The Impact of Chief Risk Officer Appointments on Firm Risk and Operational Efficiency

Abstract

To exercise risk control at the corporate level, firms often appoint Chief Risk Officers (CROs) to their top management team. By establishing CRO positions, firms can reduce firm risk and potential financial losses caused by operational disruptions. Yet, by inducing stringent control measures on risks, security, and compliance, CRO appointments might create unwieldy bureaucracies with operational hurdles and incur burdensome costs that offset efficiency. Using longitudinal secondary data collected from multiple sources, we analyze the impact of CRO appointments on firm risk and operational efficiency of 435 publicly listed firms in the U.S. from 2006 to 2016. Our results indicate that CRO appointments not only reduce risks, but also improve efficiency in operations. We delve into the power of CROs and find that more powerful CROs are more effective in enhancing the operational efficiency of firms. We further examine the contextual factors and reveal that firms operating under high industry litigation threats and industry dynamism improve operational efficiency to a greater extent after CRO appointments. Overall, CROs' appointments are more beneficial to firms when they have stronger power in the top management team and when the operating environments are uncertain and volatile.

Highlights

- CRO appointments help reduce firm risk and improve operational efficiency.
- The performance impact of CRO appointments is more pronounced when the appointed CROs have stronger power.
- Firms operating in litigious and dynamic environments benefit more from CRO appointments.

Keywords: Chief risk officers, firm risk, operational efficiency, power, industry litigation threat, industry dynamism

1. Introduction

Firms nowadays operate in a more uncertain environment and have to deal with a variety of macro and micro risks (Ho *et al.*, 2015). Risk is defined as "a phenomenon that has the potential to deliver substantial harm, whether or not the probability of this harm eventuating is estimable" (Lupton, 2013, p. 10). To minimize negative impacts caused by risk factors, executives and operations managers emphasize the importance of proactive risk management (Knemeyer *et al.*, 2009; Neiger *et al.*, 2009). Many companies appoint CROs to the top management team (TMT) to develop risk management initiatives (Beasley *et al.*, 2008). Since the appointment of the first CRO (i.e., James Lam) by General Electric, CRO positions have been created for 20 years. The position has gained more attention after the release of Sections 302 and 404 of the Sarbanes–Oxley Act of 2002 (SOX) and the occurrence of the global financial crisis in 2008. The bill legally requires firms to ensure the accuracy of financial disclosure and tighten risk controls to protect investors' interests (Leuz, 2007).

Appointing a CRO to the TMT facilitates managerial attention allocated to risk-related issues and motivates firms to adopt a strategic view to implement a comprehensive approach to risk management, which enables firms to proactively identify, assess, mitigate, and monitor potential risks that disrupt their operations. It enhances firms' ability to deal with unexpected circumstances and reduces firm risks and potential financial losses caused by operational disruptions (Ambulkar *et al.*, 2015; Tomlin, 2006). Based on this perspective, previous studies indicate that firms with a higher level of risk control are associated with higher firm value (Florio & Leoni, 2017; Hoyt & Liebenberg, 2011), lower stock volatility (Eckles *et al.*, 2014), lower tail risks, and higher stock return performances (Ellul & Yerramilli, 2013). However, risk controls may also give rise to bureaucracy, operational constraints, and administrative costs that offset operational efficiency (Pagell *et al.*, 2015). For example, creating CRO positions in the TMT might make frontline managers think that risk management is someone else's job and ignore risks in operations (Pernell *et al.*, 2017). Also, initiatives that aim to reduce workplace risks might incur burdensome costs that decrease the odds of organizational survival (Pagell *et al.*, 2020). On average, manufacturing firms spend 7% of their total operating costs on risk and compliance-related processes (Crain & Crain, 2014). Similarly, financial firms spend 6-10% of their revenue on risk and compliance (American-Banker, 2018). These costs indicate that there is a potential tension between risk control and operational efficiency. As a reflection of this tension, empirical results regarding the operating outcomes associated with CRO appointments remain inconclusive (as summarized in Table 1 and further discussed in Section 2).

In this article, we explore this tension by examining how CRO appointments affect firm risk and operational efficiency. We further investigate how the power of CROs affects the effectiveness of CRO appointments and how environmental factors, including industry litigation threat and industry dynamism, moderate the effectiveness of CRO appointments. We focus on the following research questions: *What are the impacts of CRO appointments on firm risk and operational efficiency? How does the power of CROs affect the performance outcomes and under what circumstances do CRO appointments become more beneficial to firms?* By studying 435 publicly listed firms in the U.S. from 2006 to 2016, we find that CRO appointments lower firm risk and enhance operational efficiency simultaneously, indicating risk control and operational efficiency are mutually supportive. Our results also indicate that powerful CROs enhance operational efficiency to a greater extent. We further reveal that firms operating under high levels of industry litigation threat and industry dynamism benefit more from CRO appointments.

This study contributes to operations management (OM) and risk management research in a few ways. First, our study suggests that appointing a CRO to the TMT is an effective way of reducing firm risk and improving operational efficiency simultaneously. This enhances our understanding of the paradoxical relationship between risk control and operational efficiency (Pagell *et al.*, 2015). More importantly, we delve into the characteristics of CROs and seek to understand how CROs' power affects the effectiveness of such positions. We further explore the environmental and contextual factors, showing that CRO appointments are more beneficial to firms operating under high litigation threats and dynamic environments. Our research not only provides more evidence of the impact of CROs on firm risk and operational efficiency, but also extends the literature by examining factors and circumstances in which CROs are more effective in gaining efficiency improvements.

2. Chief Risk Officer and Risk Management

C-suite appointments signal a firm's commitment to improving management effectiveness at the corporate level. For example, creating new positions of supply chain and operations management executives (SCOME) reflects a firm's commitment to improving efficiencies in supply chains and operations (Roh *et al.*, 2016; Hendricks *et al.*, 2015). Like other C-suite positions, creating a CRO position in the TMT signals a firm's strategic emphasis on risk control and commitment to more comprehensive risk management initiatives (Beasley *et al.*, 2008). For example, the CRO appointment announcement of U.S. Steel reported that *"United States Steel Corp. is creating a new post called Senior Vice President and Chief Risk Officer meant to offer a more integrated company-wide system to look at business risks and opportunities…"* (Spencer, 2011). Such an appointment indicated the firm's intention to enhance risk control at the corporate level.

CRO positions are created to tighten risk control and oversee risk management initiatives at the corporate level and can be regarded as a strategic emphasis on risk management (Karanja & Rosso, 2017). A CRO's responsibilities include leading the risk management team, communicating risk management initiatives, and making decisions related to risk management (Karanja & Rosso, 2017). Within the organization, CROs might be responsible for financial stability and loss, threats due to market dynamism, disruptions due to unreliable operations and supply chains, and potential harms to the firms due to human errors and process negligence. To enhance risk management, CRO appointments motivate firms to adopt a more holistic approach to identify, assess, mitigate, and monitor risks, rather than relying on traditional ad-hoc risk management approaches (Bromiley *et al.*, 2015).

A summary of previous studies about CRO appointments is presented in Table 1. Previous studies regarding the outcomes of CRO appointments highlight the potential tension between risk control and operational efficiency. On one hand, CRO appointments can facilitate the adoption of enterprise risk management (ERM) tools and enhance risk control, which enables firms to reduce risk exposure, safeguard business stability, and reduce financial losses due to operational disruptions (Berry-Stölzle & Xu, 2018; Ellul & Yerramilli, 2013). As a result, CRO appointments are positively related to firm performance (Florio & Leoni, 2017; Grace *et al.*, 2015), negatively related to capital costs (Berry-Stölzle & Xu, 2018), and positively related to shareholder value (Hoyt & Liebenberg, 2011).

On the other hand, CRO appointments might bring excessive risk control that hinders operational efficiency. For example, risk control initiatives might give rise to bureaucracy, a cumbersome process of approvals, operational constraints, and opportunity costs that offset operational efficiency (Lin *et al.*, 2012). Similarly, creating CRO positions in the TMT might make frontline managers believe that risk management is someone else's responsibility and reduce their awareness of operational risks (Pernell *et al.*, 2017). As a result, some research suggests that the impact of CRO appointments is marginal (Beasley *et al.*, 2008; Gupta *et al.*, 2012) or even negative (Lin *et al.*, 2012; da Silva *et al.*, 2019).

---- Table 1 about here ----

Furthermore, the actual benefits of CRO appointments across different industries are highly inconclusive. For example, Pernell *et al.* (2017) found that the appointment of CROs is positively related to the adoption of new derivatives that might lead to more risks. This is because the appointment might create an "organizational licensing" that makes lower-tier managers reduce self-monitoring of risky behaviors. Beasley *et al.* (2008) also suggested that the effect of CRO appointments on firm value (measured by cumulative abnormal return) is insignificant and determined by firm characteristics. Previous studies show that the effectiveness of CRO appointments is affected by contextual factors, such as firm leverage and firm size (Beasley *et al.*, 2008), reporting structure (Aebi *et al.*, 2012), CRO expertise (Bailey, 2019), and CRO compensation (da Silva *et al.*, 2019). In view of the complexity of the relationships, more research is needed to examine the outcomes of CRO appointments and the contingencies that determine the effectiveness of such appointments. Furthermore, previous empirical studies have mainly been conducted in the insurance and bank industries, indicating the need to explore the impact of CRO appointments across industries.

3. Theory and Hypotheses

Executive appointments signal a firm's strategic intent to improve the management in a specific aspect and attract organizational members' attention to a strategic issue (Hendricks *et al.*, 2015; Nath & Mahajan, 2008). Accordingly, we build our hypotheses on the *attention-based view* (ABV) (Ocasio, 1997) and suggest that CRO appointments bring a firm's focus of attention to risk issues and affect the way firms operate. Specifically, we consider new CRO appointments as a firm's initiative to develop comprehensive risk management (Berry-Stölzle & Xu, 2018;

Eckles *et al.*, 2014; Hoyt & Liebenberg, 2011). Accordingly, we focus only on the appointment of the first CRO in a firm (i.e., from having no CRO position to the first CRO appointment).

The premise of the ABV is that firm actions are determined by how the attention of decision-makers is channeled and distributed (Ocasio, 1997; Stevens *et al.*, 2015). The ABV offers three principles to explain firm behaviors. First, the way decision-makers act depends on their focus of attention (*attention focus*). Due to the limited organizational attention and resources, firms tend to selectively attend to strategic issues (Dutton & Ashford, 1993). Second, the allocation of organizational attention is determined by a firm's rules, resources, power dynamics, and social relationships that structurally regulate and distribute the allocation of strategic issues (*structural distribution of attention*). Accordingly, organizational structure and power dynamics within the organization would determine firms' focus of attention, which in turn affects organizational procedures and cultural beliefs (Ocasio, 1997, 2011). From this perspective, having CROs in the TMT motivates firms to allocate attention to risk issues. Third, attention is situational (*situated attention*), i.e., decision-makers' attention focus depends on the characteristics of the situation (Nadkarni & Barr, 2008), and internal and external stimuli that they face. Based on the ABV, powerful top managers tend to have a stronger voice in the TMT to implement their proposals. Also, issues that are salient to the achievement of organizational objectives tend to attract more attention from top managers and are more likely to reach a consensus within the TMT (Dutton *et al.*, 2001). Consistent with this rationale, we examine how CROs' power and industry-specific factors, i.e., industry litigation threat and dynamism, moderate the relationship between CRO appointments and performance outcomes. For brevity, we focus on operational efficiency as the dependent variable in our hypothesis development and testing. As robustness checks, we also tested how CROs' power and industry factors moderate the impact of CRO appointments on firm risk. The research model is shown in Figure 1.

---- Figure 1 about here ----

3.1 CROs and Performance Outcomes

From the ABV, firm actions are determined by the attention focus of decision-makers (Ocasio, 1997). With a new CRO appointed, an organization, particularly its TMT, pays more attention to risk issues. This, in turn, motivates the firm to increase its risk management capability and reduces risk exposure. With a CRO in the TMT, firms increase risk awareness and create a consensus of tightening risk control within the organization. CROs motivate managers to confine their attention to potential risks in decision-making, leading to the restriction of excessive risk-taking and less risk exposure (Ellul & Yerramilli, 2013). For example, Giambona *et al.* (2017) found that firms with executives that are more concerned about risks are less likely to invest in politically risky countries, thus reducing political risk exposure. In summary, firms with strong risk management emphasis tend to be more proactive in identifying risk factors and are better prepared for risk events, leading to our first hypothesis:

H1: *CRO appointments reduce firm risk.*

The impact of CROs on operational efficiency is paradoxical. On the negative side, CROs might bring tight risk control to organizations, which gives rise to bureaucracy and inefficiency. For example, firms might have to change processes and create monitoring positions to oversee risks, which give rise to employee costs and delay the processes (Beasley *et al.*, 2008; da Silva *et al.*, 2019). To reduce the risks of medical devices, the U.S. Food and Drug Administration (FDA) introduces a wide range of standards and requires multiple rounds of market approval before products can be introduced to the market. However, the standards and market approvals possibly slow down the pace of innovation in the medical device industry (Marucheck *et al.*, 2011). To tighten risk control, firms often adopt a hierarchical organizational structure with more formalized procedures. The organizational structure requires different layers of approvals and monitoring, leading to delays in decision making and the implementation of new strategic initiatives. Formalized procedures also reduce employees' autonomy and empowerment, making them more restrictive and less creative in problem-solving (Hirst *et al.*, 2011).

However, the operational expenses on strengthening risk control can be restored in the way of well-established systems that reduce costs associated with mistakes and disruptions. According to the quality management literature (Powell, 2006; Sousa & Voss, 2002), the costs associated with quality management can be redeemed in the form of reductions in internal and external failures as well as improvements in productivity and product reputation (Kaynak, 2003). This idea was summarized into Crosby's famous claim that "Quality is not a gift, but it is free" (Crosby, 1979). A fundamental premise of quality management is that the cost associated with poor performance, such as rework, loss of customers, and remedy, is larger than the cost of developing a reliable process that produces high-quality products (Crosby, 1979). By adopting tight quality management systems, firms actively improve operational procedures, monitor facility conditions, and adopt preventive measures, leading to fewer quality failures and lower correction costs that offset the quality control costs (Hackman & Wageman, 1995).

The same rationale can be applied to the risk management context. Indeed, the lack of risk management could have a significant hidden cost as losses increase exponentially when mistakes or damages happen. For example, more innovative firms tend to be risk-taking in product development. As a result, they are more vulnerable to unexpected product failures that incur remedy costs and reduce firm profits (Mackelprang *et al.*, 2015).

Operational disruptions caused by product-harm crises and service failures might induce regulatory scrutiny on operational procedures and are regarded as deterrents to operational efficiency (Cleeren *et al.*, 2017). For example, after the second Boeing 737 Max accident in 2019, regulators forced Boeing to scrutinize every aspect of the jet for potential design flaws that caused the accidents (Kitroeff & Gelles, 2020). The jet was banned in multiple countries for two years, and the delivery of new aircraft had been delayed. Boeing was charged over 2.5 billion US dollars to settle the matter (Shepardson *et al.*, 2021). Similarly, other operational failures or accidents may entail a comprehensive review of current processes, incurring additional costs, and hindering efficiency and firm performance (Khamitov *et al.*, 2020). CRO appointments facilitate firms to adopt a comprehensive approach to evaluate the potential hazards in products and services. Firms with a strong risk focus continuously evaluate risks involved in their internal procedures and implement processes to improve the reliability of products and services (Bromiley *et al.*, 2015). Frequent risk scanning of operational procedures enables firms to identify process flaws and quality problems. For example, in the product development stage, a firm can conduct more comprehensive evaluations and risk assessments before introducing new products to the market, leading to the improvement of product quality performance and reduction of potential product failures that threat the long-term viability of the firm.

Enhancing risk management entails the development of contingency plans that potentially mitigate the impact of operational disruptions. In the process of product and service deliveries, firms are vulnerable to external uncertainties and disruptions, such as supply shortages, extreme weather, and cyber-attacks (Ho *et al.*, 2015). A key element of risk management is to develop contingency plans to mitigate the negative consequences of risk factors (Tomlin, 2006). With risk factors that potentially disrupt product and service deliveries being monitored and contingency plans being formulated, firms enhance process reliability, reduce interruptions in product and service deliveries, leading to the increase of customer satisfaction.

Furthermore, risk management can help firms identify new opportunities to improve operational efficiency. To manage firm risk at the strategic level, CROs might have to restructure their operational processes, manage process uncertainties, operational risks, and environmental hazards, and integrate them into an overall corporate risk management strategy. The restructuring of operational processes helps firms identify opportunities to improve operational efficiency. For example, ERM involves constant scanning of the environment for both upside and downside risks (Bromiley *et al.*, 2015). Such scanning allows firms to get access to rich external information, such as new customer needs and technology changes (Peteraf & Bergen, 2003). The scanning procedure, at the same time, helps firms understand technology trends and motivates them to renew business models and technology portfolios to cope with the uncertainty that might undermine their long-term competitiveness (Fleming, 2001; Voss *et al.*, 2008). This not only helps firms mitigate operational disruptions, but also enables them to restructure their operational procedures and identify opportunities for efficiency enhancements. Overall, we suggest that:

H2: *CRO appointments lead to enhanced operational efficiency.*

3.2 The Role of CROs' Power

Like other C-suite officers, the power of CROs can vary significantly across organizations (Chen *et al.*, 2020; Ellul & Yerramilli, 2013). In some firms, CROs can be one of the very few most senior executives at the top of an organization's hierarchy, e.g., senior vice president, having general responsibilities and overseeing multiple organizational functions (Ellul and Yerramilli, 2013). However, CROs can also be just one of the many senior officers in a firm, managing narrowly defined risk responsibilities (e.g., legal and compliance).

From the ABV, the power dynamics within the TMT would significantly affect the allocation of organizational attention (Tuggle *et al.*, 2010a, 2010b). Executives with a strong power tend to have a stronger influence on other TMT members, making their requirements more likely to be accepted in the organization (Tuggle *et al.*, 2010b). Also, powerful executive members can raise the importance of a strategic issue to a higher level and allocate more resources to such strategic initiatives. Consistent with this rationale, we suggest that the power of CROs helps address the tension between operational bureaucracy and risk reduction associated with CRO appointments.

Powerful CROs are more likely to resolve the paradox between risk control and efficiency. Implementing an integrated risk management framework can be regarded as an organizational change that may create ambiguity and incur goal conflicts among different organizational functions (Bromiley *et al.*, 2015). The conflicting objectives for risk control and efficiency can be resolved by a powerful CRO because powerful executives can raise the importance of a strategic issue to the top of an organization, which reduces ambiguity and conflicting goals between organizational units. Also, CROs in a higher position are more likely to drive an organization-wide risk management initiative, which further reduces possible goal conflicts between organizational functions (Lines, 2007). For example, a CRO of a lower rank may focus on risk and compliance narrowly, and tend to tightly restrict new development initiatives, leading to conflict, delay, and bureaucracy. However, CROs at the top of the hierarchy overseeing both organizational development and risk management are more likely to develop high-level strategies to mitigate such a conflict (e.g., by integrating and standardizing risk assessments in the early stage of product development). This is consistent with the idea that quality (or risk management) is a top management's responsibility, not a departmental function (Powell, 2006).

Moreover, powerful CROs are more capable of reducing operational disruptions by creating a consensus on risk control. Powerful CROs tend to have a stronger voice in the TMT and are more likely to direct organizational attention to risk management. The consensus on risk control increases the mindfulness of risk issues in the entire organization. Firms with CROs at the top of the organizational hierarchy are more likely to deploy risk management initiatives across organizational units and reduce risk factors at different stages, leading to more reliable and efficient product and service deliveries without inducing too much bureaucracy (Speier *et al.*, 2011). As a result, the appointment of more powerful CROs can lead to more reduction in operational disruptions that cause inefficiency to a greater extent. Stated formally:

H3: *The positive impact of CRO appointments on operational efficiency is greater for CROs with stronger power.*

3.3 The Role of Operating Environments

The ABV posits that the focus of managerial attention is shaped by environmental factors that affect the salience of strategic issues (Ocasio, 1997). From this perspective, we suggest that CRO appointments can benefit firms to a higher degree under more uncertain and volatile environments that make risk issues more salient. We consider litigation threats and dynamism as two important indicators of a vulnerable, uncertain, and unpredictable environment.

Litigation threats refer to possible legal actions taken allegedly against companies because of their negligence or other inappropriate organizational actions (Koh *et al.*, 2014). For firms operating in industries with high litigation threats, CRO appointments cause fewer conflicts within the firms as risk management initiatives proposed by CROs will be more likely to be supported by other TMT members. For example, in the pharmaceuticals and biotech industries, where firms are constantly threatened by litigation risks, such as patent disputes and product liabilities, firms place more importance on regulatory compliance and precaution measures (Grabowski *et al.*, 2017). As a result, organizational members are more likely to act consistently to support risk control changes proposed by the CRO in a high litigation environment. This consensus from the top on the importance of risk management enables CROs to implement risk management frameworks more effectively. By contrast, for firms operating in industries with low litigation threats, TMT members may pay more attention to other pressing issues faced by the firms (e.g., cost efficiencies) than risk management and provide less agreed support for CROs, which reduces the effectiveness of CRO appointments.

Risk control and operational efficiency are more likely to be complementary in litigious industries. In such industries, firms' misconducts are more likely to be accused by stakeholders and lead to more severe consequences than those in less litigious industries (Arena & Julio, 2015; Huang *et al.*, 2019). This, in turn, raises the difficulty of making effective decisions and increases ambiguity in operations. Given the high litigation threats, firms tend to act rigidly to avoid the losses associated with potential lawsuits (Staw *et al.*, 1981; Shi *et al.*, 2018). Therefore, in litigious industries, a proactive and comprehensive risk management framework, e.g., appointing

CROs and redesigning processes to minimize exposure to litigation risks, can help reduce the ambiguity in operations and ensure a stable operational flow within the firm (Bromiley *et al.*, 2015). This suggests a lower conflict between risk control and operational efficiency in more litigious industries. By contrast, in industries with low litigation threats, firms' potential misbehaviors tend to incur less severe consequences and induce a less negative impact on the firms' operations (Hanley & Hoberg, 2012). In such situations, stringent risk control measures might lead to more constraints in operations and hinder operational efficiency. This indicates a lower synergy between risk control and operational efficiency in less litigious industries. Taken together, we expect industry litigation threats strengthen the relationship between CRO appointments and operational efficiency. We thus propose that:

H4: *The positive impact of CRO appointments on operational efficiency is greater for firms operating in industries with higher litigation threats.*

Industry dynamism refers to the rate and unpredictability of changes in the task environment of an industrial sector (Dess & Beard, 1984; Eroglu & Hofer, 2014). We expect that CROs can achieve a better synergy between risk control and operational efficiency in a dynamic environment considering the uncertainties and opportunities arising from such an environment. First, in a dynamic environment, the market conditions are more complex and less predictable (Eroglu & Hofer, 2014; Azadegan *et al.*, 2013). The uncertainty of the task environment entails information processing challenges and makes managers more vulnerable to judgment biases, resulting in a higher inconsistency in strategic decision making (Mitchell *et al.*, 2011). In such environments, tightening organizational controls enables the formalization and centralization of operational procedures that increase information processing efficiency (Cardinal, 2001; Patel, 2011). The improved information flows within the organization reduce ambiguity in operations and enhance operational efficiency (Rogers *et al.*, 1999; Tushman & Nadler, 1978). By contrast, in a stable environment, the market conditions are more predictable and less uncertain, presenting a lower need for firms to enhance information processing capabilities (Schilke, 2014). This also implies that the process redesign and improved approval hierarchies associated with risk controls contribute less to information flows and efficiency improvements. As a result, risk control and operational efficiency are less complementary in a stable environment.

Moreover, in a dynamic environment with frequent changes, it is more difficult for firms to rely on an invariant, stable set of routines to maintain their operational efficiency (Schilke, 2014). In this case, CROs can motivate firms to regularly comprehend external threats to identify risks that might jeopardize the viability of the firms (Joseph & Gaba, 2020). Such proactiveness and the efforts to comprehend potential risk factors help firms gain more information and insights about evolving customer needs and changing market conditions, which enable them to capture market opportunities and improve operational efficiency (Peterson & Wu, 2021). By contrast, in a stable environment, where environmental changes are uncommon and predictable, CROs are less motivated to scan the environment frequently, resulting in fewer opportunities for firms to improve operational efficiency. Taken together, we expect industry dynamism strengthens the relationship between CRO appointments and operational efficiency. We thus propose that:

H5: *The positive impact of CRO appointments on operational efficiency is greater for firms operating in more dynamic industries.*

4. Research Methods

4.1 Hypothesis Testing Strategies

There are a few challenges and potential endogeneity concerns for hypothesis testing. First, CRO appointments are not a random choice, suggesting that firms with CROs may be quite different from other firms without CROs (Pagach & Warr, 2011). Such a difference *per se*, rather than CRO appointments, may explain firms' performance changes over time. Similarly, as firms are paying increasing attention to risk and operations management in today's competitive environments (Knemeyer *et al.*, 2009), there may be a general trend in risk reduction and efficiency improvement, independent of CRO appointments. This suggests that the impact of CRO appointments on firm risk and operational efficiency could be over-estimated if this possible trend is not considered. Finally, although we hypothesize that industry environments (i.e., industry litigation threat and dynamism) moderate the impact of CRO appointments, industry environments may also determine firms' decision to appoint CROs. Specifically, it may be more likely for firms operating in more litigious and dynamic industries to appoint CROs, possibly biasing the estimation of the moderating role of industry litigation threat and dynamism.

We adopted the following estimation strategies to address these concerns. First, we employed propensity score matching (PSM) (Hendricks *et al.*, 2015) to simulate a random assignment process and address the possible self-selection bias. Specifically, we matched each sample firm with CRO appointment to a control firm that has a similar propensity as the sample firm to appoint CRO but eventually did not make such an appointment. We took account of firm characteristics, industry environments (e.g., industry litigation threat and dynamism), and time-specific effects when estimating firms' propensities to appoint CROs. This matching process helps ensure that the sample and matched control firms are similar and comparable.

After performing PSM, we tested H1 and H2 by quantifying the impact of CRO appointments in terms of "abnormal" change in firm risk (H1) and operational efficiency (H2). Abnormal performance change due to an event, such as CRO appointment, is the difference between actual performance change with the occurrence of the event and expected performance change without such an event (Barber & Lyon, 1996). In our research context, actual performance change is the change in firm risk and operational efficiency of sample firms with CRO appointments, and expected performance change is the change in firm risk and operational efficiency of matched control firms without CRO appointments. This quantification approach helps address possible firm performance trends and enables us to estimate the impact of CROs over different periods (e.g., one or two years) after the appointments.

We then tested H3 to H5 by estimating a cross-sectional regression model (Arora *et al.*, 2020). The dependent variable is the abnormal change in operational efficiency, while the independent variables include CRO power (H3) and industry environments (H4 and H5), as well as other control variables. An important advantage of this regression model is its simplicity and clarity for result interpretation. Specifically, as the dependent variable is the abnormal change in operational efficiency rather than operational efficiency *per se*, the coefficient of an independent variable directly indicates how the independent variable moderates or affects the impact of CRO appointments on operational efficiency. We provide more detailed explanations of these steps in the following sections.

4.2 Data Collection

We measured research variables based on longitudinal secondary data collected from multiple sources. First, we identified firms' announcements of CRO appointments by searching *Factiva* that covers news and information articles from various sources, such as *The Wall Street Journal*, *The New York Times, PR Newswire*, and *Business Wire*. The keywords used in our search included *CRO, Chief Risk Officer*, and other similar terms, such as *Vice President of Risk Management, Chief Risk Manager, Enterprise Risk Officer, Enterprise Risk Manager, and Director of Risk Management*. This data collection approach is in line with prior CRO studies (Liebenberg & Hoyt, 2003; Beasley *et al.*, 2008), enabling us to identify CROs at different seniority levels. By contrast, some other databases such as *Execucomp* and *BoardEx* focus on individual appointments at the more senior levels such as executive officers and board directors, which may exclude the appointments of less-senior CROs and reduce the variation of our CRO power measure. Nevertheless, we also performed a robustness check based on CRO appointment data collected from *BoardEx* and obtained consistent results.

Our search in *Factiva* focused on publicly listed firms as the financial and accounting information of these firms were available to measure other research variables, such as firm risk and operational efficiency. Another advantage of focusing on publicly listed firms is that these firms are subject to more stringent reporting requirements and are more visible to the public and media, making it more likely for them to make announcements of their CRO appointments. As a result, we included NYSE and NASDAQ as the keywords in our search. For firms with multiple CRO appointments from 2006 to 2016, we focused on their first CRO appointments because these first appointments, compared with other later appointments of the same firms, are more in line with the ABV and more likely to capture the firms' attention paid to risk management. Our search via *Factiva* identified 764 CRO appointments made by publicly listed firms between 2006 and 2016. After removing 329 CRO succession announcements, we had 435 publicly listed firms that made their first CRO appointments between 2006 and 2016. Table 2 shows the distribution of the 435 firms' first CRO appointments across years, while Table 3 indicates that these firms are operating in various industries ranging from financial and business services to manufacturing and transportation.

--- Tables 2 and 3 about here ---

We then obtained longitudinal data from other sources, including *Compustat*, *the Center for Research in Security Prices (CRSP), the U.S. Securities and Exchange Commission (SEC),* *BoardEx, Thomson Reuters, RavenPack, and Audit Analytics*, for variable measurements. Specifically, we measured firm risk based on daily stock data from CRSP and calculated operational efficiency using accounting data from *Compustat*. We obtained compensation data from SEC to measure CRO power. For industry environments, we collected lawsuit data from *Audit Analytics* to measure industry litigation threat and industry sales data from *Compustat* to measure industry dynamism. The data sources and measurements of these variables and other control variables are summarized in Table 4 and further discussed below. Due to missing data across different databases, our sample size was reduced from 435 to 361 for performing PSM, which was further reduced to 225 for running cross-sectional regression. Nevertheless, our one-way ANOVA test results indicate no significant difference ($p > 0.1$; not tabulated) in terms of some common firm-level variables including sales, total assets, and market value across these samples in different estimation steps, providing no evidence of sampling bias.

--- Table 4 about here ---

4.3 Propensity Score Matching (PSM)

To perform PSM, we first formulated a probit regression model in which the dependent variable indicates whether a firm makes a CRO appointment in a particular year *t*. After reviewing prior research on the appointments of CROs (Pagach & Warr, 2011; Liebenberg & Hoyt, 2003) and other chief executives such as OM executives and chief sustainability officers (Arora *et al.*, 2020; Hendricks *et al.*, 2015), we identified a list of variables that may determine CRO appointments and included them as the independent variables in the probit regression model, as shown in Equation (1). The data sources and measurements of these independent variables can be found in Table 4. Consistent with prior studies (Hendricks *et al.*, 2015; Pagach & Warr, 2011), we measured the independent variables in year *t-1*, one year before CRO appointments. We also included year dummies to control for unobserved time-specific effects.

$$
\begin{aligned}
&Probability(CRO\ Appointment_{it} = 1) \\
&= F\{\beta_0 + \beta_1 Firm\ Size_{i(t-1)} + \beta_2 Firm\ Profitability_{i(t-1)} + \beta_3 Firm\ Leverage_{i(t-1)} \\
&+ \beta_4 Market\text{-}to\text{-}Book\ Ratio_{i(t-1)} + \beta_5 Earnings\ Volatility_{i(t-1)} + \beta_6 Institutional\ Ownership_{i(t-1)} \\
&+ \beta_7 Industry\ Litigation\ Threat_{i(t-1)} + \beta_8 Industry\ Dynamism_{i(t-1)} + \beta_9 Industry\ Competition_{i(t-1)} \\
&+ \beta_{10} Polluting\ Industries_{i(t-1)} + \beta_{11} Financial\ Industries_{i(t-1)} + \ Year\ Dummies\}, \qquad (1)
\end{aligned}
$$

where i and t are firm and year indexes, respectively. F denotes the cumulative normal distribution function. There are 13,430 firms with no missing data across all the independent variables, which include 361 sample firms with CRO appointments and 13,069 control firms without CRO appointments. After running Equation (1), we obtained the predicted probability (or propensity score) of each of these 13,430 firms to make CRO appointments. We then matched each sample firm to a control firm with the closest propensity score (i.e., one-to-one nearest-neighbor matching).

We further checked the quality of our matching approach. First, we re-ran Equation (1) for the sample firms and their matched control firms. Table 5 presents the regression results. Model 1 in Table 5 indicates that before matching, six of the 11 independent variables significantly determine firms' CRO appointments. Nevertheless, Model 2 shows that after matching, none of these 11 variables are statistically significant, suggesting that sample and matched control firms have similar propensities to appoint CROs. We also checked the differences between sample and control firms across the 11 independent variables. As shown in Table 6, before matching (Panel A), sample firms are significantly different from control firms across 10 of the 11 independent variables. By contrast, Panel B suggests that after matching, the differences are not significant across all the 11 independent variables. Taken together, these test results demonstrate sample firms' similarity and comparability with matched control firms, confirming our matching quality.

--- Tables 5 and 6 about here ---

Finally, we checked whether our matched control firms appointed CROs during the sample period of 2006-2016. Specifically, we searched the names of these matched control firms and CRO-related keywords across different databases, including *Factiva*, *Execucomp*, and *BoardEx*, but could not identify the CRO appointments of these matched control firms during 2006-2016. This addresses the endogeneity concern that some of our matched control firms in fact also appointed CROs during 2006-2016, which may bias our test results.

4.4 Abnormal Change in Firm Performance

To test H1 and H2, we quantified the abnormal change in firm performance including firm risk (H1) and operational efficiency (H2) as sample firms' performance change compared with that of their matched control firms over the same period (Arora *et al.*, 2020; Barber & Lyon, 1996).

As we performed PSM in year *t-1* (one year before CRO appointments), we viewed year *t-1* as the base year and calculated the performance change from year *t-1* to other years following firms' CRO appointments. We analyzed our results up to three years after a CRO appointment (i.e., year *t+3*). In the following, we discuss how the two firm performance variables (i.e., firm risk and operational efficiency) were measured in this research.

Firm Risk. The overall or total risk a firm is facing in a specific period (e.g., one year) is represented by the fluctuation of the firm's stock returns over this period (Lam, 2018). Total risk consists of firm-specific idiosyncratic risk and market-specific systematic risk (Luo *et al.*, 2014). Mathematically, we calculated the annualized standard deviation of a firm's daily stock returns over a year to indicate its total risk in this year, while its idiosyncratic and systematic risks were obtained using the following Market model.

$$R_{it} = \alpha_i + \beta_i RM_t + \varepsilon_{it} , \quad (2)$$

where *i* and *t* refer to firm *i* and day *t*, respectively. Specifically, we first regressed firm *i*'s daily stock returns (R_{it}) on daily market returns (RM_t; measured based on the CRSP index) in each year. We then computed firm *i*'s idiosyncratic risk in a specific year as the annualized standard deviation of the residuals (ε_{it}) in that year and relied on the coefficient of daily market returns (β_i) to indicate firm *i*'s systematic risk in the same year (Lam, 2018; Luo *et al.*, 2014). As our hypothesis development suggests that CROs help reduce both internal and external risks firms are facing, we used total risk in the main analysis but also checked the robustness of our findings to idiosyncratic and systematic risks.

Operational Efficiency. Following previous studies (e.g., Lam et al., 2016; Li et al., 2010), we measured operational efficiency based on stochastic frontier estimation that focuses on a firm's relative efficiency (compared with its industry peers) in converting various operational inputs into operational output. Mathematically, we constructed a stochastic function as shown in Equation (3) to model the relationship of a firm's operational inputs [i.e., number of employees (EMP), cost of goods sold (CGS), and capital expenditure (CEX)] with its operational output [i.e., operating income (OI)]. In line with Li *et al.* (2010), our model takes account of not only the direct effects of different operational inputs but also the possible interactions among them, thus better capturing the complex relationships between operational inputs and output.

$$\ln(OI)_{ijt} = \beta_0 + \beta_1 \ln(EMP)_{ijt} + \beta_2 \ln(CGS)_{ijt} + \beta_3\, ln(CEX)_{ijt} + \beta_4 \ln(EMP)^2_{ijt} + \beta_5 \ln(CGS)^2_{ijt}$$
$$+ \beta_6 \ln(CEX)^2_{ijt} + \beta_7 \ln(EMP)_{ijt} \times \ln(CGS)_{ijt} + \beta_8 \ln(CGS)_{ijt} \times ln(CEX)_{ijt}$$
$$+ \beta_9 ln(EMP)_{ijt} \times ln(CEX)_{ijt} + \varepsilon_{ijt} - \eta_{ijt}\,, \tag{3}$$

where i, j, and t, are firm, industry (four-digit SIC code), and year indexes, respectively. The stochastic random error is indicated by ε_{ijt}. η_{ijt} captures a firm's technical inefficiency compared with the most efficient firm (i.e., the frontier) in the same industry and year. η_{ijt} ranges from 0 to 1, with $\eta_{ijt} = 0$ representing a firm without technical inefficiency. To ease the interpretation of the test results, we applied reverse coding and used $1 - \widehat{\eta_{ijt}}$ to provide a direct indication of a firm's operational efficiency.

4.5 Cross-Sectional Regression Model

We constructed a regression model as shown in Equation (4) to estimate how the impact of CRO appointments on operational efficiency varies across CRO power (H3) and industry environments (H4 and H5), after controlling various variables at the firm, industry, economy, and year levels.

$$Abnormal\ Change\ in\ Operational\ Efficiency_i$$
$$= \beta_0 + \beta_1 CRO\ Power_i + \beta_2 Industry\ Litigation\ Threat_i + \beta_3 Industry\ Dynamism_i$$
$$+ Control\ Variables + Year\ Dummies + \varepsilon_i\,. \tag{4}$$

The dependent variable is the abnormal change in operational efficiency, quantifying the impact of CRO appointments on operational efficiency. We chose the abnormal change in one year after CRO appointments (i.e., $t+1$) as the dependent variable because CRO appointments do not have a significant impact on operational efficiency in year t (i.e., the appointment year) but have the most significant impact in year $t+1$, as shown in Table 7. β_1 to β_3 indicate how the impact varies across different levels of CRO power (H3), industry litigation threat (H4), and industry dynamism (H5), respectively. As the measure of CRO power was available only when CRO appointments had been made, we measured all the hypothesized and control variables in the year of CRO appointments to ensure consistency. In the following, we discuss how these hypothesized and control variables were measured in this research.

CRO Power. Following previous research on executive power (Ellul & Yerramilli, 2013; Feng *et al.*, 2015; Florackis & Sainani, 2018), we measured a CRO's power based on principal component analysis (PCA). An important advantage of the PCA approach is its ability to transform several power-related variables or proxies into a single principal component, providing a composite measure of a CRO's overall power. This approach thus addresses the multicollinearity concern that these power proxies may be highly correlated with each other if they are included in the same regression model and also avoids the subjective judgments about the relative importance of these power proxies (Ellul & Yerramilli, 2013).

We performed the PCA of three power proxies, including CRO Executive, CRO Top5, and CRO Centrality, that have been widely used in the risk management literature (Chen *et al.*, 2020; Ellul & Yerramilli, 2013). CRO Executive indicates whether a firm's CRO is an executive officer within the firm. Although the CRO appointment data collected for this research focus on the most senior individuals responsible for risk management in a firm, their seniority relative to that of other TMT members varies across firms. While some CROs are appointed at the executive officer level, others are assigned some less-senior titles, such as enterprise risk managers and enterprise risk officers. Such a variation across firms provides important information for us to capture a CRO's power within a company. Specifically, we searched our sample firms' filings (e.g., Forms DEF 14A, 10-K, etc.) submitted to SEC via the EDGAR database to identify whether the firms have stated explicitly in these official documents that their CROs are executive officers. We then coded those CROs at the executive officer level as 1 and others as 0.

Both CRO Top5 and CRO Centrality are concerned with a CRO's compensation. As an employee who occupies a higher position in an organization's hierarchical structure should get higher pay than other employees with lower ranks, employee compensation has been widely used as a proxy for individual power within an organization (Finkelstein, 1992). CRO Top5 indicates whether a CRO is among the five highest-paid employees in a firm, while CRO Centrality quantifies a CRO's compensation relative to that of the CEO in the same firm. Empirically, we searched SEC's EDGAR database to identify a sample firm's five highest-paid employees and coded the CRO Top5 variable as 1 if the firm's CRO is one of these employees (and 0 otherwise). We also obtained the compensation data of our sample firms from the EDGAR database and measured the CRO Centrality variable as the ratio of a CRO's total compensation to that of the CEO in the same firm. If a CRO's compensation data was not available in the EDGAR database, we followed prior studies (e.g., Ellul & Yerramilli, 2013; Chen *et al.*, 2020) by measuring CRO Centrality based on the total compensation of the fifth highest-paid employee recorded in the EDGAR database and subtracted a percentage point from the resultant ratio. This measurement approach assumes that a CRO's compensation should be lower than that of the fifth highest-paid employee if the CRO's compensation is unavailable in the EDGAR database.

We then checked and confirmed that the three power proxies (i.e., CRO Executive, CRO Top5, and CRO Centrality) are highly correlated with each other ($p < 0.01$), providing initial support for performing PCA based on these power proxies. We also found that the PCA of these three power proxies yields only one principal component whose eigenvalue is higher than one, a lower limit that has been commonly used in previous studies to determine whether a principal component should be retained (Florackis & Sainani, 2018). This principal component extracted from the PCA accounts for 61% of the total variance and represents an appropriate composite measure of a CRO's overall power. We also conducted robustness checks based on the three power proxies individually and obtained consistent test results.

Industry Litigation Threat. In line with recent studies (Arena, 2018; Kim & Skinner, 2012), we relied on lawsuit filing data to measure the litigation threat of an industry. This is because lawsuit filings, compared with lawsuit settlements or outcomes, better capture the uncertainties or risks firms are facing. Although some prior studies (Kim & Skinner, 2012) have relied on class action lawsuits, a specific type of lawsuits obtained from the *Securities Class Action Clearinghouse (SCAC)*, to represent litigation threats, this approach ignores other types of lawsuits filed against firms and thus is less likely to capture the overall litigation threats firms are facing. Our research, instead, considered all the lawsuit filings (e.g., class action, product liability, copyright, patent, fraud, antitrust, personal injury, and labor law) disclosed to SEC by public firms (Arena, 2018). Obtaining these lawsuit filings from *Audit Analytics*, we measured the litigation threat of firms in a specific industry (four-digit SIC code) and year as the number of lawsuits filed against firms in this industry and year divided by the number of firms in the same industry and year. We obtained similar test results when measuring industry litigation threat alternatively with a focus on class action lawsuits (Kim & Skinner, 2012).

Industry Dynamism. The fluctuation of industry sales over time has been widely used to indicate the dynamism of the environment in which a firm is operating (Chang & Cho, 2017; Fang *et al.*, 2011). This is because firms should face more uncertainties if the sales of their industries change frequently rather than remaining stable over time. In line with the measures of other independent variables, we measured industry dynamism in a particular year based on the industry data in the same year. As a result, the dynamism of an industry (four-digit SIC code) in a particular year was calculated as the standard deviation of quarterly industry sales in this year divided by the average quarterly industry sales in the same year. We also measured industry dynamism alternatively based on annual industry sales data and obtained consistent test results.

Control Variables. As the extent to which CRO appointments affect firm performance may be explained by other factors beyond the three hypothesized variables discussed above, we included 18 control variables in the cross-sectional regression model to account for these explanations. The data sources and measurements of the 18 variables are shown in Panel C of Table 4. The selection of these control variables was informed by the literature and intended for a comprehensive coverage of factors across different levels. Specifically, these variables are concerned with CRO characteristics [whether the CRO is female and promoted internally as different genders may have different risk preferences (Gupta *et al.*, 2020), while internally promoted CROs may be more knowledgeable about firms' operations and risk environments (Bailey, 2019)], board characteristics [we included a board's size, gender diversity and experience diversity as these board characteristics may explain the firm's risk profile and performance outcomes (Aebi *et al.*, 2012; Harjoto *et al.*, 2015; Wowak *et al.*, 2021)], firm characteristics [we included a firm's size, profitability, leverage, market-to-book ratio, and earnings volatility as they may be related to the firm's operational efficiency (Lam *et al.*, 2016; Li *et al.*, 2010)], organizational structure and ownership [we focused on CEO duality and institutional ownership as they may affect the role and effectiveness of CRO (Ellul & Yerramilli, 2013; Pagach & Warr, 2011)], industry characteristics [besides the two hypothesized industry-level variables, we were interested in whether CRO appointments benefit firms more in competitive, financial, and polluting industries (Berrone *et al.*, 2013; Black & Neururer, 2020; Chang & Cho, 2017)], and economic characteristics [we used the economic policy uncertainty index developed by Baker *et al.* (2016) to account for the economic or macro-level uncertainty].

We also added two dummy variables to indicate whether a firm has adopted ERM-related tools and appointed compliance and supply chain-related executives, respectively, before the CRO appointment. This is because firms adopting ERM tools and having compliance and supply chain-related executives may have lower risk and/or higher efficiency (Berry-Stölzle & Xu, 2018; Roh *et al.*, 2016), providing an environment for CROs to better accomplish their duties. Finally, we included year dummies to control for unobserved time-specific effects.

5. Results

5.1 Hypothesis Testing Results

Table 7 presents the hypothesis testing results for H1 (firm risk) and H2 (operational efficiency). Although there are 361 matched sample firms based on PSM performed in year *t-1*, the sample size decreases gradually as the investigation period increases from years *t* to *t+3*. The sample size is generally smaller for operational efficiency compared with firm risk because some sample firms did not report relevant firm data (e.g., number of employees) required for computing operational efficiency. The test results suggest that the abnormal changes in both firm risk and operational efficiency are not significant ($p > 0.1$) in year *t* in which CROs are appointed. However, the abnormal changes in firm risk and operational efficiency become significant ($p < 0.01$) in year *t+1* and remain significant ($p < 0.1$) up to year *t+3*. Specifically, for all three years after the CRO appointments, the abnormal change in firm risk is significantly negative ($p < 0.1$), whereas there is a significant and positive abnormal change in operational efficiency ($p < 0.05$). This suggests that CRO appointments have a negative impact on firm risk but a positive impact on operational efficiency, supporting H1 and H2, respectively.

--- Table 7 about here ---

As the magnitude and significance of the abnormal change in operational efficiency are the highest in year *t+1*, it is used as the dependent variable in the cross-sectional regression model shown in Equation (4). The descriptive statistics and correlation matrix of all dependent and independent variables included in Equation (4) are shown in Table 8, while the cross-sectional regression results are presented in Table 9. Table 9 contains four models. All control variables and year dummies are included in Model 1. The three hypothesized variables (i.e., CRO power, industry litigation threat, and industry dynamism) are added sequentially in Models 2 to 4. The adjusted R-squared values of the four models range from 0.086 to 0.141, which are statistically significant ($p < 0.05$). The sample size is reduced from 248 in Table 7 to 225 in Table 9 because some control variables (e.g., board gender diversity) have missing data.

Five control variables, including internal promotion, board gender diversity, board size, ERM tool, and financial industries, are significant ($p < 0.1$) in Model 4 (i.e., the full model). This suggests that firms gain higher operational efficiency improvements from CRO appointments if they promote CROs internally, appoint more female board directors, maintain a smaller board, have adopted ERM tools, and operate in the financial industries. For the hypothesized variables, CRO power remains significantly positive ($p < 0.05$) across Models 2 to 4, indicating that the impact of CRO appointments on operational efficiency is more pronounced if the CROs have stronger power. H3 is supported. Regarding the industry environments, industry litigation threat is significantly positive ($p < 0.05$) in Models 3 and 4, while Model 4 also shows a significant and positive coefficient for industry dynamism ($p < 0.05$). Therefore, firms operating in more litigious and dynamic industries gain higher operational efficiency improvements from CRO appointments. Both H4 and H5 are supported.

--- Tables 8 and 9 about here ---

5.2 Additional Tests

We conducted some additional tests to verify the sensitivity of our findings and to rule out alternative explanations. Table 10 documents the results of these tests, with the detailed testing procedures being discussed below.

--- Table 10 about here ---

First, we computed abnormal changes in firm performance based on alternative measures of firm risk and operational efficiency. Our alternative measures of firm risk are idiosyncratic risk and systematic risk, respectively. As shown in Models 1 and 2 of Panel A, although the abnormal changes in idiosyncratic risk and systematic risk are both negative, the risk reduction is more significant for idiosyncratic risk than systematic risk. This difference indicates that CRO appointments are more likely to reduce firm-specific rather than market-specific risks. We then measured operational efficiency alternatively based on a simpler, linear stochastic function (Lam *et al.*, 2016; Yiu *et al.*, 2020). Specifically, we dropped the squared and interaction terms in

Equation (3) when modeling the relationship between the operational inputs and output, obtaining consistent test results in Model 3 of Panel A.

As *t*-test is more sensitive to outliners, we tested the abnormal changes in firm risk and operational efficiency alternatively based on Wilcoxon signed-rank test, a non-parametric test that does not require the normal distribution assumption (Arora *et al.*, 2020; Hendricks *et al.*, 2015). The corresponding test results are consistent, as shown in Models 4 and 5 of Panel A.

We also checked the sensitivity of our test results when a different period of data was used to perform PSM. Specifically, instead of based on data in *t-1* (one year before CRO appointments), we used the three-year average of data from *t-3* to *t-1* to perform PSM (Liebenberg & Hoyt, 2003) and obtained qualitatively similar test results, as documented in Models 6 and 7 of Panel A.

We also recalculated abnormal performance changes based on CRO appointment data collected from *BoardEx* rather than from *Factiva*. Specifically, we identified all firms that appointed their first CROs from 2006 to 2016 via the *BoardEx* database. We applied the same PSM approach to match each of these firms to a control firm without appointing a CRO between 2006 and 2016. We then calculated the abnormal changes in firm risk and operational efficiency based on these matched firms and obtained consistent test results, as shown in Models 8 and 9 of Panel A. Overall, the first nine models in Panel A consistently show that CRO appointments help reduce firm risk and improve operational efficiency with alternative variable measurement, test specification, matching period, and data source, supporting H1 and H2.

To address the concern that our findings regarding the performance impact of CRO appointments are due to the significant performance difference between sample and matched control firms before the CRO appointments, we conducted several additional tests. First, we conducted paired sample *t*-tests to compare sample firms' firm risk and operational efficiency with that of matched control firms in two years before the CRO appointments (i.e., years *t-1* and *t-2*) but could not find any significant difference ($p > 0.1$; not tabulated). We also calculated the abnormal changes in firm risk and operational efficiency from *t-2* to *t-1*. As presented in Models 10 and 11 of Panel A, the abnormal performance changes before CRO appointments are not significant ($p > 0.1$). Thus, sample firms are similar to matched control firms in terms of both the levels of and the changes in firm risk and operational efficiency before CRO appointments.

Regarding the cross-sectional regression model, we first employed alternative measures of the three hypothesized variables. Specifically, instead of combining the three power proxies, i.e., CRO Executive, CRO Top5, and CRO Centrality, into a composite measure of CRO power, we measured CRO power alternatively based on each of these three power proxies and obtained consistent test results, as presented in Panel B (Models 1 to 3). Our regression results are also qualitatively similar as shown in Model 4 if we measured CRO power in the year after CRO appointments (i.e., year $t+1$) rather than in the appointment year (i.e., year t).

For industry litigation threat, instead of considering all kinds of corporate lawsuits, our alternative measure focused on the class action lawsuits obtained from the SCAC directly (Kim & Skinner, 2012). We used annual, rather than quarterly, industry sales data (i.e., annual industry sales over the past five years up to the year of CRO appointments) to obtain an alternative measure of industry dynamism (Chang & Cho, 2017). Models 5 and 6 in Panel B document consistent test results based on these alternative industry-level measures.

We also included some additional controls in the cross-sectional regression model. Specifically, we created two dummy variables, with one indicating whether firms had subsequent CRO successions during our investigation period (2006-2016) and the other representing the Great Recession occurring in 2008-2009. The first dummy helps account for any difference between firms' first CRO appointments and subsequent CRO successions, while the second dummy controls for possible uncertainties arising from the Great Recession. After adding the two controls, the regression results are qualitatively similar, as presented in Model 7 of Panel B. We also found that the impact of CRO appointments is independent of subsequent successions but becomes more pronounced during the Great Recession ($p < 0.1$; not tabulated).

We followed the Heckman two-step procedure to check whether self-selection bias plays a role in our analysis based on matched sample and control firms (Arora *et al.*, 2020; Hendricks *et al.*, 2015). Specifically, we first ran the probit regression model shown in Equation (1) for the matched sample and control firms to obtain the inverse Mills ratio (IMR). We then added the IMR as an independent variable in our cross-sectional regression model shown in Equation (4). If the IMR is significant in this model, our analysis is subject to the self-selection concern. We obtained consistent test results for the hypothesized variables, as shown in Model 8 of Panel B. Moreover, the IMR is insignificant (p > 0.1; not tabulated) in the cross-sectional regression model, suggesting that self-selection bias is not a major concern when matched sample and control firms are used in our analysis (Arora *et al.*, 2020).

As our arguments used for developing H3 to H5 can be applied to firm risk as well, we replaced the dependent variable in the cross-sectional regression model with the abnormal change in firm risk from *t-1* to *t+1*. As presented in Model 9 of Panel B, the regression results indicate that the *reduction* in firm risk due to CRO appointments is more pronounced for firms with stronger CRO power and operating in more litigious and dynamic industries, consistent with our finding based on operational efficiency. Overall, our regression results are robust to alternative measures of hypothesized variables, the inclusion of additional control variables and the IMR, and the use of alternative dependent variables.

As our cross-sectional regression results suggest that firms operating in the financial industries benefit more from CRO appointments, a valid concern is whether CRO appointments are not beneficial to firms in the non-financial industries. To address this concern, we split the full sample into two sub-samples based on whether firms are in the financial industries or not, and calculated the abnormal change in operational efficiency for each sub-sample separately. The sub-sample test results shown in Models 1 to 2 of Panel C suggest that CRO appointments also improve the operational efficiency of firms operating in the non-financial industries, although the magnitude of the improvement is smaller than that in the financial industries. Another reasonable concern is whether the significant moderating role of financial industries found in the regression analysis is driven by depository institutions that account for almost 40% of our sample firms. To address this concern, we further divided firms in the financial industries into two sub-samples, with one including depository institutions and the other including other financial firms. We then compared the difference between these two sub-samples in terms of abnormal change in operational efficiency but could not find a significant difference (p > 0.1; not tabulated). This indicates that our results are not driven by depository institutions.

We also checked whether CRO appointments are beneficial to firms without adopting ERM tools because our regression results show that firms with ERM tools benefit more from CRO appointments. The sub-sample test results based on firms with and without adopting ERM tools are shown in Models 3 and 4, respectively, in Panel C. It suggests that CRO appointments benefit firms without adopting ERM tools, not only firms with ERM tools.

Finally, we explored the mechanisms underlying the impact of CRO appointments on operational efficiency. Based on our hypothesis development and considering data availability, we tested three ways in which CROs improve operational efficiency: cost reduction, internal control quality improvement, and disruption prevention. Specifically, we expected that CROs help firms reduce costs, improve the quality of internal controls, and prevent disruptions to products and services, ultimately leading to better operational efficiency. Empirically, we measured costs as a firm's annual cost of goods sold obtained from *Compustat*. We assessed a firm's quality of internal controls based on data obtained from *Audit Analytics*. According to SOX Section 404, public firms are required to assess and disclose any weaknesses in internal controls, such as financial reporting deficiencies, lack of risk assessments, and failures to comply with established standards (Beneish *et al.*, 2008; Chalmers *et al.*, 2019). *Audit Analytics* collects these weaknesses data and records the annual number of weaknesses reported by each firm, providing a direct indication of a firm's annual quality of internal controls, with a higher number of weaknesses indicating a lower quality. We identified a firm's product/service-related disruptions via *RavenPack*, a database recording the occurrence of firm-specific events based on data from over 22,000 news sources (Hill *et al.*, 2019; Shi *et al.*, 2016). *RavenPack* classifies these events into different categories. We read the description of each category carefully and identified those related to the disruptions of firms' products or services including product/service delays, outages, recalls, and suspensions. We then counted the annual number of these disruption events for each firm. We applied logarithm transformation to these three measures to account for possible data skewness. We then calculated the abnormal changes in the three variables from $t-1$ to $t+1$ and documented the test results in Panel D. It shows that CRO appointments have a negative impact on firms' cost of goods sold and numbers of internal control weaknesses and product/service-related disruptions, consistent with our expectation. Moreover, the impact is more significant for internal control weakness ($p < 0.01$) than cost of goods sold ($p < 0.1$) and product/service-related disruptions ($p < 0.1$).

6. Discussion

While there has been an abundance of research studying various C-suite appointments, the impact of CRO appointments on firm risk and operational efficiency is still under-researched. The costly regulation hypothesis posits that organizations make tradeoffs between being safe (i.e., risk-free) and being efficient (Pagell *et al.*, 2015). Previous studies have shown that firms with a lower level of workplace safety tend to be more productive and have a higher level of survival rate (Pagell *et al.*, 2020). Nevertheless, we find that CRO appointments can reduce firm risk and improve operational efficiency simultaneously. Our results show that the strategic appointment of CRO to the TMT indeed reduces the tension between risk control and efficiency. We further delve into the characteristics of CROs and find that CRO's power enhances efficiency to a greater extent. Also, we show that in an uncertain environment characterized by higher levels of industry litigation threats and industry dynamism, CRO appointments can achieve efficiency improvement to a greater extent. This provides useful insights in understanding the rationale in which risk management leads to efficiency enhancements.

6.1 Theoretical Implications

Our study supplements previous studies on chief officer appointments (Arora *et al.*, 2020; Roh *et al.*, 2016). Consistent with the crisis management studies that suggest crisis-prepared firms are less vulnerable to crisis events (Bundy *et al.*, 2017), firms with a proactive risk management framework tend to be more active in identifying risks and designing mitigation approaches to prevent the occurrence of risk events. Also, we find that attention allocated to risk management at the corporate level leads to a "side effect" of improving efficiency. Since risk is an inherent problem that represents the potential for the realization of undesired outcomes (Maguire & Hardy, 2013), strategic and proactive management of risk is the most economical way to reduce its costs. This is in line with classical quality management principles that planning for quality from the top is significantly more effective than the correction of quality problems (Sousa & Voss, 2002).

Extending previous studies that focus on the outcomes of CRO appointments (Grace *et al.*, 2015; Lin *et al.*, 2012; Pernell *et al.*, 2017), this study covers a wider range of industries. We compared the results based on financial vs. non-financial firms. The results indicate that the effectiveness of CRO appointments is greater in the financial industries. This is probably because the financial industries are under high regulatory surveillance, particularly after the global financial crisis in 2008 (Philippon, 2015), and the conflict between regulatory compliance, cost and efficiency are likely to be more salient in the financial sectors (American-Banker, 2018).

6.1.1 Conflict between Risk Management and Efficiency

We suggest that strategic risk management is an effective way to address the tension between risk control and operational efficiency. Previous studies on the impact of risk control on operational efficiency remain inconclusive (Pagach & Warr, 2011). Tightening risk control might incur burdensome costs, bureaucracy, and the rigidity of operational routines. Yet, enhancing risk management can ensure a stable flow of operations and reduce operational disruptions that offset efficiency (Farjoun, 2010). Consistent with the latter view, we find that strategic risk management, as represented by CRO appointments, can reduce firm risk and improve operational efficiency simultaneously. We suggest that CROs can raise the importance of risk management to a strategic level and facilitate a comprehensive approach to risk management. CRO appointments motivate firms to implement ERM to adopt a comprehensive evaluating protocol to balance risks and rewards (Eckles *et al.*, 2014), help resolve the conflicts associated with the implementation of risk management initiatives, and overcome the paradoxical relationship between risk controls and operational efficiency.

This study brings a new perspective, i.e., the ABV, to understand operational practices. The ABV explains how the strategic intent of the TMT can be transformed into operational practice through directing organizational attention (Ocasio, 1997). Based on the ABV (Ocasio, 1997), we suggest that with CROs in the TMT, firms can direct organizational attention to risk management and motivate firms to implement comprehensive risk management initiatives. Our study thus echoes previous studies that creating TMT positions can deliver strategic intent to internal and external stakeholders (Fu *et al.*, 2020), which improves operations strategically.

6.1.2 Power and Context for CRO Effectiveness

We delve into the nuance of CROs and highlight the importance of CROs' power that determines the effectiveness of CRO appointments. The results indicate that the impact of CRO appointments on operational efficiency is greater when the CRO has stronger power in the organization. From the ABV, the power dynamic within the organization is an important determinant of the distribution of organizational attention (Tuggle *et al.*, 2010a). CROs lacking the power to influence other TMT members might fail to channel organizational attention to risk issues and dilute the effectiveness of CRO appointments. The variation in CROs' power also explains the inconclusive empirical results regarding the outcomes of CRO appointments.

Our findings suggest that CROs who occupy a higher position in the organizational hierarchy may better coordinate the risk management initiatives and resolve the conflicts between different functional areas; this may create a cross-functional integration effect that facilitates the implementation of integrated approaches to risk management. In particular, CROs who are among the top few executives are more likely to reduce the goal conflicts between risk control and efficiency and have a wider range of influence and authority to develop strategic, organization-wide risk initiatives, leading to more significant benefits.

Our results indicate that the litigation threat of the industry is a critical boundary condition for risk management initiatives. Litigation threat represents the level of uncertainty in the external legal and regulatory environment that gives rise to the vulnerability perception of managers (Koh *et al.*, 2014; Wu *et al.*, 2020). From the ABV (Ocasio, 1997), we suggest that litigation threat is an important environmental factor that affects the attention allocation within the organization. For firms operating in high litigation risk industries, TMT members are more likely to be convinced of the importance of risk management. As a result, firms should be more proactive in creating insurance mechanisms, such as corporate social responsibility (Koh *et al.*, 2014) and internal governances (Wu *et al.*, 2020), to mitigate the potential operational disruptions. Consistent with these studies, we suggest that the litigation threat provides a legitimate environment for CROs to drive TMT attention toward risk control. The results indicate that firms under high industry litigation threats improve operational efficiency to a higher degree after CRO appointments. This supports our argument that a vague, vulnerable environment is the driver behind the complementary effect of risk and efficiency.

Finally, our findings also offer new insights for dealing with dynamic environments. Industry dynamism has been regarded as a major source of firm risk and deterrent to operational efficiency. Unlike previous studies that emphasize the importance of innovation and flexibility in coping with dynamic environments (Ahuja *et al.*, 2013), we suggest that strengthening risk control can bring discipline in operations, which in turn, improves firms' adaptability to dynamic markets. Our results indicate that firms can achieve higher operational efficiency through CRO appointments in a more volatile environment. Strategic risk management motivates firms to frequently scan their external environment to identify opportunities and threats (Clarke & Varma, 1999). With CROs in the TMT and their duties to understand external risks, firms are more likely to proactively assess the changing market environment, identify risk factors, and look for new possibilities. Firms thus are in a better position to discover and seize market opportunities and improve efficiency.

6.2 Managerial Implications

Organizations have been hesitating to invest in risk management initiatives not only because of limited empirical evidence showing the benefits of these initiatives, such as CRO appointments, but also due to the ambiguous nature of both firm risk and operational efficiency. Our study provides important implications to managers as we demonstrate that both risk reduction and efficiency enhancement can co-exist with strategic risk management. Hopefully, this will motivate more organizations to design, develop, and implement a proactive, holistic risk management framework to well prepare for any kind of operational disruptions. We provide a self-assessed guideline for those organizations that are planning to appoint CROs in their TMT. In particular, it is important that CROs be appointed at a high hierarchical level in the organization and given more general, high-level responsibilities to ensure organization-wide risk management initiatives. Firms operating in an industry with high legal and regulatory threats and/or dynamism should consider appointing CRO more favorably because it can help further improve both firm risk and operational efficiency to a great extent. By contrast, for firms operating under a stable environment with low litigation threat, relatively fewer opportunities can be identified through CRO appointments, and process controls through risk management may lead to fewer benefits but more bureaucracies.

7. Conclusions and Limitations

CRO positions have been created for more than 20 years. However, the outcomes of CRO appointments remain inconclusive. This paper examines how CRO appointments affect firm risk and operational efficiency as well as the moderating effect of CROs' power and environmental factors, including industry litigation threat and industry dynamism. We find that firms can achieve reduction in firm risk and improvement in operational efficiency simultaneously through CRO appointments. Besides, the benefits of CRO appointments are more prominent for more powerful CROs and in more litigious and dynamic industries.

This study has several limitations that offer opportunities for further investigation. First, due to limited data availability in private companies, we focused only on public firms. As the risk and efficiency implications of CRO appointments could be different between public and private firms, our results cannot be generalized to both types. Specifically, public firms are more heavily regulated and widely scrutinized by different stakeholders, probably making CRO appointments more important. Second, firms operating in other countries, especially in developing countries, might face quite different litigation threats and regulatory environments, making it interesting to explore the impact of CRO appointments on firms in these countries.

Finally, the occurrence of large-scale disruptions (e.g., the COVID-19 pandemic) would probably attract organizational members' attention to strategic risk management and motivate them to appoint CROs in their TMT. We could extend this research by benchmarking the benefits of CRO appointments before and after the COVID-19 pandemic. Moreover, we could compare the performance outcomes of those firms with and without CRO positions.

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Figures and Tables

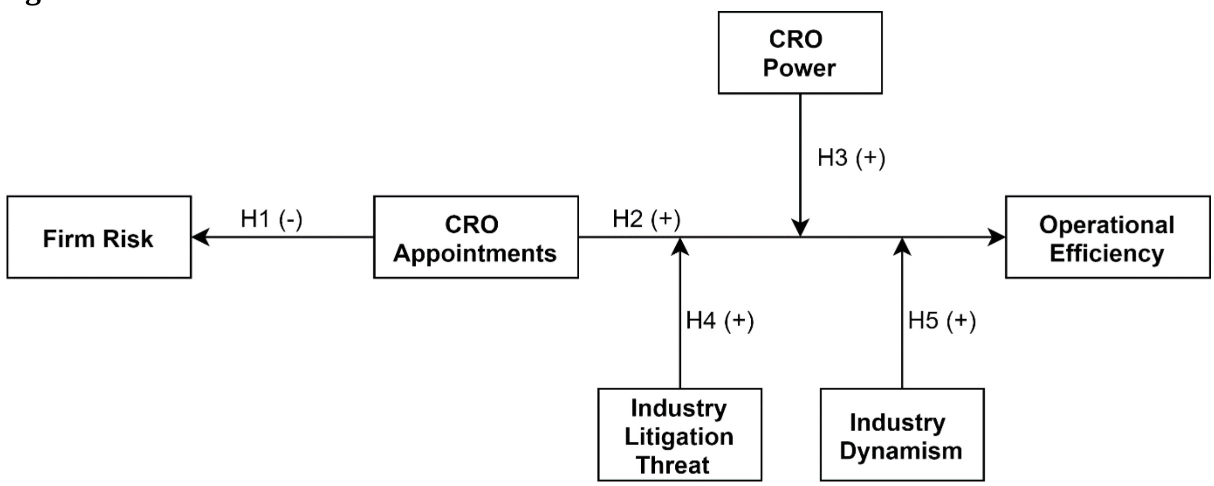

Figure 1. Conceptual model

Table 1. A summary of chief risk officer research

Articles	Aspects of CRO	Sample	Findings
		Antecedents of CRO appointments	
Liebenberg and Hoyt (2003) – RMIR (Vol. 6, No. 1)	CRO as an indicator of ERM adoption.	26 publicly traded firms in the U.S. from 1997-2001.	• Firms with a higher level of financial leverage are more likely to appoint CROs to reduce information asymmetry within the organization regarding their risk profile.
Pagach and Warr (2011) – JRI (Vol. 78, No. 1)	CRO as an indicator of ERM adoption.	138 publicly traded firms from 1992-2005.	• Larger firms, firms with volatile stock prices, and firms with greater institutional ownership have a higher propensity to appoint CROs.
Lin *et al.* (2012) – NAAJ (Vol. 16, No. 1)	CRO as an indicator of ERM adoption.	85 publicly traded PC insurance companies in the U.S. from 2000–2007	• Insurance companies that purchase more reinsurance and are geographically dispersed are more likely to adopt ERM for risk control.
		Outcomes of CRO appointments	
Supportive results			
Hoyt and Liebenberg (2011) – JRI (Vol. 78, No. 4)	CRO as an indicator of ERM adoption.	117 U.S. listed insurance firms from 1995-2005.	• The use of ERM has a positive impact on firm value (measured by Tobin's Q).
Ellul and Yerramilli (2013) – JF (Vol. 68, No. 5)	CRO power as a part of risk management index (RMI)	72 U.S. listed bank holding companies from 1995 to 2010.	• Before the financial crisis years, banks with a higher RMI tend to have lower tail risk and nonperforming loans. • During the financial crisis years, banks with a higher RMI tend to have a higher stock return performance.
Eckles *et al.* (2014) – JBF (Vol. 49)	CRO as an indicator of ERM adoption.	69 U.S. listed insurance firms from 1990-2008.	• The adoption of ERM reduces stock return volatility. • The adoption of ERM is positively related to the operating profits per unit of risk.
Florio and Leoni (2017) – BAR (Vol. 49, No. 1)	CRO as a part of ERM components.	32 non-finance listed firms with CROs and many others in Italy from 2011-2013.	• Firms with more sophisticated ERM systems have higher financial performance and market evaluation. • The appointment of internal control and risk officer and committee has a positive impact on firm value (measured by Tobin's Q).
Berry-Stölzle and Xu (2018) – JRI (Vol. 85, No. 1)	CRO as an indicator of ERM adoption.	250 U.S. listed insurance firms from 1996-2012.	• The adoption of ERM could reduce the firm's capital costs.
Bailey (2019) – JAAF (in press)	CRO expertise	196 firm-year observations of U.S. listed insurance firms from 2006 to 2012.	• CROs with supervisory and industry expertise and CROs with MBA degrees are associated with higher ERM quality. • CRO expertise is positively associated with the ROA of the firm.

Table 1 (Continued). A summary of chief risk officer research

Articles	Aspects of CRO	Sample	Findings
Non-supportive results			
Beasley *et al.* (2008) – JAAF (Vol. 23, No. 3)	CRO as an indicator of ERM adoption.	120 listed firms across all industries in the U.S. from 1992 to 2003.	• The effect of CRO appointments on firm value (measured by cumulative abnormal return) is insignificant and is determined by firm characteristics. • For non-financial firms, the cumulative abnormal return caused by CRO appointments is positively related to stock price volatility and firm size but negatively related to financial leverage.
Gupta *et al.* (2012) – GPRI (Vol. 37, No. 1)	Shareholder response to CRO appointments	73 listed firms across all industries from 1999 to 2009.	• The effect of CRO appointments on firm value (measured by cumulative abnormal return) is insignificant. • Firms with a weak governance structure are more likely to receive a positive evaluation from shareholders.
Lin *et al.* (2012) – NAAJ (Vol. 16, No. 1)	CRO as an indicator of ERM adoption.	85 listed insurance companies in the U.S. from 2000–2007.	• The adoption of ERM is negatively related to Tobin's Q and ROA. This is mainly because ERM programs may give rise to opportunity costs and bureaucracy that reduces operational efficiency.
Pernell *et al.* (2017) – ASR (Vol. 82, No. 3)	CRO appointments as antecedents of new derivatives	157 commercial banks included in the S&P 1500 index from 1995 to 2010.	• The appointment of CRO is positively related to the adoption of new derivatives that might lead to more risks. This is because the appointment of CROs might create an "organizational licensing" that makes trading-desk managers reduce self-monitoring of risky behaviors.
Aebi *et al.* (2012) – JBF (Vol. 36, No. 12)	The presence of CRO in TMT	49 listed banks with CROs and others.	• Simply having CRO and risk committee does not affect banks' performance during the global financial crisis. This is because the actual risk governance structure is more important than the symbolic setting of risk management positions. • Banks perform better when their CROs report directly to the board of directors rather than to CEOs.
da Silva *et al.* (2019) – Working paper	The presence of CRO in TMT	91 public insurance firms (with CROs) in the U.S. from 2009 to 2017.	• The presence of CRO in the TMT is negatively related to a firm's Tobin's Q. • The effect of CRO on Tobin's Q depends on CRO incentives. When CROs are included in the compensation committee and provided with equity-based compensation, their presence in the TMT is positively related to Tobin's Q.

Notes: RMIR – Risk Management and Insurance Review; JRI – Journal of Risk and Insurance; NAAJ – North American Actuarial Journal; JF – Journal of Finance; JBF – Journal of Banking & Finance; BAR – The British Accounting Review; JAAF – Journal of Accounting, Auditing & Finance; GPRI – The Geneva Papers on Risk and Insurance-Issues and Practice; ASR – American Sociological Review.

Table 2. Distribution of sample firms' first CRO appointments across years

Year	Frequency	Percentage
2006	35	8.0
2007	28	6.4
2008	48	11.0
2009	41	9.4
2010	41	9.4
2011	34	7.8
2012	54	12.4
2013	40	9.2
2014	37	8.5
2015	35	8.0
2016	42	9.7
All years	435	100

Table 3. Distribution of sample firms across industries

SIC Code	Industry	Frequency	Percentage
60	Depository Institutions	172	39.5
63	Insurance Carriers	57	13.1
61	Non-depository Institutions	26	6.0
73	Business Services	25	5.7
49	Electric, Gas, & Sanitary Services	22	5.1
62	Security & Commodity Brokers	22	5.1
67	Holding & Other Investment Offices	16	3.7
28	Chemical & Allied Products	7	1.6
87	Engineering & Management Services	7	1.6
64	Insurance Agents, Brokers, & Services	6	1.4
20	Food & Kindred Products	5	1.1
37	Transportation Equipment	5	1.1
29	Petroleum & Coal Products	4	0.9
33	Primary Metal Industries	4	0.9
65	Real Estate	4	0.9
Other	Other industries	53	12.2
Total	All industries	435	100

Table 4. Variable measurements

Variables	Measurements	Data Sources	References
	Panel A: Performance Variables		
Firm Risk	The annualized standard deviation of a firm's daily stock returns.	CRSP	Lam (2018)
Operational Efficiency	A firm's efficiency (relative to its industry peers with the same four-digit SIC code) in transforming operational inputs (i.e., EMP, CGS, and CEX) into operational output (i.e., OI) based on stochastic frontier estimation	Compustat	Li *et al.* (2010)
	Panel B: Hypothesized Variables		
CRO Power	The first principal component extracted from the PCA of three power variables including CRO Executive (whether the CRO is an executive officer), CRO Top5 (whether the CRO is among the five highest-paid employees), and CRO Centrality (CRO's total compensation divided by CEO's total compensation)	SEC EDGAR	Ellul and Yerramilli (2013)
Industry Litigation Threat	The number of lawsuits filed each year against firms in an industry (four-digit SIC code) divided by the number of firms in the same industry	Audit Analytics	Arena (2018)
Industry Dynamism	The standard deviation of quarterly industry sales (based on four-digit SIC code) in a year, divided by the average quarterly industry sales in the same year	Compustat	Chang and Cho (2017)
	Panel C: Control Variables		
CRO Gender	Code 1 for female CROs and 0 otherwise	Factiva	Wowak *et al.* (2021)
Internal Promotion	Code 1 for CROs promoted internally and 0 otherwise	Factiva	Bailey (2019)
Board Size	The number of board members	BoardEx	Aebi *et al.* (2012)
Board Gender Diversity	The percentage of female board members	BoardEx	Wowak *et al.* (2021)
Board Experience Diversity	The standard deviation of board members' numbers of years served on the board	BoardEx	Harjoto *et al.* (2015)
Firm Size	A firm's total assets based on a logarithmic transformation	Compustat	Li *et al.* (2010)
Firm Profitability	A firm's returns on assets	Compustat	Lam *et al.* (2016)
Firm Leverage	A firm's total debt divided by total assets	Compustat	Yiu *et al.* (2020)
Market-to-Book Ratio	A firm's market value of equity divided by book value of equity	Compustat	Hendricks *et al.* (2015)
Earnings Volatility	The standard deviation of a firm's quarterly earnings in a year divided by its average quarterly earnings in the same year	Compustat	Liebenberg and Hoyt (2003)
CEO Duality	Code 1 if a firm's CEO is also the president or chair of the board and 0 otherwise	BoardEx	Naiker and Sharma (2009)
Institutional Ownership	The percentage of a firm's stock held by institutional investors	Thomson Reuters	Pagach and Warr (2011)
Industry Competition	One minus the sum of the squares of each firm's market share in the same industry (four-digit SIC code)	Compustat	Chang and Cho (2017)

Table 4 (continued). Variable measurements

Variables	Measurements	Data Sources	References
Financial Industries	Code 1 for financial industries (two-digit SIC codes = 60, 61, 62, 63, 64, 65, and 67) and 0 for other industries	Compustat	Black and Neururer (2020)
Polluting Industries	Code 1 for the 20 most polluting industries in the U.S. (two-digit SIC codes = 10, 50, 33, 49, 28, 36, 12, 13, 20, 32, 30, 51, 26, 34, 29, 31, 35, 37, 24, and 27) and 0 for other industries	Compustat	Berrone *et al.* (2013)
Economic Policy Uncertainty	Average of the monthly economic policy uncertainty index developed by Baker *et al.* (2016) in each year	policyuncertainty.com	Chang and Cho (2017)
ERM Tool	Code 1 if a firm has adopted ERM-related tools or systems before its CRO appointment and 0 otherwise	Factiva	Berry-Stölzle and Xu (2018)
CXO Appointments	Code 1 if a firm has appointed chief compliance officer or chief supply chain officer before its CRO appointment and 0 otherwise	Factiva	Roh *et al.* (2016)

Table 5. Probit regression for propensity score matching

Variables	Model 1 (Pre-Matching)	Model 2 (Post-Matching)
Firm Size	0.160*** (0.010)	-0.005 (0.021)
Firm Profitability	-0.299* (0.162)	0.642 (0.409)
Firm Leverage	-0.347*** (0.098)	0.153 (0.226)
Market-to-Book Ratio	0.001 (0.003)	-0.003 (0.006)
Earnings Volatility	0.001 (0.009)	0.027 (0.022)
Institutional Ownership	0.280*** (0.057)	-0.168 (0.135)
Industry Litigation Threat	0.007 (0.016)	0.020 (0.037)
Industry Dynamism	0.235 (0.237)	-0.332 (0.638)
Industry Competition	0.043 (0.124)	0.132 (0.330)
Polluting Industries	-0.133** (0.062)	0.088 (0.169)
Financial Industries	0.611*** (0.055)	0.056 (0.142)
Intercept	-4.192*** (0.193)	0.040 (0.477)
Year dummies	Included	Included
Number of sample firms	361	361
Number of control firms	13069	361
Total number of firms	13430	722
Pseudo *R*-squared	0.187	0.009
LR chi squared	869.62***	9.42

Notes: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels, respectively (two-tailed tests). Standard errors are in parentheses.

Table 6. Differences between sample and control firms

Panel A: Pre-Matching			
Variables	Mean difference between sample and control firms	*t*-statistic	*p*-value
Firm Size	3.147	22.34	0.000***
Firm Profitability	0.116	6.78	0.000***
Firm Leverage	-0.158	-2.77	0.006***
Market-to-Book Ratio	-0.325	-0.44	0.660
Earnings Volatility	0.246	1.91	0.056*
Institutional Ownership	0.182	9.94	0.000***
Industry Litigation Threat	0.395	6.40	0.000***
Industry Dynamism	0.019	3.51	0.000***
Industry Competition	0.070	7.07	0.000***
Polluting Industries	-0.325	-12.35	0.000***
Financial Industries	0.507	24.97	0.000***
Panel B: Post-Matching			
Variables	Mean difference between sample and control firms	*t*-statistic	*p*-value
Firm Size	0.047	0.26	0.796
Firm Profitability	0.012	1.27	0.203
Firm Leverage	0.007	0.43	0.669
Market-to-Book Ratio	-0.257	-0.44	0.660
Earnings Volatility	0.172	1.08	0.280
Institutional Ownership	-0.026	-0.94	0.350
Industry Litigation Threat	0.075	0.70	0.482
Industry Dynamism	-0.003	-0.47	0.640
Industry Competition	0.001	0.10	0.923
Polluting Industries	0.008	0.31	0.756
Financial Industries	0.011	0.32	0.750

Notes: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels, respectively (two-tailed tests).

Table 7. Abnormal change in firm performance

Variables	Years	*N*	Abnormal Change	*t*-statistic	*p*-value
Firm Risk	*t-1* to *t*	359	-0.100	-0.861	0.390
Firm Risk	*t-1* to *t+1*	339	-0.326	-3.018	0.003***
Firm Risk	*t-1* to *t+2*	328	-0.213	-1.691	0.092*
Firm Risk	*t-1* to *t+3*	313	-0.216	-2.405	0.017**
Operational Efficiency	*t-1* to *t*	273	0.014	1.252	0.212
Operational Efficiency	*t-1* to *t+1*	248	0.036	3.165	0.002***
Operational Efficiency	*t-1* to *t+2*	245	0.035	2.628	0.010**
Operational Efficiency	*t-1* to *t+3*	238	0.029	1.991	0.048**

Notes: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels, respectively (two-tailed tests); CRO appointments are made in year *t* and propensity score matching is performed in year *t-1*.

Table 8. Correlations and descriptive statistics

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Abnormal Change in Operational Efficiency	1.00										
2. CRO Power	0.17	1.00									
3. Industry Litigation Threat	0.06	-0.13	1.00								
4. Industry Dynamism	0.11	0.04	-0.15	1.00							
5. CRO Gender	0.04	0.01	-0.02	0.02	1.00						
6. Internal Promotion	0.14	-0.03	0.03	-0.07	0.11	1.00					
7. CEO Duality	0.00	0.07	0.08	-0.07	0.02	-0.04	1.00				
8. Board Gender Diversity	0.15	-0.01	0.08	0.07	0.05	0.05	0.07	1.00			
9. Board Experience Diversity	-0.10	-0.09	-0.02	0.10	0.08	0.02	0.06	-0.06	1.00		
10. Board Size	-0.05	-0.08	0.15	0.29	-0.07	0.04	0.03	0.24	0.08	1.00	
11. Institutional Ownership	-0.03	0.07	-0.01	0.01	0.02	0.07	0.04	0.08	0.09	-0.12	1.00
12. ERM Tool	0.15	-0.09	0.02	-0.10	-0.01	-0.01	-0.08	0.05	-0.08	0.10	-0.03
13. CXO Appointments	0.06	-0.06	0.10	-0.15	-0.02	0.14	0.07	0.16	0.09	0.05	0.15
14. Firm Size	0.02	-0.14	0.28	0.03	-0.04	0.02	0.10	0.27	-0.01	0.63	0.01
15. Firm Profitability	-0.13	-0.02	0.21	-0.37	-0.02	-0.01	0.14	0.00	0.01	-0.24	0.15
16. Firm Leverage	-0.02	-0.05	0.20	-0.37	-0.02	0.11	0.10	0.02	-0.08	-0.07	0.00
17. Market-to-Book Ratio	0.00	0.08	-0.08	-0.04	0.11	-0.08	0.05	0.06	-0.04	-0.01	-0.09
18. Earnings Volatility	0.10	0.12	-0.09	0.06	-0.06	0.08	-0.01	0.12	-0.04	0.04	0.06
19. Industry Competition	0.04	0.09	-0.09	0.52	-0.02	-0.11	-0.10	0.05	-0.02	0.33	-0.12
20. Financial Industries	0.08	0.03	-0.10	0.42	0.05	-0.12	-0.14	-0.04	-0.06	0.18	-0.17
21. Polluting Industries	-0.01	-0.03	-0.07	-0.30	-0.08	0.19	0.19	0.09	0.02	-0.03	0.09
22. Economic Policy Uncertainty	-0.07	0.00	-0.09	-0.03	0.03	-0.03	-0.13	-0.10	-0.10	-0.07	0.11
Mean	0.03	-0.03	0.48	0.58	0.26	0.62	0.44	0.13	5.34	10.97	0.50
Standard Deviation	0.16	1.00	0.97	0.08	0.44	0.49	0.50	0.08	3.05	2.99	0.34

Variables	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
12. ERM Tool	1.00										
13. CXO Appointments	0.06	1.00									
14. Firm Size	0.18	0.13	1.00								
15. Firm Profitability	-0.08	0.18	-0.25	1.00							
16. Firm Leverage	-0.09	0.15	0.18	0.16	1.00						
17. Market-to-Book Ratio	-0.04	0.09	-0.04	0.09	-0.06	1.00					
18. Earnings Volatility	0.01	0.07	-0.02	0.10	-0.09	0.04	1.00				
19. Industry Competition	0.06	-0.33	0.17	-0.43	-0.44	-0.14	0.01	1.00			
20. Financial Industries	0.05	-0.38	0.06	-0.37	-0.38	-0.14	0.07	0.73	1.00		
21. Polluting Industries	-0.13	0.42	0.07	0.14	0.29	0.03	0.02	-0.36	-0.61	1.00	
22. Economic Policy Uncertainty	0.18	0.04	-0.04	-0.02	0.00	-0.17	-0.02	0.06	0.09	-0.02	1.00
Mean	0.17	0.20	8.80	0.06	0.20	1.99	0.28	0.62	0.62	0.19	123.61
Standard Deviation	0.38	0.40	1.97	0.07	0.18	5.53	1.89	0.36	0.49	0.39	31.41

Notes: Correlations with absolute values equal to 0.11 or above are significant at the 0.1 level.

Table 9. Cross-sectional regression results

Variables	Model 1	Model 2	Model 3	Model 4
CRO Power		0.028** (0.011)	0.030*** (0.011)	0.031*** (0.011)
Industry Litigation Threat			0.025** (0.012)	0.026** (0.012)
Industry Dynamism				0.374** (0.171)
Internal Promotion	0.055** (0.025)	0.055** (0.024)	0.051** (0.024)	0.054** (0.024)
ERM Tool	0.072** (0.030)	0.077** (0.030)	0.078*** (0.030)	0.091*** (0.030)
Financial Industries	0.054 (0.041)	0.063 (0.040)	0.071* (0.040)	0.074* (0.040)
Polluting Industries	0.023 (0.039)	0.027 (0.039)	0.044 (0.039)	0.061 (0.040)
CRO Gender	0.008 (0.025)	0.006 (0.025)	0.005 (0.025)	0.004 (0.024)
CEO Duality	0.017 (0.022)	0.011 (0.022)	0.010 (0.022)	0.008 (0.022)
Board Gender Diversity	0.301** (0.145)	0.297** (0.143)	0.295** (0.142)	0.268* (0.141)
Board Experience Diversity	-0.004 (0.004)	-0.003 (0.004)	-0.002 (0.004)	-0.003 (0.004)
Board Size	-0.007 (0.005)	-0.006 (0.005)	-0.006 (0.005)	-0.009* (0.005)
Institutional Ownership	-0.003 (0.034)	-0.009 (0.034)	-0.004 (0.033)	-0.013 (0.033)
CXO Appointments	0.042 (0.031)	0.042 (0.031)	0.038 (0.031)	0.032 (0.031)
Firm Size	-0.002 (0.008)	0.000 (0.008)	-0.003 (0.008)	-0.001 (0.008)
Firm Profitability	-0.207 (0.173)	-0.180 (0.171)	-0.269 (0.176)	-0.177 (0.179)
Firm Leverage	0.032 (0.076)	0.025 (0.075)	0.014 (0.075)	0.029 (0.074)
Market-to-Book Ratio	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)	0.000 (0.002)
Earnings Volatility	0.005 (0.006)	0.003 (0.006)	0.004 (0.006)	0.003 (0.006)
Industry Competition	0.017 (0.052)	-0.002 (0.051)	-0.004 (0.051)	-0.035 (0.053)
Economic Policy Uncertainty	0.001 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)
Intercept	-0.133 (0.128)	-0.135 (0.126)	-0.107 (0.126)	-0.336** (0.163)
Year dummies	Included	Included	Included	Included
N	225	225	225	225
F-test	1.75**	1.96***	2.06***	2.19***
R-squared	0.200	0.226	0.242	0.260
Adjusted *R*-squared	0.086	0.111	0.125	0.141

Notes: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels, respectively (two-tailed tests). Standard errors are in parentheses.

Table 10. Additional test results

Panel A: Abnormal Performance Change

Model	Years	*N*	Abnormal Change	*t*-statistic	*p*-value
1. Measure firm risk based on idiosyncratic risk	*t-1* to *t+1*	339	-0.201	-2.341	0.020**
2. Measure firm risk based on systematic risk	*t-1* to *t+1*	339	-0.117	-1.414	0.158
3. Measure operational efficiency based on linear model	*t-1* to *t+1*	248	0.032	3.031	0.003***
4. Wilcoxon signed-rank test (firm risk)	*t-1* to *t+1*	339	-0.326	-1.810	0.070*
5. Wilcoxon signed-rank test (operational efficiency)	*t-1* to *t+1*	248	0.036	2.428	0.015**
6. PSM based on three-year average (firm risk)	*t-1* to *t+1*	336	-0.198	-2.060	0.040**
7. PSM based on three-year average (operational efficiency)	*t-1* to *t+1*	247	0.022	1.838	0.067*
8. CRO appointment data from BoardEx (firm risk)	*t-1* to *t+1*	406	-0.199	-2.252	0.024**
9. CRO appointment data from BoardEx (operational efficiency)	*t-1* to *t+1*	319	0.028	2.411	0.016**
10. Change in firm risk before CRO appointments	*t-2* to *t-1*	349	-0.018	-0.128	0.898
11. Change in operational efficiency before CRO appointments	*t-2* to *t-1*	273	-0.008	-0.705	0.481

Panel B: Cross-Sectional Regression Model

Model	CRO Power	Industry Litigation Threat	Industry Dynamism	*N*	Adjusted *R*-squared	*F*-value
1. Measure CRO power based on CRO Executive	0.058** (0.022)	0.026** (0.012)	0.376** (0.172)	225	0.136	2.13***
2. Measure CRO power based on CRO Top5	0.053* (0.031)	0.023* (0.012)	0.340* (0.174)	225	0.119	1.97***
3. Measure CRO power based on CRO Centrality	0.109* (0.062)	0.020* (0.012)	0.414** (0.176)	225	0.120	1.98***
4. Measure CRO power in year *t+1*	0.028** (0.011)	0.026** (0.012)	0.352** (0.172)	225	0.136	2.14***
5. Measure industry litigation threat based on class action lawsuits	0.027** (0.011)	1.050** (0.422)	0.380** (0.171)	225	0.148	2.26***
6. Measure industry dynamism based on annual industry data	0.032*** (0.011)	0.026** (0.012)	0.065* (0.037)	225	0.134	2.11***
7. Include additional control variables	0.032*** (0.011)	0.027** (0.012)	0.381** (0.171)	225	0.142	2.16***
8. Include IMR	0.031*** (0.011)	0.027** (0.012)	0.351* (0.186)	225	0.137	2.11***
9. Use firm risk as dependent variable	-0.172** (0.084)	-0.187** (0.093)	-2.815** (1.214)	292	0.085	1.88***

Panel C: Sub-Sample Analysis

Model	Year	*N*	Abnormal Change	*t*-statistic	*p*-value
1. Financial industries (operational efficiency)	*t-1* to *t+1*	155	0.038	2.496	0.014**
2. Non-financial industries (operational efficiency)	*t-1* to *t+1*	93	0.033	1.951	0.054*
3. Firms with ERM (operational efficiency)	*t-1* to *t+1*	44	0.080	2.566	0.014***
4. Firms without ERM (operational efficiency)	*t-1* to *t+1*	204	0.027	2.211	0.028**

Panel D: Mechanism Exploration

Model	Year	*N*	Abnormal Change	*t*-statistic	*p*-value
1. Cost of goods sold	*t-1* to *t+1*	338	-0.079	-1.773	0.077*
2. Internal control weakness	*t-1* to *t+1*	286	-0.069	-2.946	0.003***
3. Product/service-related disruptions	*t-1* to *t+1*	310	-0.030	-1.766	0.078*

Notes: *, **, and *** indicate significance at 0.1, 0.05, and 0.01 levels, respectively (two-tailed tests). Control variables and year dummies are included in all regression models in Panel B. Standard errors are in parentheses.