0.017 [0.1034]	-0.002
Has adopted ISO 9001 (t-1)	0.431*** [0.0647]	0.044
Has adopted OHS 18001 (t-1)	0.796*** [0.1563]	0.082
Cross-listing (t-1)	-0.081 [0.1778]	-0.008
Slack (t-1)	-0.010* [0.0057]	-0.001
Firm age (t-1)	-0.309*** [0.0666]	-0.032
Financial leverage (t-1)	-0.229* [0.1198]	-0.024
ROA (t-1)	0.352* [0.1889]	0.036
ROE (t-1)	0.022 [0.0211]	0.002
Observations (firm-year)	6332	
Number of firms	982	
Pseudo-R2	0.15	
Wald2	5494.64	

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies.

Using the propensity scores, I conducted one-to-one matching in the year of certification and constructed 342 pairs of treatment and control firms. The pseudo R square drops from 0.190 to 0.059 after the matching process, suggesting that the explanatory power of adoption determinants for ISO 14004 decreases. I compared the

means of adoption determinants between treatment and control groups in the matched and unmatched sample and found that the differences decreased significantly in the matched groups. Additionally, the mean (median) of standardized bias dropped from 10.9% (8.0%) to 4.4% (3.5%) after matching. The results indicate that PSM yielded a reliable matched sample.

4.4.2 DID results

Table 17 shows the results of DID regarding the impact of ISO 14001 on financial risk and sales growth. Since I adopted a firm fixed effect OLS model, the *treat* variable is omitted due because it is time-invariant. In column (1) and (3), the results suggest that ISO 14001 adopters significantly reduce financial risk by 0.15% compared to that of non-adopters. A counter-intuitive result is that ISO 14001 adopters significantly decrease sales growth by 6.8% compared to non-adopters.

Based on the year-to-year comparisons in Column (2) and Column (4), I find that the impacts of ISO 14001 adoption on financial risk and sales growth grows over time, suggesting a long-term influence of ISO 14001 adoption. In Column (2), the results indicate that financial risk is increasingly undermined, from 0.11% in years 0-2 to 0.21% in years 6-8. Column (4) shows that the negative impact on sales growth is also strengthened as time goes by. In the year 0-2, the rate of sales growth is not distinguishable between adopters and non-adopters. However, in year 3-5, adopters face a reduction of 6.1% sales growth inferior to non-adopters, and in year 6-8, the gap jumps to 10.7% lower sales growth for adopters. The negative effect of ISO 14001 on sales growth is increasing over time, and it does not show up until 3 years after adoption. In summary, the results support H1 but reject H2.

Table 17 DID results

	Financial risk		Sales growth	
	(1)	(2)	(3)	(4)
Treat	-	-	-	-
Post	-0.0001 [0.00031]	-0.0007 [0.00053]	0.0544*** [0.01819]	0.0218 [0.01942]
Treat*Post	-0.0015*** [0.00057]	-	-0.0681*** [0.01789]	-
Treat*Post-years 0/1/2		-0.0011** [0.00058]		-0.0195 [0.01803]
Treat*Post-years 3/4/5		-0.0012** [0.00069]		-0.0610*** [0.01876]
Treat*Post-years 6/7/8		-0.0021*** [0.00074]		-0.1076*** [0.02299]
Financial risk	-	-	2.3328*** [0.65170]	2.2336*** [0.55671]
Sales growth	0.0016*** [0.00031]	0.0017*** [0.00031]	-	-
Constant	0.0202*** [0.00021]	0.0202*** [0.00020]	0.1068*** [0.01937]	0.1074 [0.01771]
Number of firms	684	684	684	684
Observations	6574	6574	6574	6574
R2	0.25	0.25	0.08	0.08
Wald test ($\beta_{012}=\beta_{345}$)		0.07		8.27***
Wald test ($\beta_{345}=\beta_{678}$)		2.24		5.98*
Wald test ($\beta_{012}=\beta_{678}$)		3.28*		16.29***
Wald test ($\beta_{012}=\beta_{345}=\beta_{678}$)		1.65		8.59***

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies. F statistics are presented for the Wald test.

Table 18 presents the multi-group comparison of DID in examining the moderating effects of certification time and industrial pollution level, respectively. Adopting ISO 14001 certification early can further reduce financial risk by 0.23% compared to non-adopters. However, late adopters do not benefit from reduced financial risk. On the other hand, sales growth decreases by 5.1 % for early ISO 14001 adopters more than at matched non-adopters, while late adopters confront a reduction in sales growth by 4.4% than non-adopters. The results imply that early certification would strengthen the negative impact of ISO 14001 on both financial risk and sales growth, supporting H3a but rejecting H3b.

As for the moderating effect of the industrial pollution level, the results find that adopters in high-polluting industries have 0.14% lower financial risk than that of non-adopters. In contrast, adopters in low-polluting industries do not significantly differ in financial risk from non-adopters. On the contrary, ISO 14001 adoption leads to a 5.1% decrease in sales growth in high-polluting industries than non-adoption. While in light polluting industries, adoption decreases sales growth by 7.9% compared to non-

adoption. Conclusively, being in high-polluting industries, strengthens the negative impact of ISO 14001 adoption on financial risk, while weakens the negative impact of that on sales growth. The results are in support of H4a but decline H4b.

Table 18 Multi-group DID

	Financial risk		Financial risk		Sales growth		Sales growth	
	Early certified	Late certified	High-polluting	Low-polluting	Early certified	Late certified	High-polluting	Low-polluting
Treat	-	-	-	-	-	-	-	-
Post	-0.0021*	-0.0001	-0.0007	-0.0003	0.0508**	0.0003	0.0218	0.0721
	[0.00123]	[0.00078]	[0.00043]	[0.00082]	[0.02280]	[0.0363]	[0.02153]	[0.02721]
Treat*Post	-0.0023**	-0.0008	-0.0014*	-0.0013	-0.0588**	-0.0445*	-0.0511**	-0.0790***
	[0.0014]	[0.00060]	[0.00079]	[0.00101]	[0.00236]	[0.02689]	[0.02193]	[0.02597]
Financial risk	-	-	-	-	2.193***	1.9525***	2.1320***	2.3239***
					[0.75590]	[0.79365]	[0.86413]	[0.71029]
Sales growth	0.0022***	0.0013**	0.0014***	0.0020**	-	-	-	-
	[0.00047]	[0.00053]	[0.00047]	[0.00043]				
Constant	0.0200***	0.0208***	0.0196***	0.0208***	0.1077***	0.1149***	0.1326***	0.0857***
	[0.00029]	[0.00037]	[0.00047]	[0.00031]	[0.02258]	[0.03149]	[0.02261]	[0.02702]
Number of firms	288	287	304	380	288	287	304	380
Observations	3145	2416	3090	3484	3145	2416	3090	3484
R2	0.21	0.27	0.33	0.19	0.10	0.07	0.14	0.06

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors are clustered by firms in brackets; The model includes year, industry, and region dummies

4.4.3 Robustness tests

I conducted several tests to assess the robustness of the results. First, I altered proxies for the dependent variable and retested the model. Since financial risk and sales growth may show systematic variance in specific industries, I adopted industry-adjusted financial risk and sales growth (minus the median in an industry) and found the results remained the same. Furthermore, I adopted the market model to recalculate financial risk and used two years of sales growth, leading to equivalent results.

Second, I added more control variables in the DID model, including related financial performance (i.e., ROA, ROE, ROS), and yielded similar results. The results suggest that the model results are robust while considering other possible impacts.

Third, as I found that ISO 14001 reduced financial risk, it is necessary to investigate whether ISO 14001 adoption harms actual financial benefits (Lam, 2018). I used two indicators for financial benefits, ROA based firm annual financial report, and annual abnormal return based on the Fama-French three-factor model. The DID model does not find a significant impact of ISO 14001 on ROA or abnormal return. Thus, I suggest that adopting ISO 14001

4.5 Discussion

This study provides empirical evidence that ISO 14001 certification serves as a valid signal to investors, thus reducing financial risk. Investors regard ISO 14001 adoption as a positive sign of a firm's environmental performance, abundant resources, and superior capabilities. Meanwhile, having an ISO 14001 certification enables a firm to prepare for environmental and operational disruptions, construct high-commitment human capital, and avoid the negative impacts of risk. The results are consistent with some previous studies. For instance, Bansal and Clelland (2004) found that firms with high environmental legitimacy have a low financial risk. Lam (2018) indicated that supply chain sustainable practices lead to lower financial risk. Mishra and Modi (2012) suggested that firm socially responsible practices decrease idiosyncratic risk. This finding emphasizes the significance of having ISO 14001 in maintaining financial

stability.

Furthermore, I find that ISO 14001 adoption does not affect the financial return. That is to say, while ISO 14001 certification does not bring additional returns for firms, it contributes to the capabilities of mitigating risk and maintaining stability, which is especially crucial under turbulent environment (Godfrey *et al.*, 2009). ISO 14001 certification acts as an insurance-like protections that safeguard firms against risk.

On the other hand, I find that ISO 14001 adoption hurts sales growth, which contradicts the hypothesis, and such impact is strengthened in the long run. Most existing studies indicate that environmental management will positively influence sales growth (Chan, 2005; Judge and Douglas, 1998; Menguc *et al.*, 2010). I propose two explanations for the finding that ISO 14001 harms sales growth. First, sales growth symbolizes the speed of expansion. ISO 14001 adoption changes the expansion approach of a firm from being aggressive and acquisitive to being controlled and sustainable. In other words, a firm may simplify its product lines, control production volume, and minimize carbon footprints in ISO 14001 adoption. As the product quality is improved while the production quantity is controlled, firms are constrained from rapid expansion. Another explanation is that unlike investors, customers do not take ISO 14001 certification as a positive sign. Chinese customers may regard ISO 14001 adoption as excess cost burdens to firms, thus withdrawing their willingness to purchase from the firm (Lam *et al.*, 2016; Lyon *et al.*, 2013). Combining the results of the main effects, I suggest that ISO 14001 adoption is a double-edged sword for firms' long-term stability and growth. It acts as a positive signal to investors, thus reducing financial risk in the long run. However, ISO 14001 adoption can be a negative sign in the eyes of customers and may hamper the quick expansion of firms, thus diminishing sales growth as time goes on. ISO 14001 adoption leads to a hidden paradox that damages the path to long-term resilience for firms.

Considering the moderating effects of contextual factors, I find that early certified firms meet with reduced financial risk to a greater extent. This finding strongly supports the recognition of ISO 14001 as a signal in the eyes of shareholders and is consistent with various previous studies (Delmas and Montes-Sancho, 2009; Flammer, 2013;

Klassen and McLaughlin, 1996; Lo *et al.*, 2013; Su *et al.*, 2015). Back to an early time, the environment lacks credible information about firms' environmental management and involves a prominent level of information asymmetry. Adopting ISO 14001 requires intense devotion and undergoes third-party auditing; thus, it can serve as a reliable signal for investors to build strong confidence in the firm. Meanwhile, early certification builds a first-mover advantage for firms to prepare and defend risk and mitigate the adverse impact of existing risk. However, late certification loses its strong credibility as a signal because many firms in the market have adopted ISO 14001. Late certified firms may obtain ISO 14001 through free-riding and are reluctant to devote enough effort.

I also find that early certified firms have a lower level of sales growth than late certifiers. In other words, obtaining ISO 14001 early will hamper a firm's speed of expansion and growth. Two reasons may explain the novel finding. For one thing, earlier certification symbolizes more substantial practices. Thus firms transform their approaches of development and expansion to a more considerable extent (Toffel, 2005). Late certifiers are more driven by institutional pressure and thus are more likely to decouple from actual implementation. So, their development paths are less changed. For another, earlier certification draws more attention to customers who are not in favor of ISO 14001 certification, decreasing sales growth to a more significant extent. In sum, the finding suggests that early certification reinforces ISO 14001's positive impact on stability and negative impact on growth. As a result of this, early ISO 14001 adoption amplifies the conflict between stability and growth as opposite ends. Early obtained accreditations provide firms with more insurance-like capital to withstand risk, but also decrease the potential for firms to expand and capture market share rapidly.

The finding that firms in high-polluting industries benefit more from ISO 14001 certification in mitigating financial risk is consistent with various existing studies (Cañón-de-Francia and Garcés-Ayerbe, 2009; Lucas and Noordewier, 2016). In high-polluting industries, ISO 14001 stands for a strong signal to investors. Firms in high-polluting industries face higher operational risk and meet more challenges in a technology upgrade, process improvement, and waste management, and investors as a

result of this place higher value for those firms adopting ISO 14001. In low-polluting industries, however, the value of ISO 14001 is undermined; thus, investors' confidence in the firm is weakened.

I also find that the negative impact of ISO 14001 adoption on sales growth is weakened in high-polluting industries. That is to say: ISO 14001 adoption harms sales growth less in high- than low-polluting industries. A plausible reason is that firms in high-polluting industries are difficult to change their expansion path completely. Constrained by the product types, firms in high-polluting industries naturally emit more waste and need to use end-of-pipe solutions in some circumstances (Jänicke *et al.*, 1997; Sarkis and Cordeiro, 2001). ISO 14001 adoption shows a limited impact on a firm's route of expansion, thus reducing sales growth less. Besides, customers' negative response to firms' adopting ISO 14001 certification is declining in high-polluting industries, as they perceive the adoption as being more meaningful. Hence, I see a declined negative impact of ISO 14001 on sales growth in high-polluting industries. Considering the moderating role of the industrial pollution level, I indicate that firms in high-polluting industries reconcile the conflict between growth and stability. Firms in high-polluting suffer less from the paradoxical impact of ISO 14001 adoption so that they can maintain stability while not losing many market growth opportunities.

4.6 Conclusion and implications

Overall, this study shows that environmental accreditations have paradoxical impacts on financial risk and sales growth in the long run. Boosting growth and maintaining stability is critical for firms to achieve resilience, such that firms can sustain development with minimal risk. However, the study indicates that adopting environmental accreditation may lead to different ends. Considering the contextual factors around the signal, I find that early certification time strengthens the positive effect of ISO 14001 on financial risk and sales growth. Being in heavy pollution industries strengthens the positive impact of ISO 14001 on financial risk while weakening the negative impact on sales growth.

Theoretically, this study contributes to the understanding of the relationship between ISO 14001 adoption and economic performance. Previous studies investigate the impact of certification on environmental management or financial performance, but few look at some underlying and long-term performance indicators, such as financial risk and sales growth. This study explored stability and growth as two significant objectives of firms and found that ISO 14001 adoption leads to paradoxical ends. Although ISO 14001 leads to financial stability, it is at the cost of rapid sales growth. I thus hope future researchers to explore the multi-sides impact of ISO 14001 adoption on firm performance, thereby having a comprehensive understanding of the effect of the certification. Besides, this study draws from the signalling theory to explain the impact of ISO 14001 on financial risk and sales growth as well as the moderating effects (Cañón-de-Francia and Garcés-Ayerbe, 2009). The results demonstrate that ISO 14001 adoption serves as a positive signal to the investors and a negative signal to customers; the contradiction is reinforced if the certification is obtained early and is undermined if the firm is in a high-polluting industry. The findings substantiate empirical evidence to the signalling theory and highlight the importance of considering contextual factors in the theory.

Managerially, this study provides a convincing answer to the question, which confuses managers for a long time: what is the impact of ISO 14001 on the resilience performance of firms in the long run? The finding suggests that ISO 14001 adoption reduces financial risk without harming financial returns. Reducing financial risk is essential for stable development, which enables a firm to focus on core technology, carry on innovative activities, win competitive advantages in a highly turbulent environment (Lam, 2018; Luo and Bhattacharya, 2009). However, rapid growth and sustained stability can be opposing objectives when adopting ISO 14001. Managers need to fit in a balance to maximize the benefits of firms. For start-up firms seeking fast expansion, they should be cautious about obtaining ISO 14001. The requirements for obtaining ISO 14001 certification may occupy too many efforts in improving processes, technologies, and human capital, and thus firms may miss the opportunity to proliferate. On the other hand, for those pursuing stability, ISO 14001 adoption can help

firms systematically improve the processes and gain confidence from the shareholders. Especially as some medium- or large-sized firms have reached the bottleneck of market size growth, adopting ISO 14001 is beneficial for long-term stability.

Also, managers should be concerned about the contextual factors affecting the effectiveness of ISO 14001. The earlier a firm adopts ISO 14001, the more financial stability a firm gains, and the more sales growth a firm loses. Concerning when to adopt the certification, managers must see a paradoxical situation in which stability and growth cannot be achieved simultaneously. In high-polluting industries, ISO 14001 adoption leads to stability in stock prices and loss in sales growth. Hence, considering the industry type, firms in high-polluting industries may benefit more from ISO 14001 adoption as the conflict between stability and growth is reconciled.

5 Study 3: Linking perceived stakeholder pressure to firm environmental strategy: The moderating effect of managerial value orientations

5.1 Introduction

In the age of global warming and environmental deterioration, manufacturing firms are under unrelenting stakeholder pressure to initiate environmental management (Berrone *et al.*, 2013; Crilly *et al.*, 2012; Marquis *et al.*, 2015). By satisfying different stakeholders' requirements, firms can gain legitimacy for long-term survival (Darnall *et al.*, 2010; DiMaggio and Powell, 1983). A large number of studies have explored the impact of different stakeholder pressure on adopting environmental initiatives (Berrone *et al.*, 2013; Betts *et al.*, 2015; Hoejmose *et al.*, 2014; Huang *et al.*, 2016; Phan and Baird, 2015; Sarkis *et al.*, 2010; Yu and Ramanathan, 2015), yet it is not clear what decides a firm's response facing similar different pressure (Bansal, 2003; Delmas and Toffel, 2008). In other words, why a variety of stakeholder pressure influences firms' environmental strategy differently?

In answering this question, Bansal (2003) pointed out the significant role of managers in how firms respond to different stakeholder pressure. According to the managerial cognition perspective and the upper echelon theory (Hambrick and Mason, 1984), managers' perceptions and interpretations of internal and external environment influence firms' choices strategy (Branzei *et al.*, 2004; Fryxell and Lo, 2003; Klassen, 2011; Schaltenbrand *et al.*, 2018; Yang *et al.*, 2018). For instance, managers with stakeholder orientation might put meeting the requirements of stakeholders as the primary consideration (Burton and Goldsby, 2009). Following the rationale, it can be argued that managers' awareness of environmental management affects their response to external requirements (González-Benito and González-Benito, 2006). The role of managers is particularly prevalent in firms' decision making about environmental strategy (Schaltenbrand *et al.*, 2018; Yang *et al.*, 2018). First, environmental strategy symbolizes a strong signal that can be identified by external stakeholders (Dam and

Petkova, 2014; Johnstone and Labonne, 2009), which is an essential approach for managers to demonstrate their capabilities and gain external recognition (Yeung *et al.*, 2011). Second, the decision to establish environmental strategy involves considerations about benefits or costs, intrinsic motivations, or extrinsic requirements. With this, managerial value orientations could determine the choice of these contradictions.

Despite the crucial role of managers in firm environmental management, it remains unknown how value orientations impact environmental strategy when managers are faced with different stakeholder pressure. Schaltenbrand *et al.* (2018) conducted a literature review and found three categories of studies. The first category takes up most studies. They investigate the impact of stakeholder pressure on environmental practices and almost all confirm a positive relationship (Adebanjo *et al.*, 2016; Dai *et al.*, 2015; Darnall *et al.*, 2010; Garcés-Ayerbe *et al.*, 2012; González-Benito and González-Benito, 2006; Huang and Kung, 2010; Sarkis *et al.*, 2010; Vazquez-Brust *et al.*, 2010; Wing-Hung Lo *et al.*, 2010; Yu and Ramanathan, 2015; Zhang *et al.*, 2008; Zhu, 2016). The second category is about the impact of managerial values, cognition, and interpretations on environmental practices (Babiak and Trendafilova, 2011; Bansal and Hunter, 2003; Bansal and Roth, 2000; Branzei *et al.*, 2004; Brulhart *et al.*, 2017; Fryxell and Lo, 2003; Papagiannakis and Lioukas, 2012; Schaltegger and Burritt, 2015; Schaltegger and Hörisch, 2017). These studies employ different theoretical perspectives to classify managerial cognitive features and explore the adoption, development, and implementation of environmental initiatives. The third category, also the focus of the study, investigates the combined impact of stakeholder pressure and managerial values on environmental strategy (Delmas and Toffel, 2008; González-Benito and González-Benito, 2006; Menguc *et al.*, 2010; Van Cranenburgh *et al.*, 2013). In other words, the impact of perceived stakeholder pressure on environmental strategy may be contingent upon managerial value orientations. Studies in this category are still in infancy, which calls for further research (Frynas and Stephens, 2015; Schaltenbrand *et al.*, 2018).

This study uses China as a research context. Industrial pollution from Chinese manufacturing firms, including water, air, and substantial pollution, is a vital source of

serious environmental problems. During the 2008 Beijing Olympics, the government even needed to shut down some of the high-polluting firms to ensure satisfactory air quality⁷. According to World Bank estimates in 2017, the cost of China's air pollution in 2015 accounted for 7.8% of total GDP⁸. Studying how Chinese firms react to stakeholder pressure is vital for promoting environmental practices and improve environmental performance.

This study explores the effect of perceived stakeholder pressure (i.e., competitive and social pressure) and managerial value orientations (i.e., economic and legal orientation) on the establishment of environmental strategy. On the one hand, managers will perceive the influence of different stakeholder pressure, and on the other hand, they will make decision-making choices based on their value orientations. When the pressure perceived by is consistent with a manager's value orientation, he/she will tend to develop environmental strategy and vice versa.

In general, the core of this study is how perceived stakeholder pressure is synergistic with managerial value orientation and affects firms' environmental strategy. The study employs survey to measure perceived stakeholder pressure, managerial value orientations, and environmental strategy. The study links the stakeholder theory to managerial cognition theory. More importantly, it explores the roles of managers in environmental management and has substantial contributions to the study of antecedents to environmental initiatives.

5.2 Theoretical framework and hypotheses development

5.2.1 Stakeholder pressure

Stakeholders refer to individuals or groups that influence or are influenced by firms' operational activities (Freeman and Boeker, 1984), including the public, consumers, suppliers, employees, NGOs, and shareholders. The importance of managers is implicit in the stakeholder theory: managers first perceive the pressure from stakeholders, then

⁷ <https://www.reuters.com/article/us-olympics-closures/china-to-shut-factories-ahead-of-olympics-sources-idUSSP3834220080704>

⁸ Available at <http://www.oecd-ilibrary.org/docserver/download/d1b2b844-en.pdf?expires=1517681542&id=id&accname=guest&checksum=9B43144FCF78931DCE50EBEC9B8F84E8>

interpret the importance of different types of pressure, and finally make decisions about strategic choices (Darnall *et al.*, 2010; Freeman *et al.*, 2004; Miles, 2017; Mitchell *et al.*, 1997). Mitchell *et al.* (1997) argued that managers rank the significance based on power, legitimacy, and urgency of stakeholders. Sharma and Henriques (2005) suggested that the degree of mutual reliance should determine the importance of stakeholders.

Existing studies classify stakeholders into two types. One is called primary or business stakeholders, who exert direct impacts on firms' economic interests. The other is named secondary or non-market stakeholders, who are not directly involved in firms' operational activities (Delmas and Toffel, 2004; Freeman and Boeker, 1984). The two types of stakeholders hold divergent attitudes towards environmental initiatives (Hoffman and Ventresca, 1999). Primary stakeholders pay more attention to economic benefits and care for cost and efficiency issues, while secondary stakeholders consider more about the externalities of environmental problems and the need for environmental initiatives (Delmas and Toffel, 2004).

Chinese manufacturing firms are mainly faced with pressures from the market, the government, and the public (Yang *et al.*, 2018). In the market, many firms have adopted voluntary environmental management systems, such as obtaining ISO 14001 certifications, participating in environmental agreements, and establishing environmental strategy, which forms the competitive pressure that impels managers to imitate. I define perceived competitive pressure as the pressure from competitors that have successfully adopted environmental strategy in the market. On the other hand, with the increasing emphasis on environmental management from the government and the public (Darnall *et al.*, 2010), social pressure also urges firms to initiate environmental management. Perceived social pressure refers to the pressure from non-market constituents, including the government and the public (Yang *et al.*, 2018). At this moment, this study focuses on the impact of competitive and social pressure on the firm's environmental strategy.

5.2.2 Managerial value orientations

A person's value orientation is defined as the crucial goals or principles that guide personal decisions (Rokeach, 1973). When the concept is extended to firm managers, managerial value orientation indicates the values or principles that affect corporate strategic choices and development goals (Bansal and Roth, 2000; Cordano and Frieze, 2000; González-Benito and González-Benito, 2006; Papagiannakis and Lioukas, 2012; Vazquez-Brust *et al.*, 2010). Existing literature has identified different types of managerial orientations, such as environmental awareness (González-Benito and González-Benito, 2006), entrepreneurial orientation (Menguc *et al.*, 2010), and regulatory focus orientation (Cowan and Yazdanparast, 2019). I focus on economic and legal orientation because the academic indicates two significant motivations for firms to take sustainability initiatives: profit- or legitimacy-seeking (Schaltegger and Hörisch, 2015). Managers' value orientations broadly impact the motivations. As such, this study considers two types of managerial value orientations: economic and legal orientations (Bansal and Roth, 2000; Klassen, 2011; Schaltegger and Hörisch, 2017).

Managers with an economic orientation accentuate economic development and consider financial performance in the first place when making strategic decisions. The root of the economic orientation is in the rational choice hypothesis (Cabantous and Gond, 2011; Hausman, 1995). Economic orientated managers tend to frame problems into an instrumental calculation of cost and benefit. In environmental management, the most important questions for these managers are: Does the environmental practice brings economic benefits? Does environmental practice cost high? Do stakeholders influence relate to economic interests (Cheung *et al.*, 2013; Clarkson *et al.*, 2011; Lourenço *et al.*, 2011).

On the contrary, managers with a legal orientation attach greater importance to legitimacy purposes in strategic decision making. Different from the rational decision-making theory that emphasizes calculation about economic benefits, legitimacy is at the heart of the legal orientation. The legitimacy theory argues that the survival of a firm is determined by its ability to meet social demand and obtain legitimacy (Bitektine, 2011; DiMaggio and Powell, 1983). In environmental management, legal-oriented managers commonly ask: Does the environmental practice brings legitimacy? Are the

stakeholders that impact the firm related to legitimacy?

5.2.3 Environmental strategy

Regardless of a variety of definitions about environmental strategy, two types can be classified: one is reactive environmental strategy, meaning firms only comply with the minimum restraint of laws in pollution control; the other is proactive environmental strategy, referring to that firms integrate environmental goals and mindsets that beyond regulatory requirements in firm strategy (Aragon-Correa, 1998; Aragon-Correa *et al.*, 2008; Dai *et al.*, 2017; Hart, 1995). This study concentrates on proactive environmental strategy. Namely, firms set a uniform environmental goal for each department and convey the strategy to employees, thus establishing a consistent environmental strategy.

The development of environmental strategy is strictly dependent upon managers' care for environmental protection (Yang *et al.*, 2018). That is to say, firms' establishing environmental strategy reflects the process in which managers perceive external pressure and make decisions (Maitland and Sammartino, 2015). Perceived stakeholder pressure may affect managerial cognition and decision-making in environmental strategy. Further, managerial value orientations, namely cognitive frameworks, may influence managers' intentions (Gavetti and Levinthal, 2000). Below, I will illustrate the corresponding hypotheses.

5.2.4 The impact of perceived stakeholder pressure on environmental strategy

Firms are embedded in a social network so that they will be affected by other firms in the network (McFarland *et al.*, 2008). According to Schumpeter's competitive view, observing the behavior and strategies of other firms is a vital market behavior (Jacobson, 1992). When some firms gain competitive advantages through a particular strategy, other firms will soon follow up to maintain strategic competitiveness. When managers feel a high level of competitive pressure, they are likely to take some strategic actions to strengthen market positions (Dai *et al.*, 2015). In this sense, if competitors obtain competitive advantages through establishing environmental strategy, managers would perceive the pressure, internalize the behavior, and promote environmental strategy in

their firms intending to obtain similar benefits (Dai *et al.*, 2015; Hofer *et al.*, 2012).

Meanwhile, as competitors can gain legitimacy by conducting environmental practices, firms who fail to do so might suffer from losing orders, diminishing customers, and damaged reputation. To avoid these negative consequences, managers tend to adopt environmental strategy when perceiving competitive pressure. Thus, I propose:

H1a: Perceived competitive pressure is positively related to the establishment of environmental strategy

On the other hand, social pressure, namely pressure from the government and the public, would influence the formation of environmental strategy. Firms have to meet the requirements of the government and the public to survive and sustain because the recognition and support from them are the most important sources of legitimacy (De Roeck and Delobbe, 2012). Once a firm loses support from them, it could receive harsh punishment. In the eyes of managers, conforming with the accepted or expected environmental practices required by the government is necessary for firms to acquire extra resources and even for them to gain political capital (Berrone *et al.*, 2013; Sheng *et al.*, 2011; Suchman, 1995). Fulfilling the requests from the public can help firms set up positive images and gain visibility for managers themselves. Existing studies have elaborated on similar arguments. For instance, Lee *et al.* (2018) found that perceived social expectation is related to environmental practices. Berrone *et al.* (2013) stated that regulatory and normative pressure influences firms' environmental innovation. Hence, I suggest that when perceiving social pressure, managers tend to form environmental strategy. I propose:

H1b: Perceived social pressure is positively related to the establishment of environmental strategy

5.2.5 The impact of managerial value orientations on environmental strategy

Managerial value orientations are directly related to firms' strategic choices upon environmental strategy (Stern *et al.*, 1999). A type of value orientation constitutes a

specific belief, then turns into a norm, finally leads to a behavior. Managers with a particular value orientation would form a stable criterion of judgment, which impacts the decision-making process. Previous studies have explored the influence of value orientations on environmental practices. Environmental orientation, an obligation for social responsibility, and an ethical value will enhance a firm's intention to adopt environmental practices (Bansal and Roth, 2000; Cordano and Frieze, 2000; Menguc *et al.*, 2010; Papagiannakis and Lioukas, 2012; Vazquez-Brust *et al.*, 2010).

In this study, economic and legal orientations reflect managers' inclinations towards specific strategic options. Economic-oriented managers highlight the balance between costs and benefits. Establishing environmental strategy cultivates a culture that eliminates wastes, improves efficiency, and enhances innovation capabilities, with this increasing benefits and reducing costs (Chan *et al.*, 2016; Singh *et al.*, 2015; Zhu *et al.*, 2007). Firms that establish environmental strategy can gain broad support from stakeholders, thus improving access to capital, stock returns, and sales volume (Menguc *et al.*, 2010; Sharfman and Fernando, 2008). Moreover, according to the natural resource-based view, the development of environmental strategy can help firms to gain sustainable competitive advantages (Sharma and Vredenburg, 1998). Therefore, I propose:

H2a: Economic orientation is positively related to the establishment of environmental strategy

Forming environmental strategy is an indication of being socially responsible and a critical approach to gain legitimacy (Wang *et al.*, 2018). As legal-oriented managers regard obtaining legitimacy as the priority for firms, they are willing to establish environmental strategy for this purpose. Besides, the development of environmental strategy facilitates environmental awareness among managers and employees, who would subsequently abide by regulations in strategic decision makings and production tasks (Berrone *et al.*, 2013; Potoski and Prakash, 2005b). In summary, legal-oriented managers are more likely to develop environmental strategy. I propose:

H2b: Legal orientation is positively related to the establishment of environmental

strategy

5.2.6 The moderating effect of managerial value orientations

In addition to the direct impact of managerial value orientations on the development of environmental strategy, a series of studies focus on the role of managers' beliefs, attitudes, and values in facing external threats or opportunities (Bansal and Roth, 2000; Garcés-Ayerbe *et al.*, 2012; Sharma *et al.*, 1999). When managers interpret stakeholder pressure as opportunities, they are inclined to accommodate firm strategies to external requirements proactively. On the contrary, if the stakeholder pressure is interpreted as a threat, managers tend to passively respond to the external pressure and not actively adjust firm strategies (Garcés-Ayerbe *et al.*, 2012). In this study, I propose that the managers' interpretations of stakeholder pressure depend on their value orientations. For managers who are economic-oriented, they tend to conceive a frame that interprets external pressure from an analysis of costs and benefits. On the other hand, legal-oriented managers employ the legitimacy criterion to judge the significance of stakeholder pressure. Accurately, economic-oriented managers translate competitive pressure into an opportunity to enhance their firms' competitive advantages. By imitating competitors' environmental strategy, firms can reduce costs, gain legitimacy, and improve competitiveness (Dai *et al.*, 2015). As a result, competitive pressure will propel economic-oriented managers to integrate environmental protection into firm strategic goals. On the other hand, as social pressure requirements exceed the average efforts firms afford to pay, they might sacrifice short-term economic benefits to comply with the requirements of the government and the public. Thus, economic-oriented managers tend to regard social pressure as a threat to competitive advantages and suppress the development of environmental strategy. I propose:

H3a: The impact of perceived competitive pressure on environmental strategy is enhanced when the level of economic orientation is high

H3b; The impact of perceived social pressure on environmental strategy is weakened when the level of economic orientation is high

Legal orientation indicates a criterion that judges firm behaviors according to regulatory requirements and legitimacy purposes. Legal-oriented managers tend to interpret competitive pressure as a threat that might violate a firm's legitimacy status. Kauppi (2013) pointed out that the considerations for competitive pressure result from uncertainty about the outcomes of behaviors. Imitating competitors' behaviors is a means of minimizing uncertainty and gaining competitiveness in a market. Legal orientated managers, however, have a clear understanding of firm behavior according to the law specifications and would not benchmark against competitors. In this regard, the influence of competitive stakeholders is impaired. Oppositely, perceived social pressure may be taken as an opportunity for legal-oriented managers to demonstrate conformity with regulations and gain legitimacy. Under this circumstance, the influence of social pressure on the establishment of environmental strategy is reinforced by legal orientation. In summary, managers with legal orientation are more likely to react to social pressure and less influenced by competitive pressure proactively. I propose:

H4a: The impact of perceived competitive pressure on environmental strategy is weakened when the level of legal orientation is high

H4b; The impact of perceived social pressure on environmental strategy is strengthened when the level of legal orientation is high

The conceptual framework is presented in figure 2.

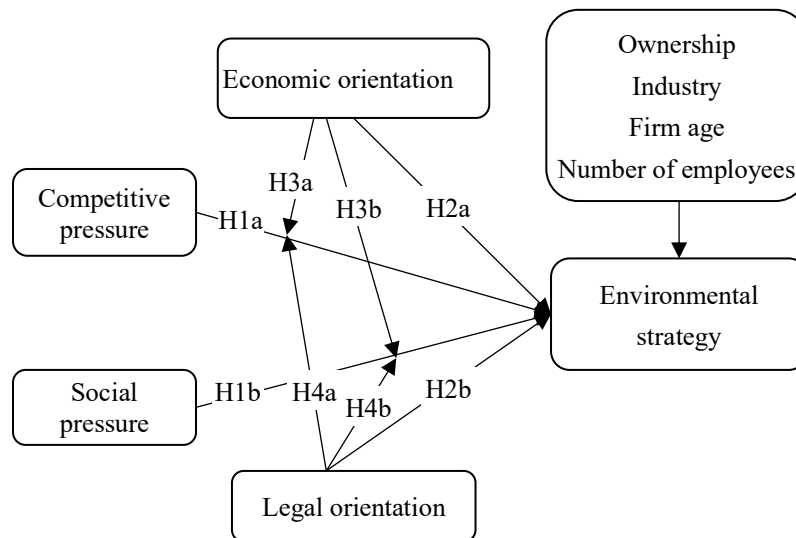


Figure 2 Conceptual framework

5.3 Methodology

5.3.1 Questionnaire design

This study employs survey, one of the most widely used research methodologies in OM research, to capture the perceptions of managers (Malhotra and Grover, 1998; Rungtusanatham *et al.*, 2003). Generally, a survey is designed for theory testing (Forza, 2002). The researcher ought to establish a conceptual model, decide about the level of concepts, identify operational constructs, and describe questions appropriately and precisely. The techniques to reduce common method bias in the questionnaire include arranging the order of items, converging items of related constructs, and using reversed measured items.

In designing the measures, two techniques are commonly employed. One is adapting existing measures, and the other is self-designing measures. The former requires that the source is from a high-quality journal, which has been widely recognized after repeated application in a large number of studies. The latter is more contextual and enables researchers to design new items for novel concepts.

This study follows established steps in designing a questionnaire with rigor (Flynn *et al.*, 2010). First, a comprehensive literature review was conducted to make sure the concepts in this study were correctly understood. Second, I adapted measures from existing literature. In order to ensure high-quality measures, translation and back-translation are conducted. That is, one professional researcher first translates English items into Chinese, then another researcher translates Chinese back to English, and finally, I compare the wording differences between the two translations to reduce language bias. Third, based on the basic questionnaire framework, face-to-face interviews with several business managers were arranged. Each item was checked for whether there were incomprehensible or vague descriptions, whether they were inconvenient to answer, and whether they were in line with firm practices. After the process, the ambiguous items were further modified, and some items were added or deleted. Finally, the questionnaire was pilot tested in 18 firms, and some fundamental descriptive analysis was performed based on the preliminary collected data.

5.3.2 Measures

Stakeholder pressure

Stakeholder pressure measures the pressure that firms perceive from different stakeholders. This study focuses on two types of stakeholder pressure: competitive pressure and social pressure. Competitive pressure comes from the successful experience of competitors in the market, while social pressure stems from non-market constituents, including the government and the public. The measures were adopted from Buysse and Verbeke (2003), Darnall *et al.* (2010), and Delmas and Toffel (2004).

Managerial value orientation

The measurement of managerial value orientation is derived from Carroll's (1991) corporate social responsibility classification. Carroll divided value orientations into four categories: economic, legal, ethical, and philanthropic orientation. This study focuses on economic and legal orientation. Economic orientation represents the priority in short-term economic benefits, while legal orientation represents the priority in complying with legal obligations.

Environmental strategy

Environmental strategy is developed through a wide and consistent environmental goal conveyed to every employee in a firm. The measurement is adapted from Buysse and Verbeke (2003), Sharma and Vredenburg (1998), Delmas and Toffel (2010), and Darnall *et al.* (2010). Table 19 summarizes the measures.

Table 19 Construct measurement

Constructs	Items	References
Competitive pressure	CP1: Our competitors successfully implement environmental management	Buysse and Verbeke (2003), Darnall <i>et al.</i> (2010), and Delmas and Toffel (2004)
	CP2: Our competitors implement environmental management and benefit a lot	
	CP3: Our competitors implement environmental management and become more competitive	
	CP4: The competitors who implement environmental management are recognized by the industry	
Social pressure	SP1: Our firm must implement environmental management because of government regulations	Buysse and Verbeke (2003), Darnall <i>et al.</i> (2010), and Delmas and Toffel (2004)
	SP2: The government control of pollution influences our firm to implement environmental management	
	SP3: The public's emphasis on environmental protection influences our firm to implement environmental management	
Economic orientation	EO1: Our company believes it is important to maximize operational benefits	Carroll (1991)
	EO2: Our company believes it is important to maximize profitability	
	EO3: Our company believes it is important to maintain a strong competitive position	
	EO4: Our company believes it is important to measure success by sustainable profitability	
Legal orientation	LO1: Our company believes it is important to perform in a manner consistent with expectations of government and law	Carroll (1991)
	LO2: Our company believes it is important to comply with country and local regulations	
	LO3: Our company believes it is important to act as law-abiding corporate citizens	
	LO4: Our company believes it is important to measure success by conformity with regulatory responsibilities	
Environmental strategy	ES1: The environmental project in every department fits well with the firm's environmental strategy	Buysse and Verbeke (2003), Sharma and Vredenburg (1998), Delmas and Toffel (2010), and Darnall <i>et al.</i> (2010)
	ES2: Our firm has a cross-functional environmental goal	
	ES3: The environmental strategy and goal are conveyed to all employees	
	ES4: We often review and revise environmental strategy in each department	
	ES5: We devise environmental strategies (e.g., environmental goals, activities, and performance evaluation) for each department	

5.3.3 Data collection

This study surveyed Chinese manufacturing firms. China has a vast territory and unbalanced regional economic development. Therefore, it is especially vital to scientifically select sampling areas to reflect the whole. This study selected four representative regions: the Yangtze River Delta, the Pearl River Delta, the Bohai Rim region, and other regions (the Northeast, Southwest, and Midwest) (Zhao *et al.*, 2006). The Yangtze River Delta, the Pearl River Delta and the Bohai Rim region are the most developed regions in China, while the economic level in other regions is low. Through multi-regional sampling, the data obtained can better reflect the overall situation.

The sampling pool of this study is manufacturing firms in the four major regions, and a random stratified sampling method is adopted. The manufacturing firms were randomly selected from the China Yellow Pages directory in each region, contacted for the intention to participate in the research by telephone or mail. After obtaining the consent of a firm, the questionnaire, along with a prepaid postage envelope to reply, was sent to the appropriate respondent. A week after the questionnaire was sent, a telephone follow-up and an email reminder were conducted, and the questionnaire was finally returned within one month.

The data collection followed Frohlich (2002) recommendations to improve the response rate of the questionnaire. First, contact firms as early as possible, explain the academic purpose, and ensure confidentiality. Second, send questionnaires to the critical informants with high relevance and provide contact information to facilitate communication with respondents. Third, make multiple reminders to prompt the respondents to complete the questionnaire in time.

A total of 812 questionnaires were sent out, and 298 questionnaires were returned. After eliminating questionnaires with a large number of missing values, contradictory answers, and serious common method problems, a total of 206 valid samples were retained. The overall response rate was 25.4%, which was at a reasonable level compared to other studies using similar methods (Ateş *et al.*, 2012; Zhu *et al.*, 2008). The sample descriptive and respondent profile is presented in table 20 and table 21, respectively.

Table 20 Sample descriptive

	Classification	Number	Percentage
Industry	Metal, machinery, and engineering	84	40.8
	Electronics and electrical appliances	40	19.4
	Textiles and apparel	21	10.2
	Chemicals and petrochemicals	16	7.8
	Food, drink, alcohol, and cigarette	13	6.3
	Building materials	10	4.9
	Publishing and printing	9	4.4
	Rubber and plastic	8	3.9
	Pharmaceutical	5	2.4
Number of employees	Fewer than 50	2	1.0
	50-99	2	1.0
	100-199	48	23.3
	200-499	70	34.0
	500-999	37	18.0
	1000-4999	38	18.4
	More than 5,000	9	4.4
Fixed asset (yuan)	Fewer than 5 million	12	5.8
	5 million - 10 million	14	6.8
	10 million - 20 million	17	8.3
	20 million - 50 million	39	18.9
	50 million - 100 million	41	19.9
	More than 100 million	83	40.3
Firm age	Fewer than 10 years	21	10.2
	10 – 20 years	91	44.2
	20 - 30 years	56	27.2
	More than 30 years	38	18.4
Region	Bohai Rim region	73	35.4
	Yangtze River delta	51	24.8
	Pearl River delta	41	19.9
	Other regions	41	19.9
Ownership	Private-owned	111	53.9
	Foreign-owned	40	19.4
	State-owned	33	16.0
	Joint venture	22	10.7

Table 21 Respondent profile

	Classification	Number	Percentage
Tenure (year)	Fewer than 2	0	0.0
	2–5	48	23.3
	6–10	82	39.8
	11–15	39	18.9
	More than 15	37	18.0
Position	Top manager (e.g., chairman, CEO, president)	46	22.3
	Middle managers (e.g., production, procurement, sales manager)	157	76.2
	Others (e.g., salesperson, purchasing agent)	3	1.5

Non-response bias refers to the bias caused by potential respondents not answering the questionnaire. The reason could be twofold. The potential respondents may decline because of sensitive content in the questionnaire, causing systematic bias. On the other hand, potential respondents may forget to answer the questionnaire due to personal issues, leading to random bias in the data.

In the process of evaluating non-response bias, the non-respondents were first contacted to learn about the reasons for not responding. Most explained there was no available time, or they forgot to reply, suggesting the existence for random error. Second, 40 no responding firms were randomly selected and searched on the website for critical characteristics such as the number of employees, firm age, ownership, fixed assets. Meanwhile, randomly selected 40 firms from collected samples and used independent sample t-test to compare characteristics with no responding firms. The result indicates that the two groups of firms did not differ in critical characteristics ($p > 0.05$). Lastly, selected 40 early and late responding firms respectively, and conducted a t-test to examine the difference in key characteristics. The result suggests no significant difference as well, suggesting non-response bias was not a severe issue (Frohlich, 2002).

Common method bias refers to the spurious variance among variables due to the use of a single source or method in data collection (Podsakoff *et al.*, 2003). The dominant problem in survey data is that a single informant answers all the questions (Berman and Kenny, 1976). To cope with the issue, I take measures *ad hoc* in

questionnaire design and examine common method bias *post hoc* (Podsakoff *et al.*, 2003).

In the questionnaire design, the constructs (i.e., stakeholder pressure, value orientation, and environmental strategy) should be distinguishable from each other. The independent and dependent variables need to be separated into different sections of the questionnaire, to moderate respondents' consistent tendency. After the data collection, this study employs Harman's single-factor analysis, which examines whether one common factor explains most of the variance. In Exploratory Factor Analysis (EFA), all items were added and not rotated, and the result showed six factors whose eigenvalues exceeded 1.0 explained 74.29% of the variance, with the first factor accounting for 29.90% of the variance. Similarly, in Confirmatory Factor Analysis (CFA), all items were loaded on a common factor, and the fit indices were not acceptable ($\chi^2=2119.74$, d.f.=252, RMSEA=0.23, NNFI=0.43, CFI=0.48, Standardized RMR=0.17). Hence, one factor was not sufficient to explain the variance, implying that common method bias was not a severe issue of the study.

5.3.4 Reliability and Validity

Reliability is the degree of consistency in the measures. The reliability test is an essential indicator of the quality of the data. Narasimhan and Jayaram (1998) proposed a two-step method to test the reliability of the construct: the first step is to test the unidimensionality of the items using EFA; the second step is to examine the internal consistency of the items by calculating Cronbach's alpha. EFA analysis with varimax rotation method is conducted, and the KMO value is 0.861. I found that all the items showed higher loadings (>0.50) on the constructs they were supposed to measure and lower loadings on these they were not supposed to measure. The result of EFA is in Table 22. As present in Table 23, The values of Cronbach's alpha for all constructs exceeded 0.70, indicating a high level of internal consistency.

Table 22 Exploratory factor analysis

	Factor loadings				
	Environmental strategy	Perceived competitive pressure	Legal orientation	Economic orientation	Perceived social pressure
CP1	.203	.861	.096	.192	.145
CP2	.221	.874	.017	.041	.189
CP3	.208	.866	.129	.042	.116
CP4	.151	.854	.071	.066	.178
SP1	.026	.227	.069	.146	.703
SP2	.078	.169	-.020	.211	.816
SP3	.114	.118	.095	.063	.847
EO1	.074	.044	.129	.856	.167
EO2	.087	.057	.101	.899	.084
EO3	.125	.157	.418	.601	.054
EO4	-.030	.109	.310	.704	.207
LO1	.130	.082	.793	.253	.046
LO2	.129	.047	.852	.139	.063
LO3	.061	.065	.879	.148	-.023
LO4	.025	.070	.823	.120	.079
ES1	.856	.133	-.040	.144	.084
ES2	.871	.127	.053	.031	.122
ES3	.815	.183	.141	.062	-.020
ES4	.863	.144	.107	-.024	.115
ES5	.846	.209	.139	.055	-.012
Eigenvalue	3.861	3.270	3.204	2.661	2.109
Total variance explained			75.521%		

Table 23 Cronbach's alpha

Constructs	Number of items	Cronbach's alpha
Perceived competitive pressure	4	0.93
Perceived social pressure	3	0.77
Economic orientation	4	0.93
Legal orientation	4	0.94
Environmental strategy	5	0.92

Validity refers to the accuracy of the items to the constructs, including content validity and construct validity. Content validity refers to a high degree of conceptual proximity of items, which is ensured by a comprehensive literature review, in-depth interviews with managers, pilot tests, and adopting established measures. Construct

validity is the degree to which the items truly measure the theoretically corresponding construct. Construct validity includes convergent validity and discriminant validity. Convergent validity refers to the convergence of the items under the same construct, reflecting the high correlation between the items and the construct. Discriminant validity means that each construct can be conceptually distinct from other constructs, ensuring the uniqueness of each construct.

In examining convergent validity, I followed the suggestion by (Hu and Bentler, 1999; O'Leary-Kelly and Vokurka, 1998) and employed CFA. In this study, all the items had factor loadings larger than 0.50, and t values were significant ($p < 0.001$). The fit indices were $\chi^2 = 272.64$, d.f. = 160, RMSEA = 0.061, NNFI = 0.97, CFI = 0.97, Standardized RMR = 0.059, indicating a high level of convergent validity. Furthermore, calculating the average variance extracted (AVE) is an additional test for convergent validity (Flynn *et al.*, 2010; Koufteros *et al.*, 2007). The values of AVE all exceeded 0.50, further supporting good convergent validity. Table 24 shows the results of convergent validity

Table 24 Convergent validity

	Item	Loading	T-value	AVE
Perceived competitive pressure	CP1	0.90	16.28	0.77
	CP2	0.90	16.42	
	CP3	0.86	15.32	
	CP4	0.83	14.48	
Perceived social pressure	SP1	0.61	8.69	0.54
	SP2	0.83	12.28	
	SP3	0.75	11.05	
Economic orientation	EO1	0.86	14.57	0.59
	EO2	0.88	15.20	
	EO3	0.60	9.02	
	EO4	0.68	10.55	
Legal orientation	LO1	0.82	13.90	0.67
	LO2	0.84	14.26	
	LO3	0.86	14.71	
	LO4	0.75	12.12	
Environmental strategy	GS1	0.83	14.42	0.71
	GS2	0.86	15.06	
	GS3	0.80	13.51	
	GS4	0.85	14.85	
	GS5	0.85	14.86	

CFA was also used to examine discriminant validity. The correlation between every two constructs was fixed to be 1.0 and compared with the freely estimated model to calculate Chi-square differences. As presented in Table 25, all Chi-square differences were significant at the 0.001 level, suggesting good discriminant validity. I include the squared roots of AVE in the diagonal line of the correlation table and compare it with each correlation coefficient. Higher squared roots of AVE than correlations indicate good discriminant validity as well (Fornell and Larcker, 1981). Table 26 shows descriptive and correlation results.

Table 25 Discriminant validity

	CP	SP	EO	LO	GS
Perceived competitive pressure	-				
Perceived social pressure	125		-		
Economic orientation	309	133	-		
Legal orientation	435	159	224	-	
Environmental strategy	539	155	323	432	-

Table 26 Descriptive and correlation table

	CP	SP	EO	LO	GS
Perceived competitive pressure	0.88				
Perceived social pressure	0.40**	0.73			
Economic orientation	0.26**	0.35**	0.77		
Legal orientation	0.21**	0.16**	0.47**	0.82	
Environmental strategy	0.41*	0.20**	0.19**	0.22**	0.84
Mean	4.67	4.94	5.62	6.15	4.89
S.D.	1.203	1.297	0.943	0.853	1.203

* $p < 0.05$; ** $p < 0.01$; Squared roots of AVE are in the diagonal line

5.3.5 Hierarchical regression analysis

In a hierarchical regression analysis, the first step was to enter the control variables: (1) Different types of industries were included as dummy variables. Industry1 referred to metal, machinery, and engineering, Industry2 was electronics and electrical appliances, and Industry3 was Textiles and apparel. Other industries were the baseline. (2) Different types of ownership were entered. Ownership1 was private-owned, Ownership 2 was foreign-owned, and Ownership3 was state-owned. The joint venture was the baseline. (3) Older firms usually have a more well-established operational structure and practical experiences. Thus, I included firm age after logarithm transformation. (4) The number of employees is related to firm size, with larger sizes more capable of implementing environmental practices. (5) Growth in profit represents the financial resources a firm can deploy in environmental initiatives.

In the second step, the main variables: perceived competitive pressure, perceived social pressure, economic orientation, and legal orientation were entered. The third step

was entering decentralized interaction terms. Decentralization is a process that I subtract the mean from a variable, which is helpful to lessen the impact of multicollinearity (Aiken *et al.*, 1991).

Following the suggestion by Aiken *et al.* (1991), a simple slope analysis was conducted to estimate the impact of perceived stakeholder and social pressure on environmental strategy under high and low levels of economic and legal orientation (mean pluses or minuses one standard deviation), respectively. The result is in Figure 2.

Multicollinearity was further examined by calculating the variance inflation factor (VIF) in each regression model. The result found that the maximum value of VIF was 2.890, well below 10.0 as the rule of thumb, indicating a subtle concern for multicollinearity problems.

5.4 Results

Table 27 shows the hierarchical regression result. In model 1, growth in profit has a positive impact on environmental strategy ($p < 0.01$), suggesting that high-profit firms tend to devote more to environmental strategy. From model 1 to model 2, the change in R^2 is 0.17 ($p < 0.001$), indicating a high level of the explanatory power of the independent variables. In model 2, perceived competitive pressure is positively related to environmental strategy ($p < 0.001$, so does legal orientation ($p < 0.05$). From model 2 to model 3, the change in R^2 is 0.07 ($p < 0.001$), suggesting a high level of the explanatory power of the interaction terms. In model 3, the interactions between perceived competitive pressure and economic orientation perceived social pressure, and economic orientation are positive ($p < 0.05$; $p < 0.1$). In other words, economic orientation strengthens the influence of perceived competitive and social pressure. On the other hand, the interaction between perceived competitive pressure and legal orientation is negative ($p < 0.1$), so is the interaction between perceived social pressure and economic orientation ($p < 0.1$). That is to say, legal orientation weakens the impact of perceived competitive and social pressure on environmental strategy.

The result of a simple slope analysis is in Figure 3. When the level of economic orientation is low, perceived competitive and social pressure are not significantly related to environmental strategy ($p>0.1$). However, under a high level of economic orientation, perceived competitive pressure and social pressure are positively related to environmental strategy ($b=0.484, p<0.001$; $b=0.19, p<0.1$). In regard to the moderating impact of legal orientation, when the level of legal orientation is low, perceived competitive pressure and social pressure have a positive influence on environmental strategy ($b=0.511, p<0.001$; $b=0.21, p<0.1$). The impact turns insignificant ($p>0.1$) when the level of legal orientation is high.

Table 27 Hierarchical regression result

Independent variable	DV: Environmental strategy		
	Model 1	Model 2	Model 3
CONSTANT	3.95^{***}(.538)	1.24(.785)	1.27(.776)
Industry1	-.08(.204)	-.03(.188)	.01(.183)
Industry 2	-.01(.245)	-.03(.225)	-.00(.218)
Industry 3	.04(.303)	.03(.279)	.03(.269)
Ownership1	-.08(.279)	-.15(.259)	-.12(.252)
Ownership2	.04(.318)	-.04(.295)	-.02(.289)
Ownership 3	-.13(.337)	-.18(.311)	-.15(.302)
Firm age	.05(.155)	.06(.143)	.04(.138)
Number of employees	.04(.076)	-.01(.070)	.01(.069)
Growth in profit	.21^{**}(.058)	.21^{**}(.053)	.21^{**}(.052)
Perceived competitive pressure (CP)		.36^{***}(.072)	.32^{***}(.072)
Perceived social pressure (SP)		.03(.067)	.06(.070)
Economic orientation (EO)		-.02(.097)	.04(.098)
Legal orientation (LO)		.15[*](.102)	.10(.102)
Environmental strategy			
CP*EO			.18[*](.074)
SP*EO			.16[*](.069)
CP*LO			-.15[†](.113)
SP*LO			-.15[†](.099)
Adjusted R ²	.04	.20	.26
F	1.818	4.860	5.154
p-value	.067	.000	.000
Change in R ²	-	.17	.07
Change in F	-	10.879	4.843
p-value	-	.000	.001

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; Standard errors are in parentheses; Bold values stand for significant regression coefficient and F-value

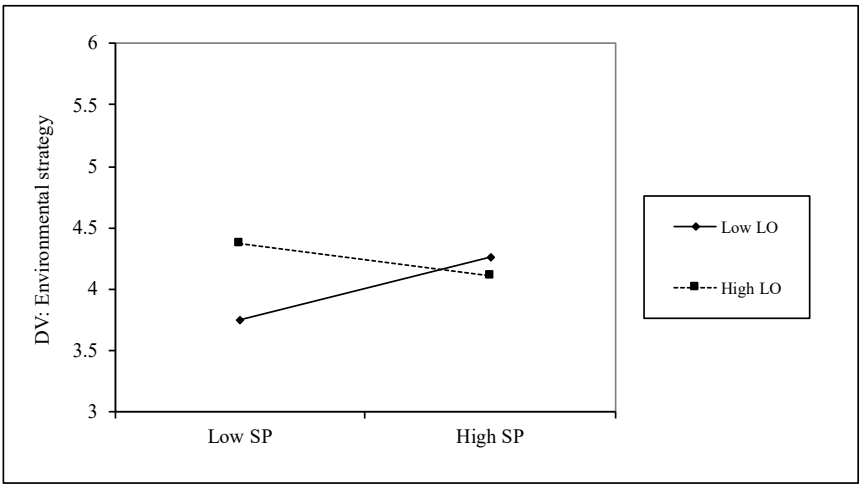
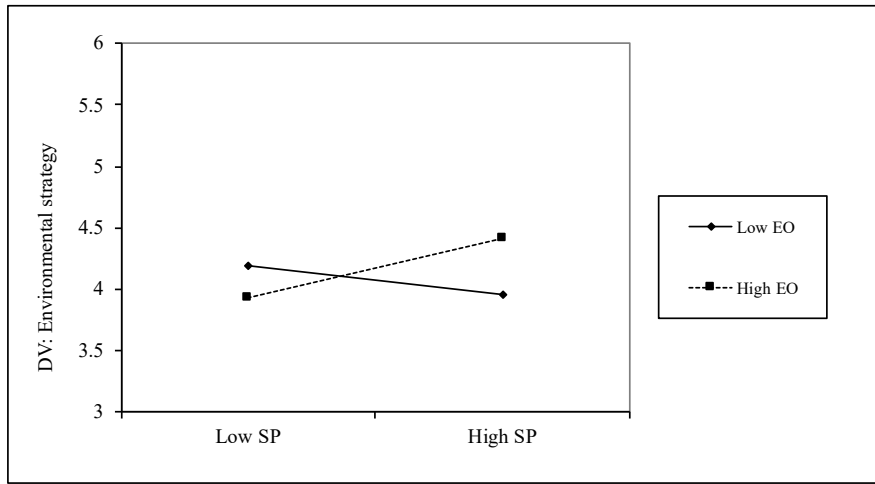
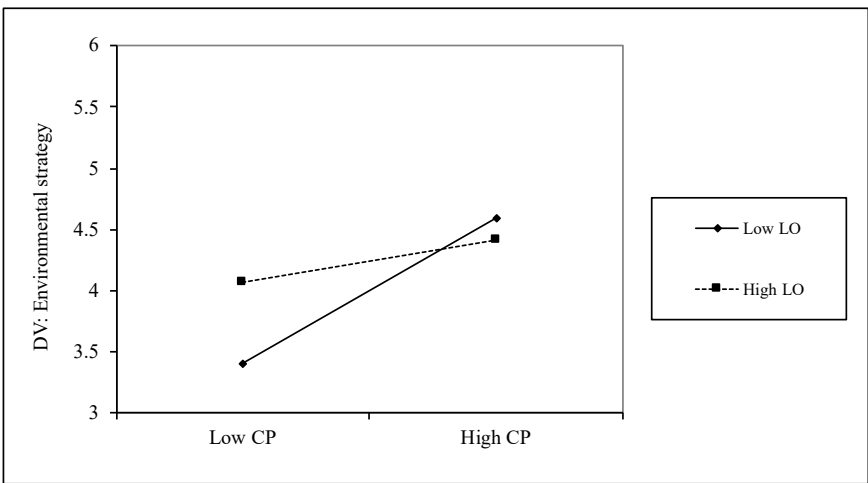
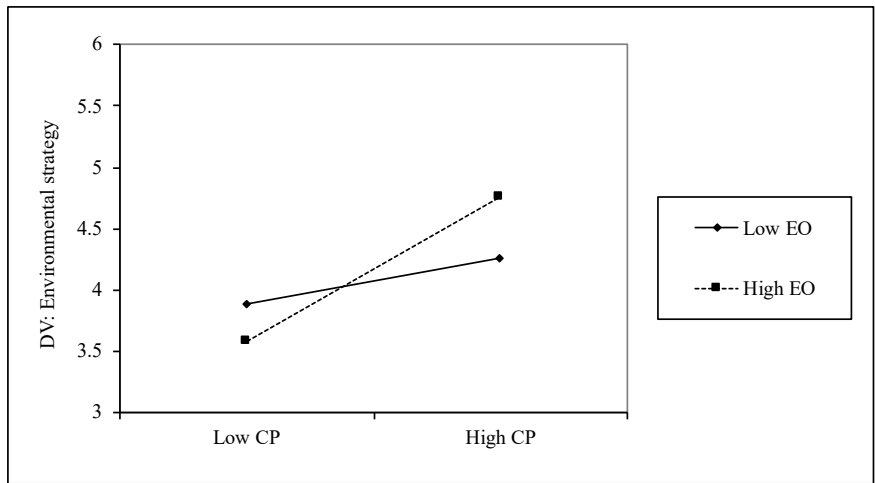


Figure 3 Simple slope analysis

5.5 Discussion and conclusions

5.5.1 Major findings

Based on survey data from Chinese manufacturing firms, this study explores the impact of perceived stakeholder pressure (i.e., perceived competitive and social pressure) on environmental strategy and the moderating effects of managerial value orientation (economic and legal orientation). The main findings are summarized in Table 28.

In terms of the main effects, I find that perceived competitive pressure is positively related to environmental strategy (H1 is supported), while perceived social pressure does not have an impact (H1b is rejected). Legal orientation is positively related to environmental strategy (H2b is supported). Economic orientation, however, does not show any influence (H2a is rejected).

In terms of the moderating effects, economic orientation enhances the impact of perceived stakeholder and social pressure on environmental strategy (H3a and H4a are supported). Legal orientation, on the other hand, weakens the influence of perceived stakeholder pressure (H3b and H4b are rejected).

Table 28 Results of hypotheses

Hypothesis (hypothesized sign)	Result (actual sign)
H1a: Perceived competitive pressure → environmental strategy (+)	Supported (+)
H1b: Perceived social pressure → environmental strategy (+)	Rejected (n.s.)
H2a: Economic orientation → environmental strategy (+)	Rejected (n.s.)
H2b: Perceived legal orientation → environmental strategy (+)	Supported (+)
H3a: Perceived competitive pressure *Economic orientation → environmental strategy (+)	Supported (+)
H3b: Perceived social pressure *Economic orientation → environmental strategy (-)	Rejected (+)
H4a: Perceived competitive pressure *Legal orientation → environmental strategy (-)	Supported (-)
H4b: Perceived social pressure *Legal orientation → environmental strategy (+)	Rejected (-)

5.5.2 Discussion

The finding that perceived competitive pressure positively affects the formation

of firm environmental strategy suggests that managers tend to imitate competitors' successful behavior to maintain a competitive position. The finding is consistent with those in Dai *et al.* (2015), Garcés-Ayerbe *et al.* (2012), and Yalabik *et al.* (2014). Nonetheless, perceived social pressure does not influence environmental strategy, indicating that managers do not implement environmental initiatives due to legitimate external requirements. It is a surprising finding that contradicts previous studies. For instance, Lee *et al.* (2018) found that social pressure increases firms' intention to take environmental responsibility. Berrone *et al.* (2013) suggested that regulatory and normative pressure from the government and the public enhance firms' environmental innovation. Zhu *et al.* (2005) indicated that among multiple types of institutional pressure, the government pressure has the most substantial impact on supply chain environmental practices, followed by supply chain and market pressure. However, the result is consistent with (Menguc *et al.*, 2010), which finds that the intensity of government regulation does not have an impact on proactive environmental strategy. A possible explanation is that the decision to develop proactive environmental strategy is based on the purpose of gaining competitiveness. When competitors benefit from implementing proactive environmental strategy, firms tend to follow proactive practices for competitive reasons. The government and the public are secondary stakeholders, which would prompt firms to reactively comply with environmental regulations and external requirements. Thus, social pressure does not impact firm environmental strategy.

Considering the effects of managerial value orientations, I find that only legal orientation is positively related to environmental strategy, which is similar to the findings in (Foerstl *et al.*, 2015; Schaltegger and Hörisch, 2017; Varadarajan, 2017). The reason can be that economic-oriented managers may be suspicious of the effective outcomes of environmental strategy. Legal-oriented managers are willing to establish environmental strategy in pursuit of legitimacy. Moreover, it is interesting that firms are motivated by external competitive pressure and internal legal orientation to adopt proactive environmental strategy. In other words, from an efficiency perspective, the decision to adopt environmental strategy stems from perceived competitive reasons

instead of the internal motives to become profitable. From a legitimate perspective, external social pressure may only lead to reactive compliance, but internal legal orientation propels firms to take environmental initiatives.

The results of moderating effects are interesting. For one thing, economic orientation heightens the influence of both perceived competitive and social pressure. Alternatively, economic-oriented managers emphasize both competitive and social pressure. For them, competitive pressure is an opportunity to imitate successful practices and gain market bargaining power. Meanwhile, social pressure can also be a chance to access to government or social resources and ties, such as preferential policies, excessive subsidies, recognition from customers, which can transform into economic benefits (Sheng *et al.*, 2011; Wei *et al.*, 2017). On the other side, legal orientation undermines both the impact of perceived competitive and social pressure. Legal-oriented managers are less influenced by competitive or social pressure. A possible explanation is that they perceive both stakeholder pressure as threats to compliance with regulations and law. Using the law requirements as the criteria impair the benchmarking roles of competitors. At the same time, the public and the government may desire an unattainable level of compliance (Foerstl *et al.*, 2015), making legal-oriented managers reluctant to adhere to overlaid social requirements. Therefore, legal orientation substitutes the impact of perceived stakeholder pressure.

One more finding is that economic-oriented managers tend to develop environmental strategy according to external pressure, while legal-oriented ones are more internally motivated. Alternatively speaking, economic orientation pushes managers to consider more about external stakeholder requirements, while legal orientation substitutes the external pressure to play a more critical role. Previous studies have compared the importance of external pressure and internal motivations in adopting environmental practices (Menguc *et al.*, 2010; Prajogo *et al.*, 2012; Qi *et al.*, 2012). This novelty of this study lies in the consideration for managerial value orientations. While economic orientation amplifies the impact of external pressure, legal orientation weakens it.

5.5.3 Theoretical contributions

First, this study enriches our understanding of the antecedents of environmental initiatives. Only a few existing studies investigate the impact of both external stakeholder pressure and internal managerial value orientation on environmental strategy, especially the interactive effects (Frynas and Stephens, 2015; Liu *et al.*, 2015; Menguc *et al.*, 2010; Schaltenbrand *et al.*, 2018; Yang *et al.*, 2018). This study demonstrates that internal and external factors influence environmental strategy differently, and there are interactive effects between them. In this sense, this study proves it is important to consider internal and external factors simultaneously and explore those synergistic or substituted impact, enriching studies about antecedents of environmental initiatives.

Second, this study integrates the legitimacy- and efficiency-seeking perspectives in examining the motives for firms to adopt environmental strategy, and it further demonstrates the differences between internal and external motives. The findings indicate that firms are impacted by external efficiency-seeking incentives and internal legitimacy-seeking motives to adopt environmental strategy, thus enriching the understanding of the two rationales.

Third, this study employs managerial roles in establishing environmental strategy, answering the call from Yang *et al.* (2018) and Schaltenbrand *et al.* (2018), who both suggest investigating firm environmental initiatives from managerial cognition and perception perspectives. Additionally, this study enlarges the research framework of Yang *et al.* (2018), such that I not only investigate the impact of perceived stakeholder pressure on environmental strategy but also take managerial value orientations into account.

Fourth, this study broadens studies about firm environmental initiatives in the Chinese context. China has its unique cultural, political, and economic environment, and managers perceive stakeholder pressure quite differently from those in the western context (Wei *et al.*, 2017). For example, Liu *et al.* (2015) conducted a literature review and found that institutional pressure has a more substantial impact on environmental strategy and economic benefits for Chinese firms than for western firms. This study

takes a step further by examining the interaction between perceived external pressure and managerial orientation, and it demonstrates the contingent impact of institutional pressure on firm environmental strategy. In particular, this study shows that social pressure actually does not have an impact on proactive environmental strategy.

Besides, the study has merits for practitioners and policy-makers. Firms need to consider the impact of stakeholder pressure and value orientation when establishing an environmental strategy. In the face of competitive and social pressure, firms should consider the impact of competitive pressure from the perspective of developing competitive advantages. At the same time, firms with legal-oriented managers are more able to take advantage of establishing environmental management as a corporate strategy. When managers are economic-oriented, they will be more affected by external stakeholders, and when managers are legal-oriented, the impact of external pressure will be lessened. Therefore, when establishing an environmental strategy, managers need to make different interpretations of external pressures according to their different value orientations in order to find the model that best suits the firm. For policymakers and the general public, it is notable that social pressure has a limited binding effect on firms. At the same time, they should distinguish the type of value orientation of a firm and be aware of different approaches to promote the development of environmental strategy among firms.

6 Conclusions and future works

6.1 Conclusions

Based on the resource-based view, institutional theory, signalling theory, and stakeholder theory, the thesis explores firm environmental initiatives in Chinese firms concerning the performance outcomes and antecedents. It mainly answers three questions: (1) How does the implementation of environmental initiatives impact operational risks? (2) How is the implementation of environmental initiatives related to economic outcomes? (3) How is the decision to adopt environmental initiatives formulated? With this respect, firm environmental initiatives are investigated in two specific forms. ISO 14001 adoption refers to the actual implementation of environmental initiatives at the operational level, while the formation of environmental strategy is based on managers' decision-making processes. Three studies are developed to explore firm environmental initiatives in terms of strategy and implementation. The first study examines the impact of ISO 14001 adoption on operational risk and the moderating effects of government monitor and slack resources. The second study focuses on the impact of ISO 14001 accreditations on financial risk and sales growth, and the moderating effects of certification time and industrial pollution levels. The third study investigates the impact of perceived stakeholder pressure and managerial value orientation on the establishment of environmental strategy.

The overall finding is that firms form environmental initiatives based on managerial cognition, and the implementation of environmental initiatives would be useful in reducing operational and financial risk at the cost of rapid growth. As such, environmental initiatives act as an insurance-assuring mechanism, instead of a performance-boosting tool. Specifically, the actual implementation of environmental initiatives (i.e., ISO 14001 adoption) is effective in saving lives. However, ISO 14001 adoption leads to paradoxical economic outcomes, including reducing financial risk and damaging sales growth. Meanwhile, managerial value orientations would interact with perceived external pressure to influence the formation of firm environmental strategy. The findings provide a comprehensive picture of environmental initiatives: the

implementation leads to multi-faceted outcomes, and the strategy formulation depends on managerial cognition. The findings of different studies are summarized below.

(1) ISO 14001 adoption reduces operational risk effectively. Receiving government monitor enhances the effect while having slack resources weakens it.

Study 1 proves that ISO 14001 adoption significantly reduces the risk of regulatory violations and casualties. More specifically, accredited firms decrease 0.68 regulatory violations and 1.1 casualties. Government monitor promotes the effect of ISO 14001 adoption, further decreasing casualties by 0.7%. However, having abundant slack resources hampers the impact of ISO 14001 adoption, increasing regulatory violations by 0.54%.

(2) ISO 14001 adoption reduces financial risk but also reduces sales growth. Early certification time is beneficial to decrease financial risk but amplifies the harm on sales growth. Being in high-polluting industries enhances the negative effect of ISO 14001 adoption on financial risk and undermines the negative effect on sales growth.

Study 2 finds that ISO 14001 adoption simultaneously reduces financial risk and sales growth, suggesting the paradoxical outcomes of obtaining ISO 14001. Although obtaining ISO 14001 accreditations does not hurt financial performance, it decreases financial risk by 0.13% and reduces sales growth by 6.7%. In other words, adopting certifications enables firms to maintain financial stability and constrains the potential to expand aggressively. Considering the moderating effects, I find that early certification time enlarges both the bright and dark side of ISO 14001 adoption. In detail, early certified firms decrease financial risk by 0.23%, while late certified firms do not experience a change in financial risk. Early certified firms reduce sales growth by 5.1%, while late certified firms only decrease by 4.4%. On the other hand, being in high-polluting industries promotes the benefits of ISO 14001 adoption and lessens the adverse outcomes. Firms polluting industries reduce 0.14% financial risk by adopting ISO 14001 certifications, while those in low-polluting industries do not have this privilege. Being in high-polluting industries causes a reduction in sales growth by 5.1%, but in light industries decreases sales growth by 7.9% when adopting ISO 14001

certifications.

(3) Perceived competitive pressure is positively related to environmental strategy, but perceived social pressure does not show an effect. Legal orientation is positively related to environmental strategy, but economic orientation does not have an impact. Economic orientation strengthens the impact of perceived competitive and social pressure, while legal orientation weakens both effects.

Study 3 links managerial cognition perspectives to stakeholder theory and shows that perceived competitive pressure has a more substantial impact on the establishment of environmental strategy than perceived social pressure does. Economic orientation promotes the impact of external stakeholder pressure on environmental strategy, while legal orientation weakens the impact. Simply put, in designing environmental strategy, economic-oriented managers are more externally driven, but legal-oriented managers are more internally motivated.

6.2 Theoretical contributions

(1) The thesis enriches the understanding of ISO 14001 adoption and operational risk and provides substantial evidence about whether corporate environmental initiatives are effective. Previous studies mainly focus on the relationship between ISO 14001 certifications and environmental performance, and the effectiveness of ISO 14001 adoption remains controversial (Boiral, 2007; Heras-Saizarbitoria *et al.*, 2011; Iatridis and Kesidou, 2016; Link and Naveh, 2006). The thesis adopts a novel angle to consider operational risk, namely regulatory violations and casualties, and to focus on the influence of environmental practices on people. In this way, the research attaches great importance to investigating externalities (e.g., the hidden costs on the people, the environment, and the society) of firm practices in OM studies.

(2) The thesis extends the research in the relationship between ISO 14001 adoption financial performance and offers new findings of whether it pays to adopt corporate environmental initiatives. Existing studies pay little attention to

long-term and potential performance, such as financial risk and sales growth. The findings indicate that while ISO 14001 brings financial stability, it is at the costs of diminishing market growth. Future research needs to examine the outcomes of environmental initiatives from multi-facets.

(3) The thesis provides empirical evidence for the antecedents of corporate environmental initiatives and enhances the understanding from the perspective of stakeholders and managers. Previous research calls for understanding the impact of external stakeholder pressure and internal managerial values on environmental strategy (Frynas and Stephens, 2015; Liu *et al.*, 2015; Menguc *et al.*, 2010; Schaltenbrand *et al.*, 2018; Yang *et al.*, 2018), especially the interaction between the two. This study finds that internal and external factors have different influences on the environmental strategy, and there is an interaction, indicating that only the unilateral consideration is incomplete.

(4) This thesis employs multiple data sources and methodologies to explore the effectiveness of ISO 14001 adoption and the formulation of environmental strategy in China. In the past, research on Chinese firms seldom adopted objective data. This thesis uses secondary data from multi-sources and adopts PSM, DID, and event study to examine the impact of ISO 14001 certification on operational risk and economic performance; On the other hand, based on survey data, this study explores the antecedents of environmental strategy from the perspective of managers. The use of multiple data sources and multiple approaches complements and extends the environmental management research in Chinese firms.

6.3 Managerial implications

The thesis has several managerial implications. Since ISO 14001 certifications can facilitate continuous improvement in operations and diminish operational risk, firms should actively get certified to mitigate operational disruptions and minimize adverse impacts on people, with this improving reputation in the long run. In particular, adopting ISO 14001 is beneficial for firms that have complicated processes and

obsolescent technology

The effectiveness of ISO 14001 adoption in minimizing operational risk can be improved for firms monitored by the government or having low slack resources. In this regard, firms should take care of their external visibility and internal resources when adopting ISO 14001. For firms under government monitor, it is urgent to implement ISO 14001 following the government requirements more substantially. On the other hand, the role of slack resources should be considered with prudence. Managers, as firm agents, may take advantage of the slack resources in gaining personal interests, deviating from the principle ends of adopting ISO 14010 certifications. Therefore, firms ought to be cautious with the deployment of slack resources in implementing ISO 14001.

As a signal that symbolizes sound environmental management, ISO 14001 certifications reduce financial risk without harming financial returns. In a turbulent environment, having financial stability helps firms to focus on core operational processes, carry out innovation activities, and gain competitive advantages (Lam, 2018; Luo and Bhattacharya, 2009). Since investors would prefer ISO 14001 certified firms to avoid risk, managers should actively promote the adoption of the benefit.

However, ISO 14001 certifications are a double-edged sword, which cannot bring financial stability and market growth at the same time. For firms seeking rapid growth, the need to expand outweighs the need to maintain stability. Obtaining ISO 14001 certifications requires substantial resource devotion and fundamental changes in process and technology. As a result, firms may miss the window to expand aggressively. For those seeking stability and long-term development, implementing ISO 14001 is a means of transforming and upgrading its existing route and achieving sustainable development. Besides, the effectiveness of ISO 14001 certifications as a signal is contextual. The industry a firm locates in and the time to obtain certification can influence the impact of ISO 14001 certifications on financial risk and sales growth. Therefore, managers need to make a judgment based on a firm's goal to maintain stability or boost growth.

Establishing an environmental strategy requires firms to consider the impact of

perceived stakeholder pressure and managerial value orientation. As the pressure of competitors easily influences firms, they should pay more attention to the behavior of competitors in their operations, follow up and imitate them promptly, and develop environmental strategy to gain competitiveness. Although firms are less affected by social pressure, it is also necessary to pay attention to the requirements of the government and the public in daily operations, considering the increasing emphasis on environmental protection.

Firms should recognize the importance of managerial roles in the formation of environmental strategies. Legal orientation enables firms to take advantage of compliance with laws and regulations to establish environmental management as their strategy. Economic-oriented managers, however, tend to calculate costs and benefits and reduce the tendency to establish environmental strategy.

Managerial value orientation also interacts with perceived stakeholder pressure to impact on environmental strategy. Economic-oriented managers are more affected by competitors and social pressures. When managers are legal-oriented, the impact of stakeholder pressure is weakened. Therefore, when establishing environmental strategy, managers need to interpret external pressures according to their different value orientations.

6.4 Limitations and future work

Although the thesis uses multiple sources of data, adopts a variety of methods to study the antecedents and outcomes of environmental initiatives, and offers valuable contributions to theory and practice, it still has some limitations and provides a venue for future research.

First, in examining the relationship between environmental initiatives and performance (Study 1 and Study 2), I adopted ISO 14001 certification as the proxy. Other possible proxies include environmental innovation, supply chain environmental management, and environmental information disclosure. Different types of environmental initiatives may lead to inconsistent results. For example, Gilley *et al.*

(2000) found that investors have different reactions to environmental practices related to products and processes; Lam *et al.* (2016) found that self-disclosed and third-party certified environmental practices lead to different abnormal stock returns. Therefore, it is necessary to explore the difference between different types of environmental initiatives.

Second, I used regulatory violations and casualties as proxies for operational risk. Since there is no available database, the variables can only be formed by self-search, which suffers from subjectivity in the screening process. Future studies may try to develop other proxies for operational risk. At the same time, it is urgent to promote information disclosure of Chinese firms and establish databases for academic research.

Third, study 1 includes government monitor and slack resources as moderators from the perspective of institutional theory and resource-based view. Study 2 adopt the certification time and industrial pollution level as a moderator from the perspective of signal theory. Future research can further expand the scope of moderating variables from corresponding theoretical perspectives, such as media exposure, operational capabilities, industry complexity, and market uncertainty. Also, since the thesis is based on Chinese firms, more Chinese unique features can be considered, such as political connection and legal unprotectability.

Fourth, Study 3 explores the impact of two types of stakeholder pressure and managerial value orientation. Future research can consider other types of stakeholder pressure, such as suppliers, customers, and the media, other value orientations, such as ethical and innovation orientation. Moreover, future research can explore environmental processes, supply chain environmental management, and even employ objective measures to obtain more reliable results.

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Appendix 1: Sample demographics for study 1 and study 2

Type	Number of firms	%
Panel A. Industry type		
Farm Products Processing (C13)	48	2.29
Food Manufacturing (C14)	41	2
Wine, drinks and refined tea manufacturing (C15)	36	2
Textile manufacturing (C17)	39	1.86
Textiles, Garments, and Apparel (C18)	33	1.57
Leather, fur, feathers, and related products and shoe-making (C19)	10	0.48
Timber Processing, Timber, Bamboo, Cane, Palm Fiber and Straw Products (C20)	8	0.38
Furniture Manufacturing (C21)	19	0.9
Papermaking and Paper Products (C22)	24	1.14
Printing and Reproduction of Recorded Media (C23)	10	0.48
Manufacture of Articles for Culture, Education, and Sports Activities (C24)	14	0.67
Processing of Petroleum, Coking, & Fuel (C25)	21	1
Raw Chemical Materials and Chemical Products (C26)	214	10.19
Pharmaceutical manufacturing (C27)	203	9.67
Chemical Fiber Manufacturing (C28)	24	1.14
Rubber and plastic product industry (C29)	65	3.1
Non-metallic Mineral Products (C30)	84	4
Smelting and Pressing of Ferrous Metals (C31)	36	1.71
Smelting and Pressing of Nonferrous Metals (C32)	70	3.33
Metal Products (C33)	55	2.62
General Equipment Manufacturing (C34)	120	5.71
Special Equipment Manufacturing (C35)	188	8.95
Automobile Manufacturing (C36)	112	5.33
Railway, shipbuilding, aerospace, and other transportation equipment manufacturing (C37)	43	2.05
Electric Machines and Apparatuses Manufacturing (C38)	209	9.95
Computer, communication and other electronic device manufacturing (C39)	303	14.43
Instrument and meter manufacturing (C40)	46	2.19
Other Manufacturing(C41)	20	0.95
Comprehensive utilization industry of waste resources (C42)	5	0.24
Panel B. Region		
Shanghai	129	6.14
Yunnan	21	1
Inner Mongolia	17	0.81
Beijing	106	5.05
Jilin	27	1.29
Sichuan	80	3.81

Tianjin	26	1.24
Ningxia	8	0.38
Anhui	64	3.05
Shandong	140	6.67
Shanxi	21	1
Guangdong	358	17.05
Guangxi	19	0.9
Xinjiang	21	1
Jiangsu	261	12.43
Jiangxi	31	1.48
Hebei	45	2.14
Henan	62	2.95
Zhejiang	268	12.76
Hainan	10	0.48
Hubei	59	2.81
Hunan	63	3
Gansu	21	1
Fujian	79	3.76
Tibet	9	0.43
Guizhou	18	0.86
Liaoning	46	2.19
Chongqing	27	1.29
Shaanxi	30	1.43
Qinghai	9	0.43
Heilongjiang	25	1.19
Panel C. Adoption Year		
2004	55	4.17
2005	76	5.77
2006	113	8.57
2007	106	8.04
2008	153	11.61
2009	125	9.48
2010	134	10.17
2011	140	10.62
2012	169	12.82
2013	94	7.13
2014	62	4.70
2015	50	3.79
2016	41	3.11
Total adopters		1318
Nonadopters		782
Total Firms		2100
Firm-year Observations		27300

Appendix 2: News search procedures for study 1

In news search at Wisenews, I use a combination of keywords⁹, including company names, different accident types, and different injury types. The period of the search is 2004-2016. After collecting and screening the news,

I record the name of the firm involved in an accident, the stock code, the date of the accident, and the number of people affected (poisoned, slightly injured, seriously injured, or dead). During the search process, I set the following rules to obtain the most relevant and correct news information:

(1) I first judge whether a piece of news is relevant by the title and exclude the news if it is irrelevant.

(2) I then set several filtering criteria: a) Accidents should occur during firms' production operations and within production sites. These examples are met with the first criteria: a factory explosion causes death, discharge of pollution poisons people and employees meet work-related accidents. b) Accidents that are related to non-manufacturing activities are not included. For instance, a transportation accident (non-manufacturing activity) or a building that is invested by the firm catches a fire (non-main business). c) Accidents that are not directly related to the company's production and operation activities are not included. For instance, a traffic accident takes place near the company. Some employees are injured when the company organizes tourism activities. d) Accidents that are caused by other companies are not counted. e) Accidents caused by exogenous factors or natural disasters are not counted, such as typhoons and earthquakes. f) Accidents that impact end consumers due to product failure is not considered.

(3) I find descriptions in the news describing the injury or death in the accident and record the number of injuries or death as casualties. For example, a news content describes "a few people injured/dead, several people were sent to the hospital, and

⁹ The search is conducted in Chinese: (公司股票简称 or 公司简称 or 公司名称) and (事故 or 事件 or 意外 or 灾害 or 污染 or 垮塌 or 坍塌 or 倒塌 or 火灾 or 爆炸 or 泄漏 or 灼伤 or 灼烫 or 坠落 or 触电 or 窒息) and ((中毒 or 工伤 or 受伤 or 轻伤 or 重伤 or 伤势 or 伤害 or 伤亡 or 死亡 or 身亡 or 生命 or 身体 or 失能 or 抢救) not (招股意向书 or 招募说明书 or 年度报告 or 季度报告 or 月度报告))

several people were poisoned.” If the description for the number is vague, such as dozens, some, or hundreds, I record the average number.

(4) There may be multiple news describing the same accident. I order the news describing the same accident and refer to the news that is the most updated and comprehensive.

(5) I only look at accidents that occur in mainland China.