Managing quality risk in supply chain to drive firm's performance: the roles of control mechanisms

ABSTRACT

Product harm scandal can be viewed as a company's nightmare. In many cases, the source of defective or unsafe components may not be the manufacturing firm itself; rather, there may be problems inherent in the supply network. This research aims to investigate the effects of two focused risk management practices, namely supplier development and proactive product recall, on firms' performance. To scrutinise the impact of two types of control mechanisms, we investigate social control and formal control as antecedents of risk management practices, and explore their moderating roles on the relationship between risk management practices and firm performance. Based on the survey-based data obtained from 209 Chinese manufacturers, structural equation modelling and hierarchical regression are used to test the proposed hypotheses. The results show that both supplier development and proactive product recall significantly contribute to financial performance and quality performance. Furthermore, both formal control and social control are the significant antecedents of the two risk management practices. Most importantly, we examine the moderating roles of the control mechanisms on the relationship between the risk management practices and firm performance. Practitioners should be aware that the control mechanisms have different moderating effects, i.e. different type of control mechanism should be employed to facilitate the risk management practices in order to achieve a better firm performance.

Keywords: Risk Management; Supplier Development; Product Recall Management; Formal Control; Social Control

1. Introduction

The largest scale of product recall in mobile phone industry, i.e. Samsung Galaxy Note 7 crisis, has put a spotlight on quality control of electronics production. The recall crisis is also raising questions about how today's manufacturing company could prevent the quality problem raised in their supply chain, and maybe more importantly, how could they prepare if the product quality happened. The product quality problem is a current issue but an old problem. From 2006 until the end of 2015, the number of product recall cases in the EU rose rapidly, by 203%[1]. Scholars and practitioners claim that among the major reasons for this rapid increase are the extent of global sourcing of materials and the magnitude of the outsourcing production of branded products to contract manufacturers (Roth et al. 2008). The lengthening of the global supply chain increases uncertainty and adds extra quality considerations to the final products. Since many firms have moved their production offshore, it becomes more difficult to assure the quality and safety of their products (Tse et al. 2011).

The impact of quality risk is felt across diverse industries. However, not all product recalls originate from poor manufacturing processes; rather, they are associated with irresponsible purchasing on the part of the firms. In other words, quality risk is inherent in the supply network (Tse and Zhang 2017). Knowing how to handle quality risks through proper risk management practices is crucial for firms if they are to survive and compete in the market, and particularly, to prevent defective or unsafe products from reaching the customer (Chavez and Seow 2012). Thus, practitioners face the challenging question: What practices are appropriate to manage and control the risks to product quality in the global supply chain? However, the literature provides only a limited understanding of which risk management practices can help to mitigate the negative consequences of quality risks and improve firms' performance, or what mechanisms can impact on the risk management practices (Hora et al. 2011; Tse et al. 2011). Conceptually, some theoretical perspectives are available to inform scholars and practitioners on how to manage supply chain risk effectively. Empirically, there is limited research on how risk management facilitates firm performance, or what important antecedents influence these risk management practices.

[1] Data are available at: http://ec.europa.eu/consumers/consumers_safety/safety_products/rapex/alerts/main/index.cfm?event=main.search

In this research, two kinds of risk management practices are investigated: proactive product recall (PPR) and supplier development (SD). PPR is a responsive practice to manage quality risk, which, when used appropriately, can mitigate the negative impact on the firm. It is a remedy action; i.e., one that takes place after risk has actually happened (Thun and Hoenig 2011). However, the quality risk should also be addressed before the defective/contaminated materials enter the firm, to effectively reduce the negative impact in the long term. For this purpose, the SD approach may be appropriate, since quality assurance of supplier products is an agency problem (Zu and Kaynak 2012). SD can be viewed as a preventive risk management practice to protect against quality risk from the upstream network, by minimising the likelihood of defective materials entering the firm. Furthermore, SD has been widely regarded as an important practice that foster quality performance (Salimian et al. 2017).

Moreover, the effects of the risk management practices on firm performance might represent a complex pattern and require a contingency perspective for investigation (Ritchie and Brindley 2007). This study adds to the literature by investigating the antecedent and moderating roles of two control mechanism, namely social control and formal control (Liu et al. 2017). While considerable attention has been paid to these control mechanisms by the business research, the supply chain risk management (SCRM) literature surprisingly did not integrate with this insight. The adoption of two control mechanism brings benefits as well as limitations to a company. Formal control is a control mechanism that focusing on using the explicit contract to specify the responsibilities and obligations of each party (Rhee et al. 2014); yet the contract is not always completed and literature argue that formal control might hinder the strategic flexibility (Lumineau 2015). In contrast, relying on shared norms and trust with the business partners, social control may provide more flexibility to a company and may reduce more transactional costs (Dong et al. 2017). This research extends the previous research by investigative the different roles of two control mechanisms in the context of SCRM.

Therefore, the purpose of this research is to build and test a model guided by theory related to quality risk management, and to offer a comprehensive picture of the mechanism of inter-organisational control in risk management. The model aims to: (i) evaluate the PPR and SD impact on firm performance; (ii) test the inter-organisational control antecedents of PPR and SD; and (iii) examine the moderating roles of the inter-

organisational control mechanism in the relationship between risk management practices and firm performance.

The rest of this paper is structured as follows. Section 2 comprises a review of the risk management literature. In Section 3, we describe the theoretical underpinnings of our research, the research model, and the hypotheses. Section 4 reports the data-gathering procedures and the operationalisation of the construct in this research. Then, in Section 5, the model of risk management, its control antecedents and moderation effect are tested using structural equations modelling (SEM) and multiple linear regression. The results are discussed in Section 6. Finally, we summarise the implications of our work for both research and practice.

2. Literature and Theoretical Development

Central to the proposed model is the notion that risk management has an impact on both financial performance (FP) and quality performance (QP). Our conceptualisation of risk management includes the preventive and reactive practices aimed at managing the potential quality risk in the upstream supply chain and reducing the negative consequences of product recall in the downstream network. In order to coordinate the activities of risk management practices, managers also need to utilise control mechanisms. Therefore, we include two control mechanisms as the antecedents of both SD and PPR. To understand the whole picture of control mechanisms, we also investigate their moderating role in the relationship between the risk management practices and the firm's performance. The conceptual model is presented in Figure 1.

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2.1 Quality Risk management and Firm Performance

In order to properly manage the quality risk, the firm needs to consider both the upstream and downstream supply chain. In the upstream supply chain, the firm needs to create a responsible purchasing approach to block the source of the defective material. This involves preventive actions to stop the risk from happening (*ex-ante action*). In the

downstream supply chain, the firm needs to take prompt and responsive action when they discover a potential product harm crisis (*ex–post action*). Thun and Hoenig (2011) state that a comprehensive SCRM plan should include both preventive and reactive action. Similarly, Lewis (2003) categorises the *ex-ante and ex-post* mechanisms as important elements in operational risk management control. The *ex-ante* activities are viewed as a preventive action that is similar to the quality management notion of 'right first time' and error-proofing. The *ex-post* mechanism addresses the management of negative consequences, just as service quality actively considers recovery from quality failure. In this research, we investigate SD as the *ex-ante* action and PPR as the *ex-post* action. Figure 1 illustrates how both risk management practices are adopted in order to mitigate the quality risk in the upstream and downstream supply chain.

Within the operations management literature, there is extensive research about the adoption of management practices to deal with risk. Most of the researchers in this field discuss how their proposed frameworks can reduce the probability and the impact of risk (Ritchie and Brindley 2007; Ho et al. 2009; Ho et al. 2010; Thun and Müller 2010). However, these studies do not focus on quality risk in the supply chain, and are limited to investigating the impact of the product recall management on brand equity (Dawar and Pillutla 2000), on stock market reaction (Zhao et al. 2009), or on marketing effectiveness (Van Heerde et al. 2007). Gray et al. (2011) investigate the quality risk in offshore manufacturing plants and find that the effect of plant location, geographic distance, and the skill level of workers can affect supply chain quality risk. Hora et al. (2011) robustly examine the product recall pattern in a case when quality risk triggered a destructive product recall in the toy industry. Their study enhances the understanding of the nature of different recall strategies and the best time to trigger the recall. Although there have been numerous studies related to product harm crisis presented in recent years, the research is still limited to the reactive activities after the product harm crisis has occurred (i.e. product recall management).

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SD, which can be regarded as a preventive risk management approach, refers to the efforts made by the focal company to build up suppliers' capability and performance (Krause 1999). Krause and Ellram (1996) argue that firms should ensure their suppliers' performance in terms of quality, cost, delivery and financial health improvement. In SD, the firm wishes to maintain a long-term relationship with reliable and capable suppliers to ensure the provision of quality components. Both the buyer firm and the suppliers contribute to the overall quality of the products, and collaborate in several activities to improve product quality (Salimian et al. 2017). Therefore, the buyer firm's managers need to make decisions about investing in suppliers' facilities in order to improve the product quality. Furthermore, the buyer firm needs to invest in education and training to build the suppliers' abilities to ensure product quality and safety (Krause et al. 2007). These activities are instigated by the purchasing firm in order to help SD regarding quality performance (QP) and capability (Zsidisin and Ellram 2003).

From the perspective of agency theory, SD is a behaviour-based practice. Such practice is concerned with process, tasks and activities that lead to risk reduction (Harland et al. 2003), and represents a suitable strategy when the supplier's uncertainty factor becomes significant (Zsidisin and Ellram (2003). Task programmability refers to the degree to which appropriate behaviour by the agent can be specified in advance, and provides an easy way to measure behaviour (Eisenhardt 1989). When a firm engages in SD, helping a supplier to develop their capability in quality and closely monitoring their operation, a template of activities can be defined and approved by both buyer and seller firms (Zirpoli and Caputo 2002; Zsidisin and Smith 2005). In other words, the activities of SD could engender high task programmability for the supplier. Generally, the more programmable the supplier's task, the easier it becomes for the buyer firm to control the supplier's behaviour. One of the aims of creating task programmability is to reduce the target cost (Zsidisin and Ellram 2003; Zsidisin and Smith 2005). To do this, the process begins with a breakdown of allowable supplier costs. The buyer firm can provide a target cost for the supplier to aim at, while the supplier can suggest possible changes in the task or even in the design in order to reach the predetermined target cost. When the buyer firm creates task programmability by implementing SD, the target cost saving is shared with the supplier. Therefore, SD can contribute to achieving a lower price and thus help the firm to remain competitive in the industry.

Moreover, the SD actions have the benefit of consolidating the idiosyncratic interaction routines that help supply chain partners to realise each other's strengths and weaknesses (Ross et al. 2009). Such consensus between the focal firm and suppliers can contribute to improving the capability to respond to uncertainties, and help the firm to remain competitive in the industry (Foerstl et al. 2010). Li et al. (2012) indicates that the supplier development plans that focusing on close collaboration relationship with the suppliers can significantly improve the quality performance and consequently enhance the competitive advantage of the buying firm. Also, Pulles et al. (2014) suggest that the SD program can significantly lead supplier contribute to buyer's innovation.

Previous empirical studies provide significant evidence to demonstrate the positive effect of SD on both a buyer's product quality and FP (Carr and Kaynak 2007; Al-Tit 2017). For example, when the buyer firm helps the supplier to build up its quality capability, the buyer gains a better understanding of the supplier's weaknesses in the production line; hence the waste generated in each procedure and the quality variance in each task is more likely to be investigated. Thus, it is easier for both parties to be alerted to possible ways of improving the component and of cutting the cost during production (Zirpoli and Caputo 2002; Carr and Kaynak 2007). In addition, Wagner and Johnson (2004) indicate that as a critical element of the strategic supplier portfolios, SD enable focal company to create competitive advantage.

Therefore, the following hypotheses are proposed:

Hypothesis 1. SD has a positive effect on QP.

Hypothesis 2. SD has a positive effect on FP.

Proactively recalling the defective product, an effective procedure for returning the product, and replacing the product are claimed as the most appropriate steps to manage a quality crisis when it has already occurred (Kumar and Budin 2006). Liu et al. (2016) indicates companies should put emphasis on a more proactive product recall (i.e. full remedy) to obtain long-term benefit of the customer satisfaction and trust. A proper product recall strategy should certainly improve the effectiveness of the return process. Although there are no 'hard and fast' rules for preparing for a product recall/withdrawal that can cover every circumstance, a predefined plan can provide some guidelines as to how different parties in a supply chain should act and manage the unsafe/defective products (BRC 2007). Better reactive activities can achieve prompt management of

problematic products in the supply chain. Researchers who hold an opposite view argue that the more proactive product recall adopt by the company will lead to worse firm value, because the investor might treat the proactive product recall as a signal that the crisis is very serve (Liu et al. 2016). However, this study focuses on how a firm prepare for the recall (i.e. remedy planning) instead of the immediate action during the crisis.

PPR aims to diminish the effect of the incident by ensuring that the buyer will not deliver the defective or unsafe products to downstream partners. If the focal firm is alerted to the problem early enough, it will be spared a massive recall. For example, if the defective products get only as far as the distributor, the firm needs only to withdraw the batch of problematic products. In contrast, in the case that the defective products have already been parcelled out and delivered to various retailers or end-customers, massive resources must be allocated for this product withdrawal. The buyer firm will suffer the high operations costs of product recall, which include the costs of contacting customers, logistics, compensation, penalties, and even lawsuits (Kumar and Schmitz 2011). Once the defective products have passed through one more layer of the downstream supply chain, the number of affected parties may increase dramatically.

From a quality management perspective, PPR can be viewed as corrective action. When defects are detected, appropriate measures must be taken to stop them further affecting the companies involved. The firm must determine the source of the defect and investigate other suspect products that might trigger another withdrawal and recall (BRC 2007). If the defect originates from sourced material, the defective component may be included in more than one batch of products. Moreover, the firms need to scrutinise the origin of the quality risk to prevent the same incident from happening again. It is inefficient for a firm to correct the same quality problems more than once (Willians et al. 2006). Also, through thorough planning of remedial action, managers can gain better understanding of which types of quality problem are most costly and difficult to resolve; that is, the problems that require multiple *ex-post* actions when the buyer delivers the faulty products to downstream parties. For example, if a product is contaminated by a toxic substance that contaminated product must not be reworked, nor broken down to sub-components for use in another product. Indeed, the firm might need to employ special resources for its disposal. If managers have prepared in advance for such an eventuality, they can set up an appropriate remedial plan, and the firm can pay extra attention to preventing contamination in the materials and final products (Kumar and Budin 2006). Thus, the

related quality and safety assurance can be enhanced by the better planning of risk remedies. Moreover, the implementation of PPR may also enhance a firm's willingness to learn which in turn can improve firm's performance (Haunschild and Rhee 2004; Hu and Flynn 2014). Therefore, the following hypotheses are proposed:

Hypothesis 3. PPR has a positive effect on QP.

Hypothesis 4. PPR has a positive effect on FP.

2.2 Roles of Inter-organisational control mechanism

Researchers argue that the success of sourcing activities depends heavily on the effectiveness of control mechanisms (Li et al. 2008). Such mechanisms can reduce opportunistic behaviour and improve the company's competitive advantage (Li et al. 2008), especially in highly uncertain environments. According to agency theory, one of the leading causes of agency problems is the presence of conflicting goals between buyer and agent. The appropriate use of control mechanisms can reduce goal incongruence and preference divergences among supply chain partners (Li et al. 2008), and so ensure responsible purchasing. According to Das and Teng (2001), there are two kinds of control mechanism, namely formal control (FC) and social control (SC). FC focuses on utilising rules and specified procedures, while SC emphasises mutual benefits and norms (Li et al. 2008).

Using the explicit contract to specify the responsibilities and obligations of each party, FC can reduce opportunism and safeguard inter-organisational relationships (IORs) (Li et al. 2010a; Schepker et al. 2014; Cao and Lumineau 2015). Recent research indicates the adoption of FC can facilitate company's capability to leverage the resource to foster performance (Wacker et al. 2016). According to Luo (2002), when foreign company establish the collaboration with the company in China, they tend to emphasize more on the role of FC. Meanwhile, in inter-firm coordination as in all kinds of alliances, there is usually a 'social side'. Here the SC mechanism comes into operation, characterised by particular traits such as relying on informal structures and self-enforcement of each party in IORs (Dyer and Singh 1998; Cao and Lumineau 2015; Zhang et al. 2017). Differing in focus compared to FC, SC requires that the group share values, beliefs and goals so that appropriate behaviours can be reinforced and rewarded. According to Gulati and Sytch

(2007), the relational governance (i.e. SC) can provide company additional relational rents in IORs so as to foster procurement performance.

In compare with the western countries, there are different views of the use of relational ties or more impersonal institutions in the emerging economies like China. Given that China had experienced a remarkable economic transformation from a centrally planned to a market-based economy, coming with increased scope and complexity of the economic transactions, the Chinese companies should rely more on the contractual control mechanism (Peng 2003). However, other researchers argue that the relational governance will still to be the major way for the Chinese companies to govern the complex transactions, because of the traditional culture and the highly uncertain nature of the business environment (Zhou et al. 2003). The empirical evidence that informing the issue of IORs control mechanism in China are inconsistent and scare (Zhou et al. 2008). Moreover, the research that investigating the roles of control mechanisms in SCRM is rarely found in the existing studies. To address these research gaps, in the context of China, we examine the roles of FC and FC in our joint SCRM practices. We argue that both SC and FC might be both the key drivers for firms to achieve effective SCRM and even strengthen the effect of SCRM practices on firm performance.

2.2.1 Impact of control mechanisms on SCRM practices

In SD, task programmability is an essential element to monitor the supplier's manufacturing process and ensure the quality and safety of the product supplied (Madhusudan 2005). Moreover, the buyer firm can monitor supplier operations and behaviour by keeping track of the documents or statistical process control data of each manufacturing task, which is one aspect of FC (Lyles et al. 2008). The process of '*keep on tracking*' is part of the effort to achieve high measurability.

The success of task programmability and output measurability requires an unambiguous ultimate target. For example, buyer and supplier need to have common objectives (for example, improving quality, mitigating risk) while jointly developing the programmable tasks in the manufacturing process. However, some inter-firm coordination activities carried out under SD are difficult to program and measure. The target levels of quality improvement and risk mitigation are ambiguous, so that it is hard to determine measurement output. Also, the group may lack knowledge of this transformation process (i.e. task programmability) of risk mitigation (Das and Teng 2001). For instance, how can

we program the task to reduce the potential quality risk in the purchased product? As the potential quality risk cannot be easily identified and quantified, it is difficult to develop a step-by-step process to reduce risk. Consequently, the SC mechanism is needed to govern the values, beliefs, and goals of SD actions.

Therefore, the following hypotheses are proposed:

Hypothesis 5. FC has a positive effect on SD.

Hypothesis 6. SC has a positive effect on SD.

In PPR, a template of activities is developed which details the appropriate managerial actions to follow when a product recall is needed. This template is an effort towards task programmability, whereby each key action is followed and monitored to prevent the spread of problematic products through the downstream supply chain. Product recall is a high measurability practice, because managers can easily count the number of defective products that are recalled from the customer. Hence, the FC mechanism can ensure that supply chain partners will appropriately handle each of the recall processes (Dawar and Pillutla 2000).

However, PPR also has ambiguous objectives that are difficult to program and measure. For instance, managers in the alliance may ask to what extent they should recall the problematic product from the downstream supply chain. Where there is only a limited quality threat (i.e. no danger of harm to customers' health), the firm may not advise consumers to return the product. Instead, managers may consider withdrawing the defective products from their downstream buyer companies (BRC, 2007). Moreover, the downstream partners might choose not to recall the product, as it will not cause an emergency. In this situation, PPR has relatively low programmability and measurability, as the tasks and objectives cannot be precisely programmed and measured (Das and Teng, 2001). Thus, the SC mechanism is useful to control the behaviours of downstream partners, as the existence of common beliefs and goals of product recall management can motivate the partner firms to perform well in the inter-firm product recall activities.

Therefore, the following hypotheses are proposed:

Hypothesis 7. FC has a positive effect on PPR.

Hypothesis 8. SC has a positive effect on PPR.

2.2.2 The moderating roles of control mechanisms

Since PPR involves activities that require close collaboration in the supply chain network, companies need to establish the most appropriate ways to enhance such collaboration. Clearly, the control mechanisms are useful for sustaining inter-organisational cooperation (Li et al. 2010b), so as to strengthen the impact of PPR on the firm's performance. For example, supply chain partners need to comply with the pre-set rules or agreements so as to identify potential problems in the components and operate the remedy practices effectively, thus minimising the negative financial impact. In other words, FC helps focal firms to enhance the positive impact of PPR on both quality and financial performance. Also, the adoption of control mechanisms can directly influence transaction costs, operational costs, and the willingness to engage in the risk management activities (Das and Teng 2001; Li et al. 2008). A firm with better SC mechanisms might be more motivated to implement, and exert more effort in leveraging, PPR to mitigate the quality risk and improve performance. In particular, PPR requires a high level of robustness, such as rapid response, accurate tracing of the source of problems and comprehensive review (Berman 1999). If supply chain partners face the challenges in product recall without the same goal or shared norms, they might lack the willingness to operate the PPR activities in a timely manner, which could result in inefficiency in tracing the source of problems or cause delay to the product withdrawal process. As a result, there might be a greater loss for the focal company during a product recall. Therefore, control mechanisms could be seen as the activator of PPR for focal firms to enhance their performance:

Hypothesis 9: FC strengthens the impacts of PPR on (a) QP; (b) FP.

Hypothesis 10: SC strengthens the impacts of PPR on (a) QP; (b) FP.

The main objective of SD is to improve supplier performance (Carr and Kaynak 2007) so as to enhance the buyer's product quality and FP. However, implementing SD does not guarantee better performance, due to the existence of various pitfalls regarding lack of trust and supplier commitment (Handfield et al. 2009). Control mechanisms, which focus on governing the inter-organisational relationship (Li et al. 2008), enable firms to avoid these pitfalls when implementing SD. According to Handfield et al. (2009), before implementing SD the buyer company should explain clearly the potential benefits, to avoid the lack of supplier commitment. Praxmarer-Carus et al. (2013) indicate that the

supplier's perceived distribute fairness is a critical predictor of supplier's satisfaction with SD program. If the buyer fails to convince the supplier that SD is profitable, the supplier may not be fully committed to the effort of implementing SD (Handfield et al. 2009). In such a case, SC mechanisms could enhance the supplier's acknowledgement of the benefits in SD. Because fulfilment of promises is one of the most important forms of SC (Fryxell et al. 2002; Luo 2002), when SC is high, suppliers perceive that the benefits of SD delineated by the buyers are more reliable. Moreover, the use of SC can create informal pressures to sustain the supply chain cooperation (Kaufmann and Carter 2006). Such informal pressures can also help to urge the suppliers to share the financial return or benefits from SD. In other words, the SC mechanism ensures the buyers will obtain the expected returns of SD. On the other hand, the use of FC can exert formal pressure on the supplier, such as through establishing an agreement to share benefits before implementing SD. For example, VarityPerkins[2] will not run an SD program until their supplier formally agrees to benefits sharing (Handfield et al. 2009). Moreover, the use of FC makes it easier for the buyers to clarify the goals and responsibilities of each party at every stage of the SD. Hence, the SD implementation could be more focused and deliverable, as explicit contract details make the efforts and the outcome of SD more measurable. Above all, we propose that:

Hypothesis 11: FC strengthens the impacts of SD on (a) QP; (b) FP.

Hypothesis 12: SC strengthens the impacts of SD on (a) QP; (b) FP.

4. Methodology

4.1 Measurements

In order to establish an appropriate measurement instrument, we undertook a thorough literature review to identify and modify the scales used in previous research. Additionally, some question items were newly created based on the literature review and the related theoretical foundations presented in the previous section (i.e. PPR). The questionnaire items (see Appendix) were reviewed by three academics and three practitioners to ensure content validity. A seven-point Likert scale was adopted to indicate the extent to which

[2] VarityPerkins, established in 1932, is a producer of diesel engines used in automotive and construction vehicles.

respondents agree or disagree with each question item, where 1 = strongly disagree and 7 = strongly agree.

Since our target respondents were directors and managers in China, the questionnaire was translated into Chinese. We consulted a leading scholar in China and Hong Kong to ensure the measurement items in Chinese reflected the business environment faced by the Chinese manufacturing industry. Following the procedure proposed by Brislin (1980), the Chinese questionnaire was subsequently translated back into English by a third party translator to ensure that the measurement items accurately reflect the original meanings.

4.2 Data collection

The unit of analysis of this study focuses on the relationships among business partners in a supply chain. The target respondents were directors or senior managers in manufacturing firms. Data were collected through a survey of Hong Kong manufacturing firms, all of which have their plants in the China Pearl River Delta (PRD) region. This research focuses on China because it is one of the most largest economies and has turned to be the manufacturing centre of the world (Deloitte 2016). Most importantly, in recent years, the Chinese manufacturers have been extensively involved in various product recall incidents. Moreover, the increased product harm incidents in China also present an imminent need to identify the efficient management practices that help to improve quality performance (Roth et al. 2008; Tse and Tan 2012). Given the above reasons, our proposed model is tested and validated by a sample of Chinese manufacturing companies.

A merged contact list containing contact information of 4505 firms dealing in apparel, furniture, plastics, metals, computer equipment, electronics, measuring instruments and miscellaneous manufacturing in Hong Kong and the PRD region was used in this research. Potential informants were contacted three times via email; these communications included a pre-notice and an initial invitation letter along with a link to the survey. Because the Institute for Supply Management, Pearl River Delta (ISM-PRD) has endorsed this research, the invitation email included the ISM-PRD endorsement letter. The survey questionnaires were sent via email, and then after 12 weeks a follow-up email/call was sent to remind the managers to respond (i.e. second round). In total 289 survey questionnaires were received, representing a 6.4% response rate. Of these, 209 were usable. Table 1 shows the information of the respondents.

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We evaluated non-response bias by assessing differences between the respondents and non-respondents. According to the procedure suggested by Armstrong and Overton (1977), researchers can conduct the X^2 tests to show that respondent and non-respondent firms share the same distribution of organisational size and annual sales at $p<0.05$. We compared the samples received in the first round (n=138) with those received in the second round (n=71). The result of the X^2 tests indicates that there are no statistical differences at p<0.05 when comparing organisational size (p=0.713) and annual sales (p=0.411) between early respondents and late respondents. Therefore, the results suggest that non-response bias is not a critical problem.

The common method bias (CMB) may exist, as all the measures use seven-point Likert scales and responses are from a single informant from each organisation (Podsakoff et al. 2003; Mura et al. 2012). To check for this, Harman's single factor test is employed (Podsakoff et al. 2003). The result of exploratory factor analysis (EFA) shows that six distinct factors with eigenvalues greater than one explain 69.116% of the total variance. However, the first factor in the EFA accounts for only 13.099%, which is not the majority of the total variance. Moreover, using AMOS 22, we apply confirmatory factor analysis (CFA) to conduct Harman's single factor test again. The model fit indices of the single factor model (X^2/df = 5.898, NNFI = 0.455, CFI = 0.499, and RMSEA = 0.153) are much worse than the suggested values (O'Leary-Kelly and Vokurka 1998), which indicates that CMB is not a threat to this research.

4.3 Measurement assessment

To check the convergent validity, we conduct CFA by correlating all the constructs. Applying CFA before testing the structural model is consistent with the two-step procedure suggested by Anderson and Gerbing (1988). First, the measurement model shows a good model fit: comparative fit index (CFI) = 0.917, X^2/df is less than 5 (1.91), root mean square error of approximation (RMSEA) is less than 0.08 (0.066). The non-normed fit index (NNFI) of 0.904, the incremental fit index (IFI) of 0.918 and goodness-

fit-index (GFI) of 0.847 further confirm that the measurement model is acceptable. Moreover, as shown in Table 2, the standardised coefficients, which range from 0.577 to 0.91, and the significant *t*-value (p<0.01) exceed the required cut-off values of 0.5 and 2 respectively (O'Leary-Kelly and Vokurka 1998). An average variance extracted (AVE) of 0.50 or higher is usually suggested in the literature (Chin 1998); as shown in Table 2, the AVE values range from 0.522 to 0.732. The composite reliability and Cronbach's alpha are all above 0.766 and 0.764 respectively. Therefore, we can claim that the reliability of each construct is acceptable.

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The AVE comparison method is adopted to assess discriminant validity (Fornell and Larcker 1981). If the square root values of AVE for both the constructs that make up the pair are higher than the inter-correlation between any two constructs in the model, then the latent construct explains its assigned item that it shares with other constructs (Fornell and Larcker 1981). Table 3 shows that the square roots of AVE (bold numbers in diagonal) are greater than the correlations among the constructs (off-diagonal values). The result provides evidence of good discriminant validity.

5. Data Analysis

In this section, we use the structural equations modelling (SEM) method to test all the direct relationships in the baseline model (i.e. H1 – H8), and adopt the hierarchical regression method to obtain the moderation results (i.e. H9 – H12).

5.1 Structural model

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Figure 3 shows the overall results for the structural model. There is a good model fit, with acceptable values - X^2/df = 2.033; CFI = 0.904; RMSEA = 0.070; GFI = 0.836; IFI = 0.905; NNFI = 0.891. Specifically, the structural path between SD and QP is positive and significant (0.160, p<0.05). Thus, a high level of SD is seen to result in a high level of QP, lending support to H1. Likewise, the path coefficient from SD to FP is also significant (0.318; p<0.001), supporting the notion that SD has a positive impact on the firm's FP. Hence, H2 is supported. As the relationship between PPR and QP is positive and significant (0.347, p<0.001), H3 is confirmed. The significant path coefficient (0.309, p<0.001) supports the claim that PPR has positive and direct effect on FP. Therefore, H4 is accepted. Moreover, for the relationship between the risk management practices and control mechanisms, all four hypotheses (H5-H8) are approved. The structural path between FC and SD is positive and significant (0.353, p <0.001), as is the relationship between FC and PPR (0.316, p <0.001). Likewise, the positive effect of SC on SD is also significant (0.332, p <0.001). Finally, the impact of SC on PPR is positively significant (0.463; p<0.001).

We also test the effects of three control variables (i.e. Industry Category, Firm Size and Technology Level) on the two performance constructs. The path coefficients for the control variables on FP and QP are all insignificant. The values for the standardised path coefficient from Firm Size, Industry Category and Technology Level to QP are -0.003, 0.097, and 0.047, and to FP are 0.076, -0.029, and 0.071 respectively. The insignificant path coefficients imply that these factors do not influence the relationships in the proposed model.

5.2 Moderation analysis

To test the moderating effects we use multiple linear regression with the hierarchical procedure. In step one of the regression, we analyse the control variable (Firm Size) as

the independent variable. Then, the variables of risk management practices and control mechanisms are entered in step two and step three respectively. In step four, we examine the interaction terms. To reduce multicollinearity, we transform each construct to mean-centred before producing the interaction terms (Liu 2015). The variance inflation factor (VIF) scores in our models are all below the cut-off value of 10 (O'Brien 2007). Hence, multicollinearity is not a serious issue for the analysis. As shown in Table 4 (Dependent Variable: QP) and Table 5 (Dependent Variable: FP), the effects of the control variable are insignificant. Moreover, in step two of both regression models, our results are similar to those from our structural model (Figure 3). Both SD and PPR have significant and positive effect on both FP and QP.

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Insert Figure 4 here.

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Insert Figure 5 here.

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Insert Figure 6 here.

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This research finds that the two types of control mechanism have different moderation effects in the relationships between risk management practices and performance. In the models for QP, the interaction between FC and PPR is positive and significant (β=0.149), which supports H9a. Hence, FC strengthens the effect of PPR on QP. FC also positively moderates the relationship between PPR and FP (β=0.119). Therefore, H9b is confirmed. With regard to SD, we find that only SC has a significant moderating effect on its impact on the FP (β=0.120), so H12b is supported. Following the procedure of Aiken and West (1991), Figures 4 to 6 present the results of simple slope tests. To illustrate the moderation effect, both moderators were assigned the value of one standard deviation

above and below their means. Although the effects of PPR are significant at both high and low level of FC, PPR is more efficient when the company has higher FC (for QP: β=0.1377 with low level of FC and β=0.2858 with high level of FC; for FP: β=0.1891 with low level of FC and β=0.4255 with high level of FC). Likewise, the relationships between SD and FP are significant at both high and low SC levels (β=0.1466 with low level of SC and β=0.3440 with high level of SC). However, SD is more effective under high SC than under low SC, when it is influencing FP. In summary, based on the simple slope analysis, the results obtained from regression analysis are further supported.

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Insert Table 4 here.

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Insert Table 5 here.

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6. Discussion

Our results contribute to the risk management literature by showing that both PPR and SD are strong determinants of both QP and FP. Our analysis is consistent with the view in the SD literature that inter-firm cooperation in investigating and solving quality problems can improve FP (Carr and Kaynak 2007). The SD approach can benefit both buyer and supplier firms regarding quality and cost if there is a formalised procedure of profit sharing for both firms. Moreover, the results of this research are consistent with those of Zirpoli and Caputo (2002), who found that both buyer and supplier firms take notice of suggested ways to improve the component or cut the cost during production through SD.

Triggering a PPR in response to a product flaw can mitigate the warranty cost and provide an excellent customer relationship in the long run. Moreover, our result suggests

that PPR is a strong determinant of QP. Firms that are ready and willing proactively to withdraw any defective product will be more aware of the quality issues of each component of their products (Kaynak 2003), and high awareness of the potential threat of recall will facilitate the identification of vulnerabilities in their products and operation. As a result, these firms can design a product recall simulation exercise for their more vulnerable items, and will be more likely to investigate the potential root causes of any defect. It should be noted that the relationship between PPR and QP is stronger than the relationship between SD and QP. Furthermore, our result shows that the PPR also significantly influences the FP, which suggests that the operation of PPR is positively related to the long-term profit of the company.

Fiol and Lyles (1985) state that different types of operations comprise different types of information, so the types of control mechanism adopted to manage those operations will vary. Further, the moderating effects of each control mechanism vary across the relationships between PPR and firm's performance. FC, rather than SC, amplifies the effects of PPR on both QP and FP. As product recall is a complex operation, focusing on establishing formal and comprehensive agreements could help the company to control systematically the uncertainties it creates. Proper FC is important to ensure the on-time adoption of PPR, since delayed action may result in worse firm performance in a product recall. In the context of emerging markets such as China, substantial literature demonstrates the critical role of SC mechanisms (Li et al. 2010b). However, the results obtained from the moderating analysis indicate that Chinese companies may require FC mechanisms when they plan the PPR to improve business performance. Although Li et al. (2010b) argue that Chinese managers may regard FC mechanisms as a signal of distrust in IORs, they should be an effective means to clarify responsibilities in a product recall. Extending the research of Li et al. (2010b), our research finds that FC is a unique factor that amplifies the effects of PPR on QP and FP.

Surprisingly, we find that neither control mechanism strengthens the effect of SD on QP. However, the insignificant moderating effects of control mechanisms highlight the fundamental role of SD in a firm's QP. Despite different control mechanisms, SD essentially impact on buyer firm's QP. Moreover, this research finds that the SC positively moderates the relationship between SD and FP. However, the moderating effect of FC is not significant in this relationship. The significant moderating effect of social control is consistent with Blonska et al. (2013), who demonstrate the relational

capital can strengthen the efficiency of the SD that overcome the pitfalls of supplier development by encouraging benefits sharing. This finding provides further support for Lee and Humphreys (2007) argument, which emphasises the strong link between *Guanxi* and SD. In China, where IORs are characterised by greater SC, there is an expectation that favours will be exchanged and repaid in the long run. SD activities, such as training, technology education, and even direct investment, can be seen as a form of favour given by the buyers (Cheng et al. 2012). Under strong SC, the favours received from the activities of SD should place more pressure on suppliers to offer on-time delivery service and continuous supply of required materials or components (Cheng et al. 2012).

This study contributes both theoretically and practically to the field of SCRM. The previous literature in SCRM focuses either on the antecedents which foster the implementation of SCRM (Grötsch et al. 2013) and on the relationship between SCRM practices and firm performances (Wiengarten et al. 2010). From the perspective of agency theory, we extend current literature by investigating a theoretical framework that includes both antecedents and performance outcomes of the SCRM practices. Second, although numerous studies have proposed various SCRM practises and strategies (Finch 2004; Norrman and Jansson 2004; Tang 2006; Tummala and Schoenherr 2011), only a handful of them provide empirical evidences for the validation of these practices (Hendricks et al. 2009; Colicchia and Strozzi 2012; Fan et al. 2017). We respond to this call by empirically examining the operational consequence of both risk management practices (i.e. SD and PPR). Third, to the best of our knowledge, this research is the first attempt to study the direct effect and moderating effect of the control mechanisms on SCRM practices. The various roles of control mechanisms help resolve the question of whether either SC or FC impact directly on risk management practices, or whether the control mechanisms work together with appropriate risk management practices to improve firms' performance. Although the antecedent roles of control mechanisms in risk management practices are highly significant, the results of moderating analysis reveal the effects of control mechanisms on risk management practices from a different perspective.

We also provide several suggestions for industrial practitioners based on the research findings. First, manufacturing firms may wish to rethink their common practices used to deal with quality risk. This research shows that PPR can impact on QP, and the relationship between PPR and QP is even stronger than the relationship between SD and QP. Thus, firms should not only allocate resources to maintain SD activities and to avoid

the possibility of defective products from the supplier production process. Rather, the research model suggests that firms should also be aware of the power of PPR, in which firms are willing to withdraw a potentially problematic product in advance before a product-harm crisis is sparked. Also, formal control and social control mechanisms can improve both risk management practices. Therefore, establishing explicit control rules and cultivating social norms among key supply chain partners can more effectively manage quality risk in the complex global supply chain environment. However, a critical implication for the practitioners is that the use of different control mechanisms might have a different effect in strengthening the relationship between the risk management practice and firm performance. To achieve the optimal performance outcome, firms should build their SCRM strategies in accordance with the use of different control mechanisms. Specifically, it is beneficial for the company to adopt FC to strengthen the effect of PPR on both FP and QP. Managers should understand that the use of SC may not help to improve the effect of PPR on FP and QP. However, when implementing the SD to improve FP, firms should advocate SC in a buyer-supplier relationship.

The two practices of supplier development and proactive product recall are found to influence the product quality. The results also show that the performance effect of risk absorption is positively related to the firm's financial performance. Moreover, the agency theory can be selected as the primary theory to provide the dynamic view of inter-firm cooperation in risk management. The two forms of control mechanism are both found to positively influence the two types of risk management practices. However, the relationship between proactive product recall and financial performance is found to be insignificant. Additionally, the research finds that product quality is an important mediating variable in proactive product recall and firm's financial performance. It is hoped that this study will spawn an interest in empirical study of supply chain quality risk management in future operations management research.

7. Conclusions

This research has proposed and tested two risk management practices, SD and PPR, and their relationships with product quality and financial performance. The two practices are found to influence the FP and QP. Agency theory can be selected as the primary theory to provide a dynamic view of inter-firm cooperation in risk management. The two forms of

control mechanism, FC and SC, are both found to positively influence the two types of risk management practices. However, the moderating roles of control mechanisms are somewhat surprising. This research finds that only FC has a significant moderating effect on the relationship between PPR and both types of performance, while only SC significantly amplifies the effect of SC on FP. We suggest that given the product recall in China could be extremely complex and highly uncertain, companies should rely on the FC to clarify the responsibilities and control the uncertainty. Also, we suggest that with greater SC, companies could be guaranteed that they will be repaid for SD activities from the suppliers. Therefore, SC amplifies the effect of SD on the buyer's business performance.

While this study makes a significant contribution to both academic theory and industrial practice, several limitations must be considered when interpreting the research findings. First, the research uses only a single key respondent from each firm to collect the data. The use of a single respondent to rate diverse SC-related question items may generate some inaccuracy and more than the usual amount of random error. Future research should seek to utilise multiple respondents in each participating organisation to improve the accuracy and to reduce the random error.

Departing from the internal operational process as a core focus of the traditional view of SC risk management, this study focuses on inter-firm cooperation in risk management. Extending this study to other settings will be useful to allow comparison of significant findings across different contexts, for example, Sino-foreign alliances in SC risk management.

Appendix

The respondents were asked to indicate the extent to which they agree or disagree with the below statements as applicable to their firm: (1 = strongly disagree – 7 = strongly agree)

Supplier Development		
SD1	We provide training for suppliers on quality requirements.	(Krause 1999; Sanchez-Rodriguez et al. 2005; Carr and Kaynak 2007; Nagati and Rebolledo 2013)
SD2	We set up tasks and procedures for supplier production with our key suppliers.	
SD3	We hold meetings with suppliers on a regular basis to solve quality problems.	
SD4	We invest in our key suppliers' facilities to improve product quality.	
SD5	We require our key suppliers to return the documents or statistical process control (SPC) data so we can keep track of the production quality (e.g. error rate, defect rate, defect, SPC).	
Proactive product recall		
PPR1	We recall/withdraw products from our customers proactively if the products are defective.	(Siomkos and Kurzbard 1994; Heerde et al. 2007)
PPR2	If our product has a quality problem, we will unconditionally replace the defective product for our customers.	
PPR3	We investigate the cause of product recall/withdrawal in order to avoid it happening again.	
PPR4	Checklists are typically provided detailing the appropriate managerial actions to follow when we need to recall/withdraw a product.	
Formal Control		
FC1	Detailed contract is the most important way to guarantee cooperation success.	(Li et al. 2008; Li et al. 2010b)
FC2	Strict enforcement of detailed contract is essential for controlling the behaviours of all parties.	
FC3	All working rules specified in a detailed contract should be followed.	
FC4	All partners should respect all explicit procedures in a detailed contract.	
Social Control		
SC1	We rely on our partners to keep their promises.	(Li et al. 2008; Li et al. 2010b)
SC2	Our partners are always frank and truthful in their dealings with us.	
SC3	Without monitoring, the partners would fulfil their obligations.	

The respondents were asked to indicate the level of changes in their firm over the past three years (1= decreased significantly; 4= no change; 7= increased significantly)

Quality Performance		
QP1	The warranty cost of our product[1].	(Koufteros et al. 2007)
QP2	Our capability to offer a quality product that meets customer expectations.	
QP3	Our capability to offer a reliable product that meets customer needs.	
QP4	Our capability to offer a durable product that meets customer needs.	
QP5	Our capability to offer a high performance product that meets customer needs.	
Financial Performance		
FP1	Firm's net income before tax.	(Calantone et al. 2002; Merschmann and Thonemann 2011)
FP2	Sales Growth.	
FP3	Return on investment.	
FP4	Overall profitability.	

Note: 1. Reverse coded

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Tables

Table 1. Respondents

Organisation annual revenue		**Percent**
<HK$10 million		22.5%
HK$10 million-HK$50 million		43.5%
HK$50 million-HK$200 million		25.8%
>HK$200 million		8.1%
SIC	**Industry description**	
30	Rubber and miscellaneous plastics products	18.6%
35	Industrial and commercial machinery and computer equipment	21.5%
36	Electronic and other electrical equipment and components, except for computer equipment	55.5%
39	Miscellaneous manufacturing industries	14.4%
Firm Size		
<=200		59.3%
201-500		21.1%
>1000		19.6%

Table 2. Construct Loading and Reliability Index

Construct	**Indicator**	**Item Loading[a]**	**T-value***	**Cronbach's Alpha**	**Composite Reliability**	**AVE**
SD	SD1[b]	0.786	-	0.852	0.859	0.556
	SD2	0.91	14.020			
	SD3	0.765	11.668			
	SD4	0.577	8.391			
	SD5	0.644	9.512			
PPR	PPR1[b]	0.87	-	0.839	0.842	0.575
	PPR2	0.802	12.946			
	PPR3	0.671	10.354			
	PPR4	0.67	10.324			
FC	FC3[b]	0.871	-	0.915	0.916	0.732
	FC2	0.892	17.341			
	FC4	0.835	15.492			
	FC1	0.823	15.095			
SC	SC3[b]	0.712	-	0.764	0.766	0.522
	SC1	0.762	8.810			
	SC2	0.692	8.311			
QP	QP1[b]	0. 637	-	0.85	0.852	0.538
	QP2	0.842	9.522			
	QP3	0. 773	9.010			
	QP4	0.752	8.841			
	QP5	0.641	7.809			
FP	FP1[b]	0.758	-	0.863	0.864	0.613
	FP3	0.802	11.281			
	FP2	0.787	11.074			
	FP4	0.784	11.036			

Note: a. Item loading is also known as the standardised regression weight. b. Fixed parameters. * All item loading significant at 0.01 level

Table 3: Discriminant Validity – AVE comparison

	PPR	**FC**	**FC**	**SD**	**FP**	**SC**
PPR	**0.758**					
FC	0.460	**0.856**				
QP	0.436	0.427	**0.733**			
SD	0.524	0.458	0.330	**0.745**		
FP	0.451	0.256	0.475	0.465	**0.783**	
SC	0.568	0.547	0.378	0.450	0.454	**0.723**

Note: The diagonal elements are the square root of AVE

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Table 4. Hierarchical regression for Quality Performance

Dependent Variable: Quality Performance						
Variable	Step 1	Step 2	Step 3a	Step 4a	Step 3b	Step 4b
Control Variable						
Company Size	-0.008	-0.051	-0.056	-0.053	-0.035	-0.034
Main Effect						
SD		**0.197*** **	**0.135***	**0.122***	**0.169****	**0.167****
PPR		**0.267*** **	**0.196*** **	**0.215*** **	**0.215*** **	**0.236*** **
Moderator						
Formal Control (FC)			**0.223*** **	**0.255*** **		
Social Control (SC)					**0.138***	0.123
Moderation Effect						
FC x SD				-0.090		
FC x RCR				**0.149****		
SC x SD						0.050
SC x RCR						0.007
R^2	0.000	0.155	0.196	0.214	0.169	0.172
F	0.013	**18.677*** **	**10.428*** **	**2.337***	**3.477****	0.297
ΔR^2		0.207	0.000	0.025	0.028	0.030
F Change	0.646	**26.712*** **	0.048	**3.344****	**7.393*** **	**4.081****
Max VIF				1.391		1.628

Note: The significant parameter estimates are set in bold.
* p<0.1 **p<0.05 ***p<0.01

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Table 5. Hierarchical regression for Financial Performance

Dependent Variable: Financial Performance						
Variable	Step 1	Step 2	Step 3a	Step 4a	Step 3b	Step 4b
Control Variable						
Company Size	0.056	0.000	0.006	0.006	0.021	0.019
Main Effect						
SD		**0.302*** **	**0.298*** **	**0.279*** **	**0.262*** **	**0.254*** **
PPR		**0.236*** **	**0.232*** **	**0.246*** **	**0.163** **	**0.226*** **
Moderator						
Formal Control (FC)			0.016	0.060		
Social Control (SC)					**0.193*** **	**0.132** **
Moderation Effect						
FC x SD				0.076		
FC x RCR				**0.119***		
SC x SD						**0.120***
SC x RCR						0.091
R^2	0.003	0.210	0.210	0.236	0.238	0.268
F	0.646	**18.077*** **	**13.506*** **	**10.327*** **	**15.831*** **	**12.235*** **
ΔR^2		0.207	0.000	0.025	0.028	0.030
F Change	0.646	**26.712*** **	0.048	**3.344** **	**7.393*** **	**4.081** **
Max VIF				1.391		1.628

Note: The significant parameter estimates are set in bold.
* p<0.1 **p<0.05 ***p<0.01

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Figures

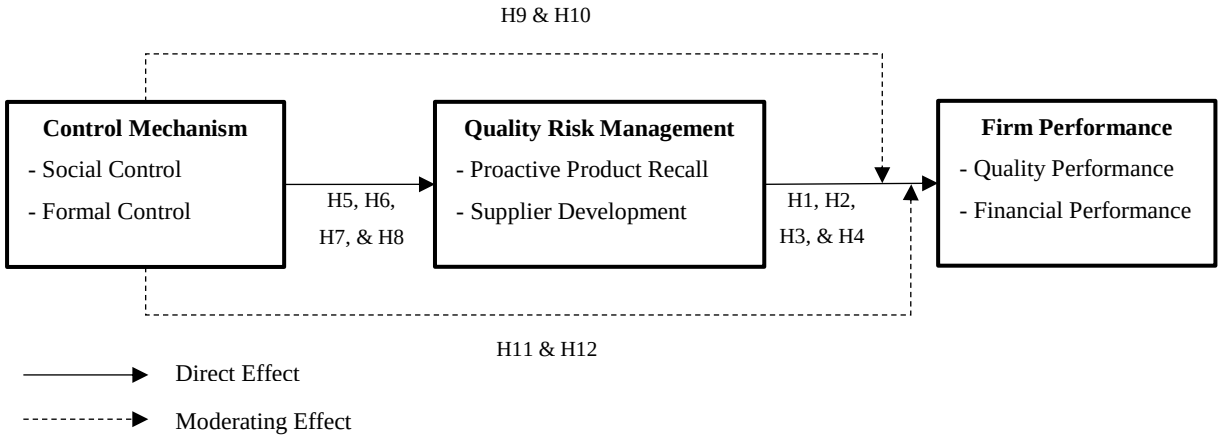


Figure 1. Conceptual Model

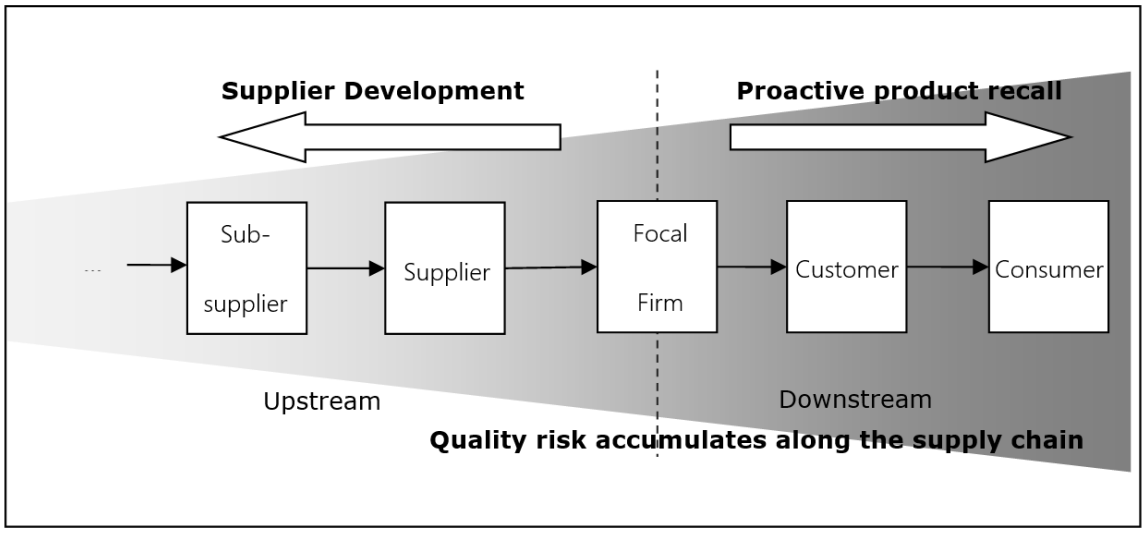
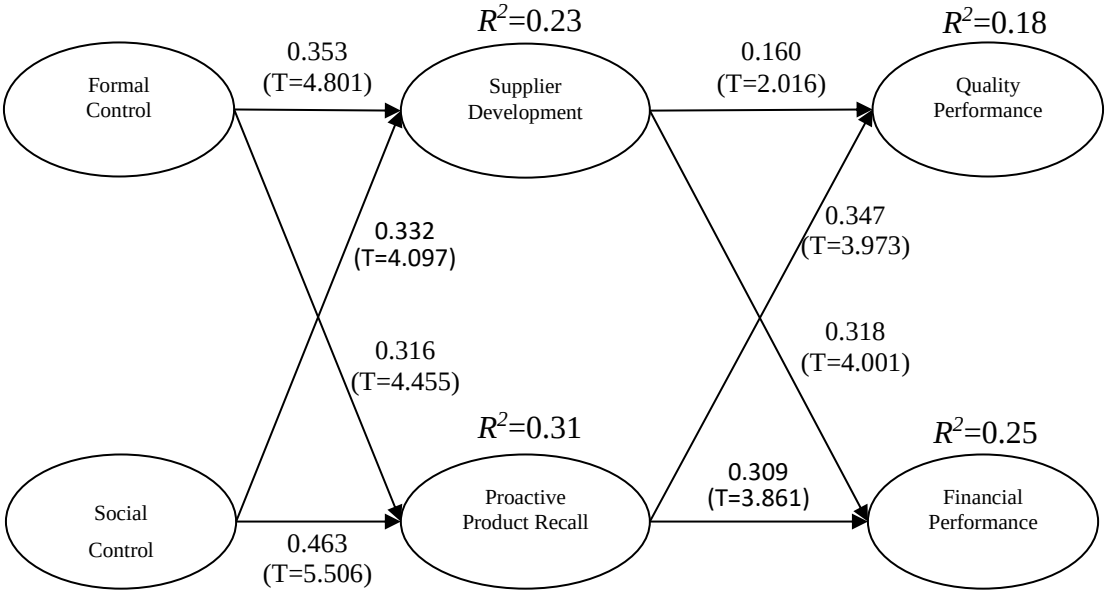


Figure 2. SD and PPR adopted in firm's supply chain



Note: 1. Numbers show above the arrow represent the standardised regression weight. 2. All structural paths are significant at 0.05 level

Figure 3. Structural Model

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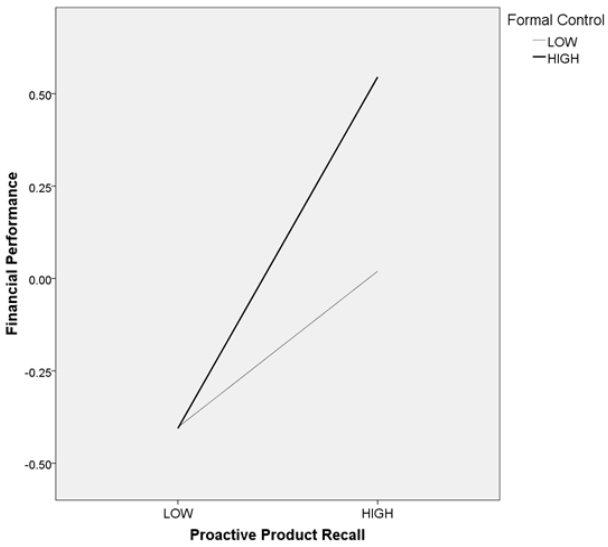

Figure 4. Moderating effect of FC on relationship between RCR and FP

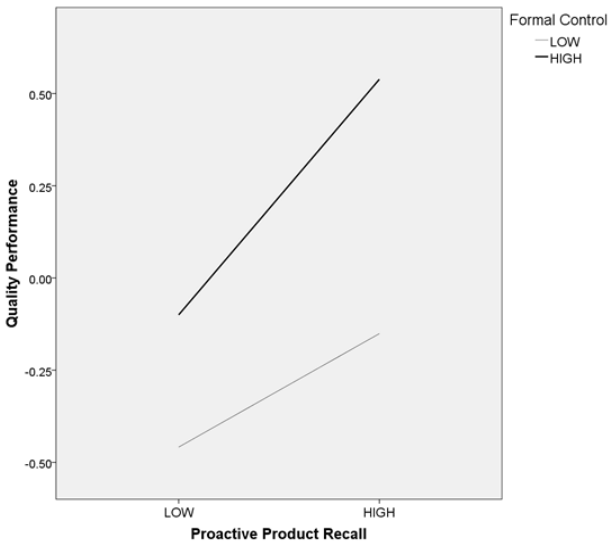

Figure 5. Moderating effect of FC on relationship between RCR and QP

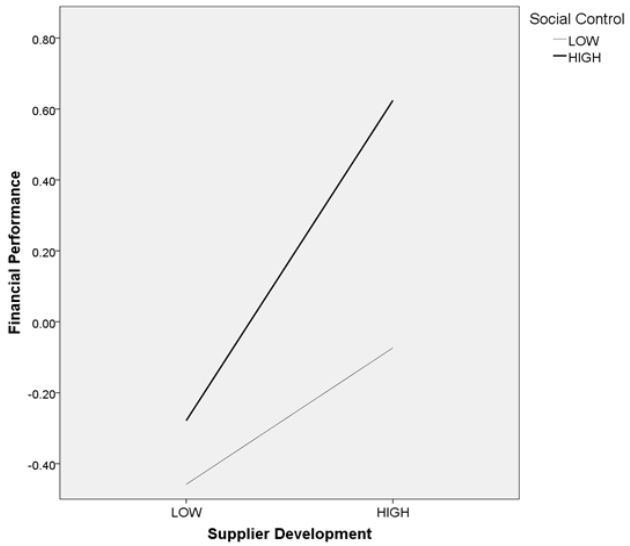

Figure 6. Moderating effect of SC on relationship between SD and FP

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