The Financial Impacts of Environmental Violations on Supply Chains: Evidence from an Emerging Market

Abstract

Based on 100 environmental violations occurring in China in 2018 and matched supply chain relationship data obtained from Bloomberg, our research shows that environmental violations have negative financial impacts on not only the violators but also their supply chain partners including customers and suppliers. Nevertheless, environmental transparency and supply chain diversity help these supply chain partners mitigate the negative effects arising from the environmental violations. While the mitigating role of environmental transparency is more pronounced for customers than suppliers, supply chain diversity has a similar mitigating effect for both customers and suppliers.

Keywords: environmental violation; emerging market; environmental transparency; supply chain diversity; market value

1. Introduction

Corporate environmental violations are a common phenomenon in emerging markets (Marks, 2010; Van Rooij, 2006; Yee et al., 2014). For instance, a two-month inspection conducted by the Chinese government in 2017 found that more than 13,000 Chinese companies, or 70% of those inspected, violated environmental rules to various extents (BBC News, 2017). Such environmental violations may affect not only the focal firms (e.g., fines and forced facility closures) but also their partners along the supply chains. For example, Schaeffler, a German vehicle manufacturer, faced an estimated loss of 43 billion US dollars due to the environmental violations of its key supplier in China (Sit, 2017). In addition to tangible financial losses, the reputations of these supply chain partners may be impaired as well. In fact, Western companies are often blamed for the environmental violations occurring in their supply chains in emerging markets even though they are not directly involved in the environmental violations (Hoskins, 2017; Chapman, 2018). Some recent examples include major fast fashion brands such as H&M and Zara who were criticized for the polluting viscose production of their suppliers located in developing countries in Asia (Hoskins, 2017). The above anecdotal evidence suggests that it is important for firms to gain a better understanding of how they may be negatively affected by the environmental violations occurring in their supply chains in emerging markets but also how they can mitigate such negative impacts if any.

Environmental violations in emerging markets have attracted researchers' attention in recent years (Zhao et al., 2014; Lo et al., 2018; Wang et al., 2019). Various event studies have been conducted to examine the impacts of firms' environmental violations on their own stock returns in the context of emerging markets (Huang et al., 2017; Lo et al., 2018; Xu et al., 2012; 2016; Wang et al., 2019). Although these studies have shown that violators are punished for their environmental violations in terms of decreased stock returns, less is known about the possible spillover effects of these environmental violations on other parties along the violators' supply chains. An exception is Lo et al.'s (2018) research that investigated the impacts of environmental violations on the stock returns of Chinese firms as well as their oversea customers. However, Lo et al. (2018) did not examine how environmental violations may also affect the violators' suppliers. The lack of research focusing on the spillover effects from a

focal firm to its upstream supply chain is reflected in other studies beyond environmental violations (Hendricks et al., 2020; Nichols et al., 2019). Therefore, how firms' environmental violations affect their upstream suppliers remains an empirical research question. Moreover, although Lo et al. (2018) revealed some factors that help mitigate the negative impacts arising from environmental violations, these factors are concerned with the violators rather than their supply chain partners. This suggests that little is known about how supply chain partners (not the violators) can protect themselves from the environmental violations.

Indeed, although the anecdotal evidence does suggest that a firm's environmental violations should have negative impacts on its supply chain partners (Hoskins, 2017; Sit, 2017), such impacts may vary across different supply chain partners. For instance, firms that are more transparent in disclosing environmental information may be perceived as more trustworthy, protecting them against the environmental violations occurring in their supply chains (Fennis and Stroebe, 2014; Lin et al., 2017). By contrast, firms that rely more on a small number of supply chain partners may be less flexible in switching partners, making it more difficult for them to prevent operational disruptions when environmental violations occur in supply chains (Gupta et al., 2015; Thomé et al., 2014). Therefore, it is worth investigating how environmental transparency and supply chain diversity may help a firm mitigate the negative impacts of environmental violations occurring in its supply chains. However, the mitigating roles of environmental transparency and supply chain diversity may function differently in a violator's upstream and downstream supply chains. For instance, environmental transparency may play a more important mitigating role for the violator's customers (than suppliers) as these customers are more visible and closer to end consumers and the public. Therefore, it should be interesting to compare the differences between the violator's customers and suppliers. Taken together, this study aims to answer the following questions.

1. How do firms' environmental violations affect their supply chain partners including suppliers and customers?
2. How do the impacts of environmental violations vary across supply chain partners with different levels of environmental transparency and supply chain diversity?
3. How do environmental transparency and supply chain diversity benefit the violators'

suppliers and customers differently?

Based on 100 environmental violations occurring in China in 2018 and matched supply chain relationship data obtained from Bloomberg, our event study results show that environmental violations do have negative impacts on not only the violators but also their supply chain partners in terms of decreased stock returns. In particular, the average stock returns of these supply chain partners drop by 0.93% over six days following the environmental violations, representing a loss of 270 million US dollars in market value. Our research thus demonstrates the negative spillover effects of environmental violations in supply chains. Moreover, our regression analysis further shows that the impacts of environmental violations on supply chain partners are less negative if those supply chain partners are more transparent in disclosing environmental information and running more diversified supply chains. These findings suggest that environmental transparency and supply chain diversity can help firms mitigate the negative spillover effects of environmental violations occurring in their supply chains. Our research also compares the differences between customers and suppliers. Although both customers and suppliers experience negative spillover effects due to the environmental violations, the mitigating role of environmental transparency is more pronounced for customers than suppliers. Nevertheless, supply chain diversity has a similar mitigating effect for both customers and suppliers.

Our research makes several important contributions. First, we contribute to the emerging literature on the spillover effects in supply chains. Although prior research has investigated the spillover effects of environmental violations on customers (Lo et al., 2018), it is unclear how these violations may also affect suppliers. Our research, based on matched buyer-supplier relationships obtained from Bloomberg, considers environmental violations' spillover effects on both customers and suppliers. This investigation direction provides a more comprehensive view on the spillover effects in supply chains and might inspire researchers to further explore the impacts of environmental violations on other parties along the violators' supply chains. The negative spillover effects on both customers and suppliers as documented in our research also remind firms of the importance of addressing environmental issues in upstream as well as downstream supply chains. In addition to the direct impacts of environmental violations, we

further investigate how the impacts of environmental violations vary across supply chain partners with different levels of environmental transparency and supply chain diversity. This investigation provides new insights into the roles that environmental transparency and supply chain diversity play in the context of environmental violations. The findings also provide important implications for firms to better manage the negative effects resulting from the environmental violations occurring in their supply chains. Finally, we compare the differences between customers and suppliers in terms of the spillover effects of environmental violations as well as the mitigating roles of environmental transparency and supply chain diversity. The comparison advances our understanding of the possible interplay among environmental violations, supply chain positions, and mitigation strategies.

2. Hypothesis Development

2.1 The Impacts of Environmental Violations on Supply Chain Partners' Stock Returns

In line with prior studies (e.g., Chiou et al., 2011; Melnyk et al., 2003; Porteous et al., 2015), we define environmental violations as the failure of firms' activities to comply with environmental laws and regulations formulated by government bodies, thereby resulting in an inability to satisfy core responsibilities in relation to environmental sustainability. The increasing number of environmental violations in emerging markets has attracted researchers' attention in recent years. Researchers in operations management and other disciplines have adopted various approaches such as case study, survey, and modeling to study both the antecedents and consequences of environmental violations in emerging markets (Zhao et al., 2014; Economy and Lieberthal, 2007; Priyadarshini and Gupta, 2003; Marquis et al., 2011; Lo et al., 2018; Xu et al., 2012; 2016; Wang et al., 2019; Zhou et al., 2016; Choi, 2019; Chan et al., 2018). For instance, prior research has suggested that greater emphasis on economic development, lax enforcement of environmental regulations, inadequate supervisory mechanisms, and low opportunity costs and penalties make environmental violations more frequent in emerging markets compared with that in developed countries (Economy and Lieberthal, 2007; Priyadarshini and Gupta, 2003; Zhao et al., 2014; Marquis et al., 2011). Researchers have also investigated the impacts of environmental violations on focal firms in

terms of reputational penalties and decreased stock returns (Karpoff et al., 2005; Wang et al., 2019; Lo et al., 2018). In particular, prior research has adopted the event study methodology to quantify how firms' environmental violations affect their stock returns, a proxy for overall firm value that better captures both the tangible (e.g., financial penalties) and intangible (e.g., reputational damages) impacts of the environmental violations (Dasgupta et al., 2001; Huang et al., 2017; Wang et al., 2019; Lo et al., 2018). For example, Wang et al. (2019) investigated 145 environmental pollution events occurring in China from 2008 to 2015 and found that these events have significant negative impacts on the stock returns of the Chinese firms concerned. Similarly, Lo et al. (2018) examined 618 environmental incidents of Chinese manufacturing firms occurring between 2006 and 2013 and showed that Chinese investors react negatively to the announcements of environmental incidents.

Although prior research has focused on the negative impacts of environmental violations on the violating firms, these environmental violations may have negative spillover effects along the violators' supply chains. The concept of spillover effects denotes "the extent to which information provided in messages changes beliefs about attributes that are not mentioned in the messages" (Ahluwalia et al., 2001, p. 458). In other words, the spillover effects emphasize that when an event reshapes the circumstances of one company, it can have a collateral impact on other businesses that are not directly related to or responsible for the event (Balachander and Ghose, 2003). Recently, operations management researchers have started to investigate the spillover effects in supply chains, especially in downstream supply chains (Hendricks et al., 2020; Lo et al., 2018; Nichols et al., 2019). For instance, Nichols et al. (2019) investigated the spillover effects of firms' supply chain news on consumers' perceptions of the firms' product quality, while Hendricks et al. (2020) examined how the meltdown of the Fukushima nuclear plant during the 2011 Great East Japan Earthquake induced spillover effects on other nuclear plants located in different countries.

Consistent with these prior studies, we employ the logic of spillover effects to investigate how firms' environmental violations affect other parties along their supply chains such as customers and suppliers. First, from an operations management perspective, environmental violations increase the possibility of disrupting operations among supply chain partners. For

example, governments in emerging markets such as China and Brazil have forced the closure of thousands of companies in widespread crackdown on pollution (Nace, 2017; Bloomberg Environment Report, 2019). Such closures and other disruptions of the violators' facilities have negative implications for their customers and suppliers. For example, environmental violations can make the violators incapable of supplying goods or providing services to their customers, disrupting the customers' operations and resulting in lost sales for these customers. Similarly, environmental violations can reduce the violators' demand for goods and services, preventing their suppliers from selling products to the violators and creating elevated inventory issues and allied operating costs for these suppliers. Some anecdotal evidence supports this operations disruption view. For example, in 2017, the closure of Schaeffler's key supplier in China due to environmental violations disrupted Schaeffler's operations and prevented "3m vehicles from rolling off the lines as planned, with an estimated economic impact of US$43bn" (Sit, 2017). Therefore, environmental violations disrupt operations for not only the violators but also their supply chain partners including customers and suppliers.

Environmental violations may not only disrupt supply chain partners' operations physically but also impair their reputations intangibly. Kumar et al. (2019) posited that firms' reputations are derived from the combination of the individual reputations of partners throughout the whole supply chain. They further demonstrated that misconduct associated with a focal firm has a significant negative impact on its buyer's reputation. Prior research has also documented the positive contagion of reputation from buyers to suppliers, suggesting that a supplier's reputation is dependent on the reputations of its customers as well (Lange et al., 2011; Reuber and Fischer, 2005). For example, being a supplier of Apple Inc., the world's most admired company based on *Fortune* magazine's rankings in the past 13 years (Fortune, 2020), is commonly seen as "a badge of prestige" (Bradshaw, 2017). Therefore, we expect environmental violations to affect not only the violators' reputations but also that of their supply chain partners, although these supply chain partners may be not directly involved in the environmental violations concerned but they are closely linked to the violators through supply chain relationships (Lin-Hi et al., 2015; Nichols et al., 2019). This spillover effect also explains why retailers in developed countries are often criticized and blamed for the environmental

violations of their suppliers in emerging markets even though these retailers may not take part in the environmental violations directly (Hoskins, 2017; Chapman, 2018). For instance, fast fashion brands such as H&M and Zara came under heavy criticism following the allegation that their suppliers' viscose production in China, India, and Indonesia resulted in severe environmental damage (Hoskins, 2017).

Taken together, we expect environmental violations to induce negative spillover effects in supply chains through disrupting operations and impairing reputations, which lead to both tangible (e.g., financial penalties and lost sales) and intangible (e.g., reputational damage and customer dissatisfaction) impacts. As traditional performance indicators such as sales, costs, and profits are less likely to capture both the tangible and intangible impacts, we follow prior research (e.g., Huang et al., 2017; Lo et al., 2018; Wang et al., 2019) by employing the event study methodology to quantify such impacts in terms of stock returns, which take "both tangible and intangible components into account" (Lam et al., 2019, p. 6). For example, in their event study on e-commerce initiatives, Dehning et al. (2004, p. 57) made it explicit that stock returns measure "both tangible and intangible benefits from e-commerce initiatives, not just the tangible outcomes generally recorded in accounting measures of assets or profits." This is because, based on the efficient market hypothesis (Fama, 1970), the changes in stock returns around an event such as environmental violation represent investors' assessment of the overall impacts (tangible and intangible) due to the event, in view of all information available on the markets. As a result, we propose the following hypothesis.

H1. Environmental violations have negative impacts on the stock returns of supply chain partners.

2.2 The Roles of Environmental Transparency and Supply Chain Diversity

Although we expect environmental violations to induce negative spillover effects in supply chains, the magnitude of such effects may vary across different supply chain partners. In particular, as we have argued that environmental violations will impair the reputations of supply chain partners due to their linkages to the violators, those supply chain partners who are more transparent in disclosing environmental information are perceived as more trustworthy

and their reputations may be less affected by the environmental violations (Jahansoozi, 2006; Poppo and Schepker, 2010). Similarly, as we have anticipated that environmental violations will also disrupt supply chain partners' operations, those supply chain partners running more diversified supply chains are more flexible in supply chain management and may be more capable of coping with the disruptions resulting from the environmental violations (Martínez Sánchez and Pérez Pérez, 2005; Thomé et al., 2014). Therefore, we further investigate how the impacts of environmental violations are different for supply chain partners with different levels of environmental transparency and supply chain diversity.

We first consider the role of environmental transparency. Corporate transparency, in general, signifies the extent to which firm-specific information is publicly visible (Bushman et al., 2004). It indicates whether a firm makes its information accessible and available to its stakeholders in a clear and accurate manner (Granados et al., 2010; Zhu, 2004; Schnackenberg and Tomlinson, 2016). Consistent with these studies, we view a firm's environmental transparency as the extent to which it makes the environmental information about its operations and supply chains, whether positive or negative, publicly available and accessible to its stakeholders including investors. As firms' reputations are expected to be impaired by environmental violations occurring in supply chains due to the spillover effects as discussed above, being more transparent in disclosing environmental information may help protect firms against such spillover effects. This is because, as the literature on corporate transparency has suggested, a firm with a high level of transparency signals its honesty and accountability to stakeholders, improving their trustworthiness in the firm, especially when negative events occur (Jahansoozi, 2006; Poppo and Schepker, 2010).

The buffering role of environmental transparency should be even more crucial for supply chains in emerging markets, in which information is less transparent and supply chain activities are more distant from investors (Zhang et al., 2016). As a result, investors may have to rely on a firm's environmental transparency to make sense of whether they can trust in the firm when environmental violations occur in its supply chains. Firms with high levels of environmental transparency can demonstrate their accountability and honesty for the environmental violations occurring in supply chains, lessening investors' concerns and leading to less negative investors'

reactions. Empirically, previous research has demonstrated that more transparent companies suffer less from their environmental violations (Fennis and Stroebe, 2014; Reimsbach and Hahn, 2015). Our research further extends this notion by arguing that environmental transparency also helps protect firms against the environmental violations occurring in their supply chains. Hence, we develop the following hypothesis.

H2. The impacts of environmental violations on supply chain partners' stock returns are less negative if these supply chain partners have a high level of environmental transparency.

While environmental transparency helps firms alleviate the potential impairment of reputation due to environmental violations occurring in supply chains, supply chain diversity enables firms to reduce the possible disruption of operations resulting from such violations, which can also mitigate the negative spillover effects. Consistent with prior research, we view supply chain diversity as a diversification strategy adopted by a firm to source from a wide range of suppliers and to sell to different customers (Adobor and McMullen, 2007; Flynn and Flynn, 1999; Sousa and Voss, 2007). A high level of supply chain diversity can help mitigate the negative spillover effects due to its capability of reducing a firm's overdependence on a single supply chain partner but also increasing its flexibility in managing supply chains (Federgruen and Yang, 2009; Hendricks et al., 2009). First, a firm with a wide range of suppliers and customers should be less likely to rely on a single supplier or customer (Gupta et al., 2015). As a result, when an environmental violation occurs in one of the firm's suppliers or customers and even the violation disrupts the operations of that particular supplier or customer (e.g., plant closure), it may not affect this firm greatly due to the low dependence on that supplier or customer. It is also relatively easy for this firm to identify replacement suppliers or alternative customers in its diversified supply chain to fill the void in material supply or product selling.

Moreover, a high level of supply chain diversity implies a more flexible supply chain, enabling the firm to implement a prompter reaction to unexpected market changes or to the unpredictable consequences arising from the environmental violation (Martínez Sánchez and Pérez Pérez, 2005; Thomé et al., 2014). Unanticipated environmental violations generate

excessive volatility in demand and significant unforeseen costs, for example, in terms of shipping lead times (Wu et al., 2007). Consequently, a high level of supply chain flexibility is preferable as it enables a firm to increase its procurement and distribution ranges to better respond to the unexpected events and effectively synchronize supply and demand (Swafford et al., 2006). This argument is consistent with researchers' observation that diversified supply chains permit firms to reduce risks and uncertainties, not least when unstable market conditions prevail (Anupindi and Akella, 1993; Chod et al., 2019; Swaminathan and Shanthikumar, 1999). Taken together, we expect firms with more diversified supply chains to better address the possible disruption of operations resulting from the environmental violations, leading to less negative spillover effects. Therefore, we develop the following hypothesis.

H3. The impacts of environmental violations on supply chain partners' stock returns are less negative if these supply chain partners have a high level of supply chain diversity.

2.3 The Differences between Customers and Suppliers

Although we expect environmental violations to induce negative spillover effects on supply chain partners by impairing their reputations and disrupting their operations, such reputation impairment and operations disruption may work differently for customers and suppliers. For example, anecdotal evidence suggests that environmental violations and other negative events are more likely to affect the reputations of customer firms facing end consumers and the public (Hoskins, 2017; Chapman, 2018). In the above hypothesis development, we have proposed that environmental transparency and supply chain diversity help firms mitigate the negative spillover effects. Due to the possible differences in the reputation impairment and operations disruption for customers and suppliers, environmental transparency and supply chain diversity may also play different mitigating roles for customers and suppliers. As a result, we further investigate how the mitigating roles of environmental transparency and supply chain diversity differ for the violators' customers and suppliers.

We first focus on the role of environmental transparency. There is no doubt that news media and the public often blame downstream firms such as retailers for the environmental violations occurring in their upstream supply chains (Hoskins, 2017; Chapman, 2018).

However, it is less common that upstream firms such as manufacturers are criticized for the environmental violations occurring in their downstream supply chains. Researchers have also made similar observations, focusing on the negative reputation spillover from suppliers to customers, rather than the reverse (Nichols et al., 2019; Kumar et al., 2019). Although anecdotal evidence and prior research have also shown the positive reputation contagion from customers to suppliers (Bradshaw, 2017; Reuber and Fischer, 2005), such a positive effect may be less relevant in the case of negative events such as environmental violations. This is because compared with downstream customers, upstream suppliers are less visible to and more distant from end consumers and the public, making it less likely for these suppliers to be criticized for the environmental violations occurring in downstream supply chains. Moreover, due to power asymmetry in buyer-supplier relationships (Sutton-Brady et al., 2015), it is more likely that the public and news media hold the violators' customers (rather than suppliers) accountable for the environmental violations. As a result, the reputations of the violators' customers (rather than suppliers) should be impaired more significantly. As environmental transparency help protect firms against the impairment of reputation induced by environmental violations, such protection may be more important for customer firms whose reputations are more likely to be impaired by the environmental violations. This argument is in line with recent CSR research which suggests that while CSR can function as insurance protecting firms against negative, risky events, such insurance protection is more valuable for those firms facing higher litigation and equity risks (Jia et al., 2020; Koh et al., 2014). Therefore, we expect environmental transparency to play a more critical role in mitigating the spillover effects for customers than suppliers and thus propose the following hypothesis.

H4. The role of environmental transparency in mitigating the spillover effects of environmental violations is more pronounced for the violators' customers (rather than suppliers).

We then consider the role of supply chain diversity. It is clear that environmental violations often disrupt the operations of the violators (Nace, 2017; Bloomberg Environment Report, 2019), but it is less clear whether such disruptions will have more negative spillover

effects for the violators' customers or suppliers. While the disruptions will lead to lost sales for the violators' customers due to the inability of the violators to supply goods or provide services to their customers, the inventory and operating costs of the violators' suppliers will also be increased as a result of the reduced demand for goods and services from the violators. Moreover, it seems that the role of supply chain diversity is important for both the violators' customers and suppliers when facing disruptions resulting from the environmental violations. In particular, supply chain diversity makes a firm, no matter it is a customer or supplier of the violator, to be less likely to rely on this specific violator (Gupta et al., 2015). This will enable the violator's customers to use replacement suppliers to avoid lost sales but also allow the violator's suppliers to identify alternative customers to reduce inventory and operating costs. Therefore, whether supply chain diversity plays a more important mitigating role for the violators' customers or suppliers remains an empirical research question. We thus propose two competing hypotheses.

H5a. The role of supply chain diversity in mitigating the spillover effects of environmental violations is more pronounced for the violators' suppliers.

H5b. The role of supply chain diversity in mitigating the spillover effects of environmental violations is more pronounced for the violators' customers.

3. Methods

3.1 Research Context

Our research focused on the environmental violations of publicly-listed firms in China for several reasons. First, the GDP growth of China reached 6.6% in 2018, making it one of the largest economies in the world (World Bank, 2019). Whilst this places China at the forefront of international economic development, the rapid economic growth has resulted in severe environmental accidents and environmental degradation (Xu et al., 2012). Although the Chinese government has implemented new "green" plans to improve air quality and tighten environmental regulations since 2013 (Leng, 2018; Choi and Luo, 2019), corporate environmental violations still remain a common phenomenon in China (BBC News, 2017; SCMP, 2017). Such an asymmetry between rapid economic growth and weak environmental

protection represents a typical case for emerging economies and an ideal context for our research.

Moreover, from a supply chain management perspective, Chinese firms play an important role in the management of global supply chains. On the one hand, as "the world's factory", Chinese firms produce and supply different kinds of products to firms around the world. On the other hand, as one of the world's largest economies, the market demand in China attracts a lot of foreign companies to sell goods and provide services to Chinese firms and consumers. An investigation of how Chinese firms' environmental violations affect their supply chain partners should provide important implications for firms conducting or intending conducting businesses with firms in China.

Finally, we were able to identify the environmental violations of publicly-listed Chinese firms via the China Stock Market & Accounting Research (CSMAR) database and also to identify the supply chain partners of these violators via the Bloomberg SPLC database. It was relatively difficult to identify firms' environmental violations and supply chain partners in emerging markets due to low information transparency in such markets, but the two databases mentioned above enabled us to overcome this difficulty and to collect the relevant data for testing our proposed hypotheses.

3.2 Data and Sample

As mentioned above, we relied on the CSMAR database to identify the environmental violations of publicly-listed firms in China. CSMAR is a comprehensive database covering various types of information about publicly-listed Chinese firms and has been widely used in prior research focused on the Chinese context (e.g., Lam et al., 2016; Xu et al., 2012; 2016). In addition to the more commonly used datasets containing Chinese firms' accounting and financial information, CSMAR includes other datasets focused on the non-financial information of these firms such as merger & acquisition, corporate governance, and corporate violation. In particular, the corporate violation dataset contains detailed violation records of publicly-listed Chinese firms including violator names, trading symbols, stock exchanges, violation types, violation activities, and publication dates. This specific dataset within the

CSMAR database thus provided useful information for us to identify publicly-listed Chinese firms' environmental violations. As this dataset covers various types of corporate violations, we searched the dataset with environment-related keywords such as "environment", "environmental pollution", "air pollution", "water pollution", and "land pollution". We read all the searched records carefully and only retained those relevant to the violations of environmental regulations. Some examples of this type of corporate violation are shown below.

- Bohai Water Industry Co., Ltd. was fined 1.9 million RMB for illegal discharge of untreated sewage materials.
- Chongqing Sanxia Paints Co., Ltd. was shut down temporarily as its emissions of air pollutants exceeded the emission standards.
- Hubei Guangji Pharmaceutical Co., Ltd. was charged with emitting excess air pollutants and fined 0.3 million RMB.

Due to the limitation of the supply chain relationship data used in this research, we focused only on the environmental violations occurring in 2018. Specifically, the Bloomberg SPLC database was the only data source available for us to identify the Chinese violators' supply chain partners including customers and suppliers. This database covers the supply chain relationships of about 35,000 firms around the world including Chinese firms, but unfortunately it "only provides a cross-sectional dataset with the latest annual relationships" (Kim and Davis, 2016, p. 1905). As our research was conducted in mid-2019, we were able to identify the Chinese violators' supply chain relationships in 2018 based on the latest annual relationships data obtained from the Bloomberg SPLC database. As firms may change their supply chain relationships over years, it is less accurate if we use the latest annual relationship data to determine firms' supply chain partners before 2018. As a result, we focused on Chinese firms' environmental violations in 2018 (and thus their supply chain partners in 2018) to ensure consistency and avoid mismatch. Moreover, we excluded any environmental violations if they were concurrent with other events of the same firms such as labor and social issues, lawsuits, mergers and acquisitions based on our searches in the CSMAR database. This is because these confounding events might also affect firms' stock returns, confusing the impacts of environmental violations on stock returns (Ding et al., 2018). There were 111 environmental

violations occurring in 2018 as identified from the CSMAR database. After eliminating 11 environmental violations with confounding events, 100 environmental violations remained for this research. The distribution of firms with environmental violations across the top 10 industries based on China Securities Regulatory Commission's (CSRC) Industry Classification Codes is shown in Table 1, suggesting that environmental violations occur more frequently in the Raw Chemical Materials and Chemical Products industry.

--- Table 1 about here ---

We identified these Chinese violators' supply chain partners via the Bloomberg SPLC database. This database maps the supply chain relationships of publicly-listed firms around the world based on the reported transactions between the buyer and supplier firms and has been used in recent research on supply chain management (e.g., Agarwal et al., 2017; Kim and Davis, 2016; Kumar et al., 2019). As a firm's environmental violation is more likely to affect its major supply chain partners, we focused on the top three first-tier customers and suppliers of a Chinese violator based on the amount of transactions between these firms and the violator as recorded in the Bloomberg SPLC database. Ideally, we should be able to identify 600 supply chain partners (i.e., 300 supplier firms and 300 customer firms) for the 100 environmental violations concerned, but as there were only one or two supply chain partners for some small violators, we obtained 498 supply chain partners of the Chinese violators from the database, which included 259 supplier firms and 239 customer firms. Finally, 206 supply chain partners (102 supplier firms and 104 customer firms) with available stock return data for conducting the event study were retained as the final sample. The geographic distribution of these supply chain partners across different countries is shown in Table 2, suggesting that the suppliers and customers of the violators are from developing (e.g., China and India) as well as developed (e.g., United States and Germany) countries. Table 3 also shows the descriptive statistics of the violators and their supply chain partners in terms of number of employees, market value, total assets, sales, inventory, and cost of goods sold.

--- Table 2 about here ---

--- Table 3 about here ---

After identifying the violators and supply chain partners, we collected their financial,

accounting, and environmental data from the Bloomberg database to measure the research variables investigated in this research. The detailed measurements of these variables are discussed below.

3.3 Event Study

We employed the event study methodology to quantify the impacts of environmental violations on the stock returns of the violators and their supply chain partners. This methodology has been widely adopted in the operations management literature to explore how various operations management events such as manufacturing outsourcing and international alliance affect firms' stock returns (Jiang et al., 2007; Park et al., 2003; Zhang and Aldridge 1997). This methodology, based on the efficient market hypothesis, is able to quantify the impact of an event within a relatively short period (e.g., a few days). This is an important advantage for our research as we investigate the impacts of environmental violations on not only the violators but also their supply chain partners whose stock returns may become noisy over a longer period (e.g., a few months or years after the events). Moreover, this methodology quantifies the impacts in terms of "abnormal" stock returns rather than "actual" stock returns, controlling overall stock market movements and providing a more accurate estimation of the impacts due to environmental violations. Specifically, abnormal returns (ARs) are the differences between the actual stock returns with the occurrence of the environmental violation events and the expected stock returns without such environmental violation events (Sorescu et al., 2017), as shown below.

$$AR_{it} = R_{it} - E(R_{it}) , \quad (1)$$

where *i* and *t* are firm and day indexes, respectively. R_{it} is the actual stock returns, which can be measured based on the stock price data of firm *i* on event day *t*. $E(R_{it})$ is the expected stock returns, which can be calculated by estimation only (Ding et al., 2018). In accordance with previous research (Hendricks and Singhal, 2003; Lam et al., 2016), we adopted the market model to calculate the expected stock returns of firm *i* on event day *t*, $E(R_{it})$, as shown below.

$$E(R_{it}) = \alpha_i + \beta_i R_{mt} , \quad (2)$$

where R_{mt} is the market return on day *t*. As the supply chain partners investigated in our

research included firms located in China and other countries, we used the return of the FTSE World Index as the market return due to its coverage of securities in 48 different countries including China (FTSE Russell, 2019). We obtained the estimates for α_i and β_i by regressing the market model over a 210-trading day estimation window ending 11 days before the occurrence of the environmental violation. We maintained an 11-day gap between the event day and the estimation window to avoid the influence of the environmental violation on the estimation of the expected returns (Ding et al., 2018).

In addition to the ARs on the event day, it is a common practice for an event study to calculate the cumulative abnormal returns (CARs) surrounding the event day to capture the cumulative effect of an event (Park et al., 2003). This is because the effect of an event can be dispersed over several days following the event day due to the gradual availability of information and the interpretation of the event's impact on future firm performance (Woodroof et al., 2019). This is especially the case for our research as we investigated the impact of an environmental violation event on not only the violator but also its supply chain partners. Consistent with Chen et al. (2007), we measured the CARs over an 11-day event window ranging from the event day to ten days after the event (0, 10) to better capture the full impact of an environmental violation event.

We tested the significance of ARs and CARs based on the Patell *z*-test and skewness corrected *t*-test due to their advantages over traditional *t*-test and their popularity in the event study literature (Ding et al., 2018). In particular, while the Patell *z*-test is robust to potential heteroscedasticity among abnormal returns over the event window, the skewness corrected *t*-test corrects the test statistics for possible skewed distributions of abnormal returns (Harmancioglu et al., 2019; Wood et al., 2017).

3.4 Cross-sectional Regression

Consistent with prior event studies (e.g., Lam et al., 2016; Xu et al., 2016), we developed a cross-sectional regression model to further examine how the stock returns due to environmental violations vary across supply chain partners with different levels of environmental transparency (H2) and supply chain diversity (H3) as well as how the mitigating roles of environmental

transparency (H4) and supply chain diversity (H5) are different for customers and suppliers. Specifically, this model regresses the CARs obtained from the event study on environmental transparency, supply chain diversity, supply chain partners (coded 1 for customers and 0 for suppliers), and the interactions among these variables, after controlling other firm-level factors, as shown below.

$$
\begin{aligned}
CAR_i = {} & \beta_1 Environmental\ Transparency_i + \beta_2 Supply\ Chain\ Diversity_i \\
& + \beta_3 Environmental\ Transparency_i \times Supply\ Chain\ Partners_i \\
& + \beta_4 Supply\ Chain\ Diversity_i \times Supply\ Chain\ Partners_i \\
& + \beta_5 Firm\ Size_i + \beta_6 Firm\ Profitability_i + \beta_7 Firm\ Liquidity_i + \beta_8 Firm\ Age_i \\
& + \beta_9 Days\ of\ Inventory_i + \beta_{10} Ownership\ Structure_i + \beta_{11} Supply\ Chain\ Partners_i \\
& + \beta_{12} Country\ Dummy + \beta_{13} Industry\ Dummies + \varepsilon_i. \qquad (3)
\end{aligned}
$$

CAR. The dependent variable is the CARs of supply chain partners due to the environmental violations. Consistent with prior event studies (e.g., Boyd et al., 2019; Lam et al., 2016), we chose the most significant CAR across all event windows as the dependent variable in the regression model but also checked the robustness of our test results with an alternative CAR over a different event window.

Environmental Transparency. We operationalized a firm's environmental transparency according to its environmental disclosure score obtained from the Bloomberg database. Bloomberg monitors the degree to which publicly-listed firms around the world disclose their environmental information based on the data collected from various sources including "annual and sustainability reports, direct communication, press releases, third-party research, and news items" (Tamimi and Sebastianelli, 2017, p. 1660). With such comprehensive data collected, Bloomberg develops a proprietary method to assign an environmental disclosure score to each firm concerned, which ranges from 0 to 100, with 0 indicating no disclosure of environmental information and 100 representing complete environmental disclosure (Giannarakis et al., 2014). This Bloomberg database has been widely used in recent research focused on firms' environmental disclosure (e.g., Giannarakis et al., 2014; Tamimi and Sebastianelli, 2017; Hassan and Romilly, 2018). Consistent with these studies, we used the environmental disclosure scores obtained from the Bloomberg database to indicate a firm's level of

environmental transparency. As the environmental violation events included in our research occurred in 2018, we measured environmental transparency based on firms' environmental disclosure scores in 2017 to avoid possible confounding effect. The values of environmental transparency of our sample firms range from 0 to 72, with mean and standard deviation equal to 20.65 and 18.88, respectively.

Supply Chain Diversity. A firm with more suppliers and customers should have a more diversified supply chain. We thus identified a firm's suppliers and customers from the Bloomberg SPLC database and operationalized its supply chain diversity according to the total number of suppliers and customers it has (Kim and Davis, 2016; Sousa and Voss, 2007). To account for the skewness distribution of number of customers and suppliers across firms, we applied logarithm transformation in our measure of supply chain diversity. The values of supply chain diversity (after logarithm transformation) of our sample firms range from 1.39 to 12.73, with mean and standard deviation equal to 7.04 and 2.39, respectively.

Supply Chain Partners. Based on the supply chain relationship data obtained from the Bloomberg SPLC database, we coded supply chain partners as 1 for the customers of the violators and 0 for the suppliers of the violators.

Control Variables. We controlled for several firm-level variables, including firm size, firm profitability, firm liquidity, firm age, days of inventory, and ownership structure in our regression model as they may be related to the stock returns due to environmental violations. In particular, firms with higher levels of profitability, liquidity, inventory, and more diversified ownership structure may have more resources and slacks to address the environmental violations, resulting in less negative stock returns, whereas larger and older firms may be more likely to be blamed for and thus affected by the environmental violations, leading to more negative stock returns. We measured the control variables based on the firm characteristics of the supply chain partners rather than the violators. Specifically, we measured firm size as the logarithm transformation of number of employees (McGuire and Dilts, 2008), firm profitability as operating margin divided by sales (Aoki et al., 2014), firm liquidity as the difference between current asset and inventory divided by current liability (Delen et al., 2013), firm age as the number of years since IPO (Lam et al., 2019), days of inventory as 365 times inventory divided

by cost of goods sold (Hendricks et al., 2009), and ownership structure as the percentage of shares held by insiders including officers and directors (Demsetz and Villalonga, 2001). We also included country and industry dummies in the regression model to control the heterogeneity across countries and industries. Country dummy indicates whether the supply chain partners concerned are in China (coded as 1) or other countries (coded as 0), while industry dummies are based on the supply chain partners' two-digit Global Industry Classification Standard (GICS) codes.

4. Test Results

4.1 Event Study Results

The abnormal returns of the violators and their supply chain partners over an 11-day event period are documented in Tables 4 and 5, respectively.

--- Table 4 about here ---

--- Table 5 about here ---

As shown in Table 4, the average AR of the violators is -1.02% on the event day, which is statistically significant ($p < 0.01$) based on both the Patell *z*-test and skewness corrected *t*-test. This significant negative test result is consistent with that in previous studies (e.g., Dasgupta et al., 2001; Huang et al., 2017; Wang et al., 2019; Lo et al., 2018), which suggests that the violators are punished immediately in the stock markets for their environmental violations.

However, there are no significant abnormal returns on the event day ($p > 0.1$) for the supply chain partners as shown in Table 5. Instead, the average ARs of the supply chain partners are negative and significant on day 1 (-0.26%, $p < 0.1$), day 3 (-0.22%, $p < 0.1$), and day 6 (-0.49%, $p < 0.01$) based on both the Patell *z*-test and skewness corrected *t*-test. These test results confirm our decision to observe the abnormal returns over a few days following an environmental violation as it might take time for investors to make sense of how the environmental violation affects the violator's supply chain partners. As the average ARs are significant on days 1, 3, and 6, we further calculated the CARs over relevant event windows, i.e., (0, 1), (0, 3), and (0, 6), in addition to the full event window, i.e., (0, 10). As shown in

Table 5, the average CARs are negative and significant ($p < 0.05$) over the event windows (0, 3), (0, 6), and (0, 10). Moreover, the average CAR is more significant ($p < 0.01$ based on Patell *z*-test) over the event window (0, 6) than other event windows. Specifically, the average CAR over the event window (0, 6) is -0.93%, representing an average decrease of 270 million US dollars in market value for the supply chain partners. Hence, H1 is supported.

4.2 Cross-sectional Regression Results

As the average CAR over the event window (0, 6) is the most significant, we used it as the dependent variable in our regression analysis (Boyd et al., 2019; Lam et al., 2016).

--- Table 6 about here ---

--- Table 7 about here ---

The means, standard deviations, and correlations of all our research variables are shown in Table 6, while Table 7 presents the regression results. As shown in Table 7, Model 1 includes all control variables. Environmental transparency and supply chain diversity are added in Models 2 and 3, sequentially. Finally, the interactions between supply chain partners and environmental transparency as well as supply chain diversity are included in Models 4 and 5, respectively. The number of observations reduces from 188 in the event study to 179 in the regression analysis due to missing data for a few supply chain partners. All the five models are statistically significant ($p < 0.1$) with adjusted *R*-squared values ranging from 0.05 to 0.10. The maximum VIF value among all independent variables is 2.28, which is well below the acceptable threshold of 10 and suggests there is no significant multicollinearity issue in our models (Neter et al., 1996).

The coefficient of environmental transparency remains positive and significant ($p < 0.05$) across Models 2 to 5, indicating that the impacts of environmental violations on the stock returns of supply chain partners are more positive (or less negative) for those supply chain partners with higher levels of environmental transparency. H2 thus is supported. Similarly, Models 3 to 5 shows a positive and significant ($p < 0.05$) coefficient for supply chain diversity. It means that the stock returns due to environmental violations are more positive (or less negative) for those supply chain partners with more diversified supply chains, supporting H3.

The interaction between supply chain partners and environmental transparency remains positive and significant ($p < 0.05$) in Models 4 and 5. As customers and suppliers were coded as 1 and 0, respectively, in the supply chain partners dummy variable, the test results suggest that the mitigating role of environmental transparency is more pronounced for customers than suppliers, supporting H4. Finally, although Model 5 shows a negative interaction between supply chain partners and supply chain diversity, the interaction is not statistically significant ($p > 0.1$). Therefore, there is no evidence that the mitigating role of supply chain diversity is more pronounced for suppliers or customers. Both H5a and H5b are rejected.

5. Robustness Test Results

We conducted several robustness tests to check the sensitivity of our findings and to account for alternative explanations. The robustness test results are shown in Table 8 and the detailed testing procedures are discussed below. Overall, these tests demonstrate the robustness of our research findings and reveal some new insights.

--- Table 8 about here ---

First, we checked whether there is information leakage before the announcements of the environmental violation events. Specifically, we computed the ARs for both the violators and their supply chain partners on days -2 and -1 (i.e., two days before the event). The test results as shown in Panel A suggest that the average ARs on days -2 and -1 are not significant ($p > 0.1$) for both the violators and their supply chain partners. Therefore, there is no evidence of information leakage before the events, supporting our decision to examine the impacts of environmental violations starting from the event dates.

We also checked the sensitivity of our test results to possible time clustering as all the environmental violation events included in our research occurred in 2018. Following Jacobs and Singhal's (2017) approach to perform adjusted *t*-test to control for clustering, we obtained consistent test results for the average CAR of supply chain partners, as shown in Panel B (Model 1). It thus suggests that time clustering is not a major concern in our research. In fact, although all the environmental violation events occur in the same year, they are distributed across different dates and firms, making time clustering less severe compared with other single-

date event studies (Jacobs and Singhal, 2017).

We compared the difference between suppliers and customers in terms of CARs. Specifically, we divided the full sample of supply chain partners into two sub-samples, representing the violators' suppliers and customers, respectively. We then computed the CARs for each of the two sub-samples separately. The test results shown in Models 2 (suppliers) and 3 (customers) of Panel B suggest that the average CARs are negative and significant ($p < 0.1$) for both suppliers and customers. We also performed independent samples *t*-test (not tabulated) to compare the average CARs of the two sub-samples but did not find a significant difference ($p > 0.1$). These test results confirm that environmental violations have negative impacts on the violators' customers (Lo et al., 2018) as well as suppliers.

We performed propensity score matching (PSM; Rosenbaum and Rubin, 1983) to address possible endogeneity issues arising from self-selection bias. Specifically, as we calculated a sample firm's abnormal returns as the difference between its actual stock returns and expected stock returns that were estimated based on the market model, a possible concern is that the sample firm could be quite different from and incomparable with those firms used to estimate the expected stock returns, making the resulting abnormal returns biased. This endogeneity concern is valid in our research context as environmental violations do not occur by chance or randomly, suggesting that firms with environmental violations in supply chains could be quite different from other firms without such environmental violations. As a result, the calculated abnormal returns might be due to such differences rather than the environmental violations per se. PSM helps addresses this concern as it mimics the random assignment process by matching each sample firm with environmental violations in supply chains to a control firm that had a similar propensity as the sample firm to have environmental violations in supply chains but eventually did not have such environmental violations. After this matching process, the sample firms and their matched control firms are similar and comparable, making it more likely to attribute the resulting abnormal returns to the impacts of the environmental violations rather than to the differences between the sample and control firms.

Empirically, we first constructed a logistic regression model with the dummy dependent variable indicating whether a firm has environmental violations in supply chains and the

independent variables include firm size, firm profitability, and industry fixed effects (Barber and Lyon, 1996). After running the logistic regression, we obtained all firms' predicted probabilities (or propensity scores) of having environmental violations in supply chains. We then matched each sample firm to a control firm that has a similar propensity score as the sample firm, ensuring the comparability between the sample firm and its matched control firm. Finally, we calculated the CARs as the changes in stock returns between the sample and control firms over the same event window. The test results based on PSM remain negative and significant ($p < 0.1$), as shown in Panel B (Model 4).

We then tested whether environmental transparency and supply chain diversity as proposed in our research can really "offset" the negative spillover effects induced by environmental violations. Specifically, we computed the CARs for firms with high levels of environmental transparency and supply chain diversity, i.e., the environmental transparency and supply chain diversity of these firms are higher than the average values. The average CAR of these firms is -0.17%, which is not statistically significant ($p > 0.1$) as shown in Panel B (Model 5), suggesting that firms with high levels of environmental transparency and supply chain diversity are not affected by the environmental violations occurring in their supply chains.

Finally, we checked the sensitivity of our regression results by adopting alternative measures of the research variables included in the regression model. Specifically, we measured firm profitability alternatively as return on assets (ROA) and return on equity (ROE), respectively (Lo et al., 2014; Pugliese et al., 2014). We also replaced the dependent variable, CAR (0, 6), with the CAR over the full 11-day event window, i.e., CAR (0, 10). The regression results based on these alternative measures remain consistent, as shown in Panel C. Specifically, the coefficients of environmental transparency and supply chain diversity as well as the interaction between environmental transparency and supply chain partners are positive and significant ($p < 0.1$) across all the models, but there is no significant interaction between supply chain diversity and supply chain partners ($p > 0.1$).

6. Conclusion and Discussion

To conclude, our research demonstrates the spillover effects of environmental violations in supply chains based on an analysis of 100 environmental violation events of Chinese firms occurring in 2018. Specifically, we show that environmental violations have negative impacts on the stock returns of not only the violators but also their supply chain partners including suppliers and customers. We also find that such negative impacts can be mitigated if these supply chain partners are more transparent in disclosing environmental information and running more diversified supply chains. While the mitigating role of environmental transparency is more pronounced for customers than suppliers, supply chain diversity has a similar mitigating effect for customers and suppliers. These findings provide important implications for research and practices.

6.1 Implications for Research

Researchers in operations management and other disciplines have been paying much attention to environmental violations in emerging markets and well documented the impacts of such violations on the stock returns of the focal firms concerned (Dasgupta et al., 2001; Huang et al., 2017; Wang et al., 2019). Recent research (e.g., Lo et al., 2018) also investigated environmental violations' impacts on the violators' customers, but it is still unclear how environmental violations may also affect other parties along the violators' supply chains. Our research takes a step further by considering the impacts of environmental violations on both customers and suppliers. We document significant negative stock returns for both customers and suppliers due to the environmental violations. Our additional analysis further suggests that environmental violations' impacts on customers and suppliers are comparable. These findings highlight the important but neglected impacts of environmental violations on upstream supply chains, which might inspire researchers to further investigate environmental violations' impacts on other parties beyond the violators' first-tier supply chain partners. Such investigations can enrich the current literature on the spillover effects in supply chains that has been dominated by research focused on the spillover effects from suppliers to customers (Nichols et al., 2019; Kumar et al., 2019).

Although recent studies have started to investigate the impacts of environmental

violations on customers, they are still focused on factors that mitigate the negative impacts on the violators rather than on the customers (Lo et al., 2018). Our research, by contrast, considers factors that help protect firms against the environmental violations occurring in their supply chains. Specifically, our research examines how supply chain diversity and environmental transparency enable firms to alleviate the negative impacts resulting from the environmental violations in their supply chains, providing new insights for operations management.

Supply chain diversity has long been an important research topic in operations management. While early research has emphasized the importance of having simplified, concentrated supply chains to maintain long-term relationships with supply chain partners, reduce transaction and administrative costs, and develop superior competitive positions (Bozarth et al., 2009; Bode and Wagner, 2015), recent studies highlight the complex, non-linear relationships between supply chain diversity and firm performance such as return on assets, Tobin's Q, and innovation outputs (Lu and Shang, 2017; Sharma et al., 2020). However, these studies have focused on supply chain diversity's direct performance implications rather than its possible moderating role. Our research takes a different approach. Instead of focusing on the direct impact of supply chain diversity on a firm's stock returns, we investigate how supply chain diversity moderates the impacts of environmental violations on stock returns. This investigation direction helps reveal the important role that supply chain diversity plays in mitigating the negative impacts of environmental violations on stock returns. This finding provides an interesting complement to Dong et al.'s (2020) research which shows that supply chain diversity negatively moderates the relationship between R&D intensity and financial performance. It thus seems to suggest that supply chain diversity plays a more beneficial role in an uncertain (rather than stable) environment. These findings might motivate researchers to shift their focus from supply chain diversity's direct performance impacts to the complex, varying roles that supply chain diversity plays under different conditions or environments.

Our research further suggests that, in the occurrence of an environmental violation, supply chain diversity is beneficial to a firm no matter whether it is the violator's customer or supplier. This is because supply chain diversity allows the violator's customer to source from replacement suppliers but also enables the violator's supplier to sell to alternative customers.

Our research thus highlights the importance of adopting a more balanced, comprehensive view on supply chain diversity rather than just focusing on the perspective of customers. Specifically, prior research in operations management has often taken a customer's perspective and focused on a customer firm's supply base diversity (Bode and Wagner, 2015; Lu and Shang, 2017; Dong et al., 2020; Sharma et al., 2020). For instance, Sharma et al. (2020) examined whether a firm's total number of suppliers is related to its innovation performance, without considering the possible innovation impact due to the firm's total number of customers. Similarly, Dong et al. (2020) focused on how a firm's return on R&D investment is moderated by the diversity of its suppliers rather than customers. By showing the importance of supply chain diversity for both customers and suppliers, our research might inspire researchers to adopt a more balanced, comprehensive view on supply chain diversity to re-visit some well-studied topics such as R&D investments and innovation performance (Dong et al., 2020; Sharma et al., 2020) and take both upstream and downstream diversities into account.

The consideration of environmental transparency in this research also makes some new contributions to the corporate transparency literature. Previous studies have suggested that corporate transparency in general and environmental transparency in particular can help build a strong brand and trustworthiness from stakeholders, protecting the focal firms in the case of negative events (Fennis and Stroebe, 2014; Reimsbach and Hahn, 2015; Lin et al., 2017). Our research extends this notion to the context of supply chains by showing that environmental transparency also enables firms to mitigate the negative spillover effects induced by environmental violations occurring in their supply chains. This can be explained by the ability of environmental transparency to protect firms from the possible impairment of reputation due to the environmental violations. This interesting finding should encourage researchers to explore the buffering role of environmental transparency (and corporate transparency in general) in alleviating the effects of other negative events occurring in firms' supply chains.

However, researchers should realize that the extent to which a company benefits from environmental transparency may depend on its position in a supply chain. In particular, our research suggests that environmental transparency plays a more pronounced mitigating role for the violators' customers than suppliers. This may be due to their difference in supply chain

positions, with the downstream customers being more visible and closer to end consumers and the public. Such visibility and closeness make these downstream customers more likely to be blamed for the environmental violations, posing a greater need to rely on environmental transparency to reduce the negative effects. These interesting insights urge researchers to pay more attention to a firm's supply chain position when studying the interaction between the firm's environmental transparency and negative events occurring in its supply chain. The consideration of a firm's supply chain position may also help explain the mixed transparency-performance relationships documented in the corporate transparency literature (Albu and Flyverbom, 2019), which is worth further investigation. For instance, it would be interesting to investigate whether the transparency-performance relationships are more positive for firms located in downstream (rather than upstream) supply chains.

6.2 Implications for Practices

There is no doubt that emerging markets have contributed significantly to the development of the global economy. However, the emphasis on economic development rather than environmental protection also leads to increasing numbers of corporate environmental violations in emerging markets (BBC News, 2017; SCMP, 2017). The weak legal systems and poor law enforcement further make firms in emerging markets such as China "find it cheaper simply to pay fines than to adhere to the regulations" (Economy and Lieberthal, 2007, p. 93). Such a perception also suggests that environmental violations in emerging markets may have little impact on other parties along the violators' supply chains as they are not even involved in the environmental violations. However, our research shows that environmental violations in emerging markets do have significant negative impacts on not only the violators but also their supply chain partners including customers and suppliers. In particular, we demonstrate that these supply chain partners suffer an average loss of 270 million US dollars in market value due to the environmental violations, which is much higher than the typical amount of fines the violators need to pay for their environmental violations (Economy and Lieberthal, 2007). This finding suggests that firms may underestimate the actual costs associated with environmental violations occurring in their supply chains. Such an underestimation may be due to firms' focus

on environmental violations' tangible impacts (e.g., fines), ignoring other more important intangible consequences such as reputational damages. Our research quantifies the significant impacts of environmental violations in terms of stock returns, which take both the tangible and intangible implications into account.

Moreover, our research shows that both customers and suppliers experience significant decreases in stock returns due to the environmental violations. Although news media and the public have paid more attention to the impacts of environmental violations on the customer firms such as retailers that serve end consumers (Hoskins, 2017; Chapman, 2018), our research suggests that the supplier firms' decreased stock returns are similar to that of the customer firms. Therefore, we urge firms to integrate the environmental performance criterion into their selection of supply chain partners including suppliers and customers in emerging markets, reducing the probability of environmental violations in their supply chains and protecting their shareholders' value. Indeed, as Sit (2017) put it when discussing the Schaeffler case in China, "When choosing a supplier, the German company should consider whether it obeys China's environmental rules."

However, sometimes environmental violations, as unpredictable events, are unavoidable in emerging markets even though firms choose their supply chain partners carefully. Our research suggests that firms can prepare themselves for the occurrence of environmental violation events in their supply chains and mitigate the possible negative impacts on the firms concerned. Specifically, our research shows that firms suffer less from the environmental violations in supply chains if they have high levels of supply chain diversity and environmental transparency. Our additional analysis further suggests that those firms with high levels of supply chain diversity and environmental transparency in fact are not affected by the environmental violations occurring in their supply chains. This finding demonstrates the ability of supply chain diversity and environmental transparency to "offset" the negative effects induced by environmental violations and has practical implications for firms.

Although firms have long been asked to simplify their supply chains to reduce costs and to build closer buyer-supplier relationships (Bode and Wagner, 2015; Bozarth et al., 2009), over-simplified supply chains may make firms more vulnerable to negative events such as

environmental violations occurring in their supply chains. Our research suggests that maintaining diversified, flexible supply chains enable firms to better respond to the environmental violations in supply chains, preventing possible disruptions and thus mitigating the negative impacts arising from these environmental violations. Therefore, our research warns firms of the danger of having too simplified, concentrated supply chains in today's uncertain environment that is full of unpredictable negative events. Moreover, although customer firms located in downstream supply chains usually have more power and find it easier to switch to a new supplier when facing disruptions (Sutton-Brady et al., 2015), our research shows that the mitigating effects of supply chain diversity are similar for both upstream and downstream supply chains. This finding further encourages firms to maintain a high level of supply chain diversity to address environmental violations, independent of whether they are located in the upstream or downstream supply chains of the violators.

Firms have well recognized the importance of being transparent in disclosing environmental information to stakeholders, as reflected in the increasing number of environmental or sustainability reports issued by firms over years (Si2 and IRRC Institute, 2018). Indeed, having a high level of environmental transparency can improve firms' reputation and trustworthiness as perceived by stakeholders. Yet, firms may be less aware of the important role that environmental transparency plays in protecting firms against the negative events such as environmental violations occurring in their supply chains. Our research suggests that the disclosure of environmental information can enable firms to signal their honesty and accountability for environmental issues in operations and supply chains, serving as a buffer to protect the firms when environmental violations occur in their supply chains. Therefore, our research provides new empirical evidence that further encourages firms to engage in environmental disclosure as the buffering role of environmental transparency can move beyond organizational boundaries, especially in the context of supply chains in emerging markets. However, firm should realize that the buffering role of environmental transparency could vary depending on their positions in supply chains. In particular, as firms in downstream supply chains that face end consumers and the public are often blamed for the environmental violations occurring in their upstream supply chains (Hoskins, 2017; Chapman, 2018), it is

more crucial for these firms to have a high level of environmental transparency to buffer the negative effects. Therefore, firms can assess the urgency of engaging in environmental disclosure in view of their supply chain positions.

6.3. Limitations and Future Research

This study is not without limitations, which suggest avenues for future research. First, our research focuses on the environmental violations of Chinese firms. Although focusing on a single market is consistent with prior research's practices (e.g., Lam et al., 2016; Xu et al., 2012; 2016), it may miss the opportunity to compare the difference across different markets. As the economic development as well as environmental regulations vary across emerging markets, it will be interesting for future research to conduct a similar research in other emerging markets (e.g., Brazil and Russia) and compare the consequences of environmental violations across countries. Relatedly, we use the FTSE World Index to calculate the expected stock returns as the supply chain partners investigated in our research are from different countries, as shown in Table 2. However, such a single market index approach might undermine the prediction power due to the variation in stock market movements across countries. We thus encourage future research to use other market indexes that are more specific to the supply chain partners' countries and verify the conclusions drawn in this research.

Another limitation is that we only focus on publicly-listed firms as their stock return data are available. Such a focus might limit the generalizability of our research findings to private firms, especially small and medium-sized enterprises (SMEs). This is because environmental violations may have stronger impacts on the reputations of publicly-listed firms than the less visible private firms. Also, it may be more difficult for SMEs to make their supply chains diversified and flexible to address the disruptions induced by environmental violations. Therefore, we encourage future research to further explore the impacts of environmental violations on private firms, especially SMEs, based on other performance indicators beyond stock returns. A related concern about stock returns is that investors may over-react or under-react to corporate events such as environmental violations, especially when these events occur in firms' supply chains that are distant from the investors. This raises doubts about the

connection between short-term stock returns and long-term firm performance, which is worth further investigation.

Moreover, our research focuses on *ex-ante* moderating factors in terms of environmental transparency and supply chain diversity, ignoring firms' *ex-post* actions or responses that may also affect the impacts of environmental violations occurring in supply chains. We thus encourage future research to further investigate how firms respond to environmental violations once these violations have occurred in supply chains. Such investigations can advance our understanding of not only the impacts of, but also the responses to, environmental violations. Relatedly, although we explain the negative impacts of environmental violations on supply chain partners through operations disruption and reputation impairment, we do not measure operations disruption and reputation impairment empirically and it is also difficult to test their mediating roles directly based on the event study methodology. We thus call for additional research using other methods (e.g., qualitative or survey methods) to provide a direct, empirical test of the mediating roles of operations disruption and reputation impairment.

Finally, due to the limitation of the supply chain relationship data collected from the Bloomberg SPLC database, our sample only includes environmental violations occurring in 2018. Considering the rapid changing environments in emerging markets such as China, the impacts of environmental violations on supply chains could be different over time. We thus encourage future research to explore the possibility of using alternative databases or methodologies to provide a longitudinal investigation of environmental violations' impacts across years.

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Table 1. Top 10 Industries of Violators

Industry	Code	Frequency
Raw Chemical Materials and Chemical Products	C43	33
Medicine Manufacturing	C81	8
Nonferrous Metal Mining	B07	7
Transportation Equipment Manufacturing	C75	6
Information Technology	G	6
Non-ferrous Metal Smelting, Rolling, Drawing, and Extruding	C67	6
Electrical Machinery and Equipment Manufacturing	C76	4
Special Equipment Manufacturing	C73	4
Food Manufacturing	C03	3
Food Processing	C01	3

Table 2. Distributions of Supply Chain Partners Across Countries

Panel A: Suppliers	
Country	Frequency
China	63
United States	20
Germany	7
United Kingdom	5
India	2
Japan	2
Switzerland	2
Thailand	1
Panel B: Customers	
Country	Frequency
China	53
United States	23
Germany	14
United Kingdom	7
France	3
South Korea	2
India	1
Norway	1

Table 3. Descriptive Statistics of Violators and Supply Chain Partners

Panel A: Violators					
Firm Characteristics	Unit	Mean	Std. Deviation	Minimum	Maximum
Number of Employees	Thousand	3.61	3.09	0.15	16.99
Market Value	Million US$	941.47	940.29	55.48	4783.41
Total Assets	Million US$	1030.14	1194.21	85.06	7383.62
Sales	Million US$	646.76	1126.74	42.15	8518.36
Inventory	Million US$	185.25	582.94	5.30	5613.00
Cost of Goods Sold	Million US$	2637.53	12167.88	20.82	71225.55
Panel B: Suppliers					
Firm Characteristics	Unit	Mean	Std. Deviation	Minimum	Maximum
Number of Employees	Thousand	23.29	44.92	0.50	363.00
Market Value	Million US$	20352.86	102714.32	6.99	892230.70
Total Assets	Million US$	19267.76	57087.69	44.46	431223.00
Sales	Million US$	10037.15	20990.69	31.34	158273.00
Inventory	Million US$	1172.15	1996.27	1.75	16245.45
Cost of Goods Sold	Million US$	31396.92	122534.8	4.85	631533.21
Panel C: Customers					
Firm Characteristics	Unit	Mean	Std. Deviation	Minimum	Maximum
Number of Employees	Thousand	70.33	115.36	0.64	464.52
Market Value	Million US$	37798.17	172479.03	11.21	1201000.00
Total Assets	Million US$	41857.44	88009.02	7.61	506812.00
Sales	Million US$	28156.15	46266.03	12.26	276237.13
Inventory	Million US$	2881.45	4806.38	1.40	24270.09
Cost of Goods Sold	Million US$	23893.95	55925.06	11.69	474837.00

Table 4. Event Study Results for Violators

Day	*N*	Average AR	Patell *z*-test	Skewness corrected *t*-test
0	100	-1.02%	-5.05***	-3.50***
1	96	-0.28%	-1.20	-1.02
2	95	-0.86%	-2.54**	-1.95*
3	93	0.21%	1.31	0.76
4	93	-0.15%	-0.19	-0.68
5	92	-0.17%	-1.14	-0.58
6	91	-0.19%	-0.54	-0.63
7	91	-0.14%	-0.83	-0.56
8	91	0.14%	0.83	0.55
9	91	0.04%	0.27	0.15
10	91	0.06%	0.47	0.24

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed tests).

Table 5. Event Study Results for Supply Chain Partners

Day	*N*	Average AR/CAR	Patell *z*-test	Skewness corrected *t*-test
0	206	-0.06%	-0.39	-0.36
1	197	-0.26%	-1.33*	-1.88*
2	196	-0.06%	-0.33	-0.37
3	191	-0.22%	-1.34*	-1.33*
4	191	0.09%	0.62	0.45
5	190	0.04%	0.17	0.05
6	188	-0.49%	-3.48***	-2.46***
7	188	-0.16%	-0.48	-1.03
8	186	-0.28%	-0.84	-1.22
9	186	0.12%	0.98	0.69
10	186	0.13%	0.67	0.76
(0, 1)	197	-0.33%	-1.20	-1.27
(0, 3)	191	-0.50%	-1.71**	-1.68**
(0, 6)	188	-0.93%	-2.46***	-1.98**
(0, 10)	186	-1.13%	-1.91**	-1.91**

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (one-tailed tests).

Table 6. Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9	10	11
1. CAR (0, 6)	1										
2. Environmental Transparency	0.21***	1									
3. Supply Chain Diversity	0.23***	0.43***	1								
4. Firm Size	0.07	0.55***	0.66***	1							
5. Firm Profitability	0.10	0.03	0.03	-0.08	1						
6. Firm Liquidity	-0.10	-0.08	-0.11	-0.27***	0.35***	1					
7. Days of Inventory	0.07	0.02	-0.21***	-0.24***	0.21***	0.01	1				
8. Country Dummy	-0.19***	-0.62***	-0.47***	-0.53***	-0.13*	0.00	0.09	1			
9. Firm Age	0.05	0.37***	0.31***	0.46***	-0.04	-0.14**	-0.08	-0.43***	1		
10. Ownership Structure	-0.12	-0.20***	-0.28***	-0.23***	-0.10	-0.06	0.06	0.47***	-0.27***	1	
11. Supply Chain Partners	0.02	0.13*	0.20***	0.28***	-0.08	-0.06	-0.04	-0.09	0.01	0.02	1
Mean	-0.01	20.65	7.04	4.14	0.11	1.30	119.16	0.55	27.30	0.28	0.50
Standard Deviation	0.07	18.88	2.39	0.71	0.12	0.93	176.51	0.50	28.69	0.27	0.50

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed test).

Table 7. Cross-sectional Regression Results

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Environmental Transparency		0.22**(2.06)	0.23**(2.08)	0.24**(2.27)	0.25**(2.31)
Supply Chain Diversity			0.22**(2.02)	0.21**(2.03)	0.21**(1.95)
Environmental Transparency × Supply Chain Partners				0.16**(2.02)	0.14*(1.57)
Supply Chain Diversity × Supply Chain Partners					0.04 (0.51)
Firm Size	-0.03(-0.31)	-0.05(-0.51)	-0.15(-1.31)	-0.18(-1.51)	-0.18(-1.50)
Firm Profitability	0.16*(1.77)	0.18**(2.07)	0.16*(1.74)	0.19**(2.04)	0.18**(2.00)
Firm Liquidity	-0.17*(-1.84)	-0.18**(-2.02)	-0.17*(-1.92)	-0.19** (-2.11)	-0.18** (-2.07)
Days of Inventory	0.10(1.29)	0.06(0.67)	0.06(0.73)	0.01(0.10)	0.01 (0.13)
Country Dummy	0.08(0.85)	0.02(0.17)	0.04(0.39)	0.06(0.50)	0.06(0.49)
Firm Age	-0.03(-0.39)	-0.05(-0.62)	0.01(-0.63)	-0.02(-0.28)	-0.02(-0.28)
Ownership Structure	-0.08(-0.83)	-0.11(-1.16)	-0.01(-0.96)	-0.10(-1.04)	-0.09(-1.02)
Supply Chain Partners	0.02(0.20)	0.01(0.12)	0.01(0.05)	0.00 (0.05)	0.04 (0.05)
Industry Dummies	Included	Included	Included	Included	Included
Number of Observations	179	179	179	179	179
R-squared	0.13	0.15	0.16	0.20	0.20
Adjusted *R*-squared	0.05	0.07	0.08	0.10	0.10
F-value	1.57*	1.75**	1.92**	2.04**	1.94**

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (two-tailed tests for control variables, one-tailed tests for hypothesized variables). Standardized coefficients are reported. *t*-statistics are in parentheses.

Table 8. Robustness Test Results

Panel A: Average AR					
Model	Day	*N*	Average AR	Patell *z*-test	Skewness corrected *t*-test
1. Violators on Day -2	-2	100	-0.02%	-0.76	-0.03
2. Violators on Day -1	-1	100	-0.01%	-0.49	-0.06
3. Supply Chain Partners on Day -2	-2	206	0.05%	0.31	0.28
4. Supply Chain Partners on Day -1	-1	206	0.19%	0.91	1.07

Panel B: Average CAR					
Model	Day	*N*	Average CAR	Patell *z*-test	Adjusted *t*-test (control for clustering)
1. All Supply Chain Partners	(0, 6)	188	-0.93%	-2.46***	-1.72**
2. Suppliers Only	(0, 6)	93	-1.10%	-1.95**	-1.59*
3. Customers Only	(0, 6)	95	-0.76%	-1.68**	-1.32*
4. Propensity Score Matching	(0, 6)	164	-1.09%	-2.20**	-1.65*
5. High Environmental Transparency and Supply Chain Diversity	(0, 6)	61	-0.17%	-0.51	-0.49

Panel C: Cross-sectional Regression							
Model	*N*	Environmental Transparency	Supply Chain Diversity	Environmental Transparency × Supply Chain Partners	Supply Chain Diversity × Supply Chain Partners	Adjusted *R*-squared	*F*-value
1. Measure Firm Profitability as ROA	179	0.25**(2.29)	0.21**(1.98)	0.14*(1.54)	0.04(0.54)	0.09	1.85**
2. Measure Firm Profitability as ROE	179	0.26**(2.37)	0.22**(2.00)	0.14*(1.60)	0.05(0.56)	0.09	1.88**
3. Use CAR (0, 10) as the dependent variable	179	0.31***(2.86)	0.23** (2.14)	0.19**(2.13)	0.01(0.10)	0.06	1.53*

Notes: *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$ (one-tailed tests).