Supply chain quality management and product recall: A multi-method research

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Abstract

This study empirically investigates the impact of supply chain quality management on product recalls. Combining the methods of case study and quantitative survey, we find that a company's product recall system includes both tracking and traceability and process management. We also find that quality management teamwork and supplier selection are positively associated with product recall systems. Quality management teamwork is positively associated with supplier selection and involvement. In addition, both quality management teamwork and supplier involvement enhance product recall systems indirectly through supplier selection. The findings improve current understandings on how to manage product recalls in globalized supply chains.

Keywords: Product recall, supply chain quality management, multi-methodological research

Introduction

A product recall is the removal of a product that was found to be hazardous to consumers from the market. Studies have found that product recalls have significant and negative impacts on firm performance (Davidson III and Worrell, 1992, Zhao et al., 2013). Reports show that product recalls are on the rise in both developed countries and emerging economies and in several industries including food, automobiles, pharmaceuticals and toys (Lyles et al., 2008, Ni et al., 2016). Outsourcing and globalization of production have led to complex and deep supply chains which made manufacturers vulnerable to product quality failures. As the threats of product-harm

crises could come from suppliers' purchasing, design, manufacturing, and delivery operations, the safety and security of the Made-in-China products and components have attracted substantial attention from both researchers and managers (Roth et al., 2008, Song et al., 2017). Most of existing studies regarding product recalls have been on the impact of product-harm crises and product recalls (Steven et al., 2014, Steven and Britto, 2016, Zhao et al., 2013). There is limited empirical evidence on how to develop a product recall system and the impact of quality and supply chain management, especially in emerging markets because it is difficult for researchers to directly measure how firms manage product recalls (Chen et al., 2009).

Quality management is made up of a set of mutually reinforcing principles, practices and technique that are critical to customer satisfaction and firm survival. Researchers argue that firms must now look beyond their own internal operations and adopt a system-level perspective to actively manage quality in supply chains (Flynn and Flynn, 2005). Supply chain quality management (SCQM) can be defined as the "formal coordination and integration of business processes involving all partner organizations in the supply channel to measure, analyse and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace" (Robinson and Malhotra, 2005:319). It is a systems-based approach to performance improvement by leveraging the linkages with supply chain partners (Foster, 2008) which can reduce product defects and to ensure safety and security across supply chains (Song et al., 2017). Although researchers have found that SCQM can reduce supply chain risks and improve firm performance (Song et al., 2017, Zhang et al., 2017), few studies have linked SCQM with the development of product recall systems.

This study addresses two research questions. First, what are the components of a product recall system? Second, how does SCQM affect product recall systems? The findings provide empirical evidence on the content of a product recall system and how to design and manage the system by adopting SCQM. The results can also enhance current understandings on how product calls can be managed using a supply chain perspective. Moreover, the study helps Western firms to select and manage suppliers in emerging economies to reduce supply chain risks and the negative impacts of product-harm crises.

Literature review

Product recalls occur when firms' products violate safety standards, fail to conform to specifications or contain defects that could cause substantial harm (Chen et al., 2009, Hora et al., 2011). Design flaws and manufacturing defects of any member of a supply chain may lead to product calls (Hora et al., 2011). Researchers argue that product recalls are among a firm's worst nightmares because they give rise to both direct (e.g. logistics, disposal, restitution, and legal and liability costs) and indirect costs (e.g. loss of sales, brand image and reputation and erosion of market value) (Roth et al., 2008, Hora et al., 2011) and cause the decline of the stock price or even bankruptcy. Researchers have also empirically investigated the causes of product recalls and the factors affecting the impacts of product recalls. Conceptual frameworks have been proposed on how to manage product recalls in globalized supply chain involving Chinese manufacturers.

SCQM extends the firm-centric and product-based quality management approaches from a supply chain perspective, allowing a firm to leverage supply chain partners' resources and capabilities and to achieve high levels of quality-related performance at low costs (Robinson and Malhotra, 2005, Flynn and Flynn, 2005). SCQM involves

establishing collaborative relationships with suppliers for quality management and improvements, which lead to the development of cumulative capabilities benefiting the whole supply chain. SCQM is characterized by the strategic and operational collaboration between an organization's internal functions and external supply chain partners and by the joint management of intra- and inter-organizational quality-related relationships, communications and processes (Robinson and Malhotra, 2005, Zhang et al., 2017, Foster, 2008). Researchers have proposed various frameworks to conceptualize SCQM among which internal and supplier quality management are two key components. Researchers have empirically investigated the impacts of SCQM on performance outcomes and the relationships among the SCQM components. Although empirical evidence exists that SCQM improves a firm's quality performance, few studies have explored how SCQM affects product recall systems.

Research methods

This study adopted a multi-methodological approach (Choi et al., 2016, Boyer and Swink, 2008). Case study method was used to identify elements to measure the constructs and develop hypotheses and quantitative survey method was then employed to test and refine the hypotheses. This choice was motivated by the research objectives and the lack of empirical evidence on Chinese manufacturers' product recall systems. Case study method helps to identify real product recall systems and provides an in-depth description of SCQM in a natural setting, which form a foundation for further examination (Boyer and Swink, 2008). Quantitative survey enables researchers to measure a firm's product recall systems and SCQM practices which are not be directly observable and validate the findings (Boyer and Swink, 2008). Combining the two approaches allows researchers to yield data for triangulation and derive solid research results (Choi et al., 2016).

Phase 1: Case study

We theoretically selected three manufacturers from the food, automobile and pharmaceutical industries because Chinese manufacturers in these industries are playing critical roles in global supply chains and have attracted much attention due to quality issues (Lyles et al., 2008, Roth et al., 2008). The three cases were chosen based on literal replication as they all faced stringent government regulations and industrial pressures on quality and have developed product recall systems and adopted SCQM. The data sources for this study included semi-structured interviews, personal observations and secondary data (e.g. information from the internet and internal documents) allowing triangulation on important issues. The interviews were guided by a research protocol, which was initially developed based on the research questions and the relevant literature. The reliability was addressed through the use of the research protocol and the development of the case study database. Using multiple data sources and maintaining a chain of evidence help this study to establish construct validity. Purposive coding was conducted to identify instances on product recall and SCQM. The research team individually coded the case materials and met to discuss the classifications. If there were disagreements, the team discussed the coding and the case materials until consensus was achieved. The pattern-matching logic was used to strengthen the internal validity.

The case companies view product recalls as critical follow-up reactions to product defects and recovery measures for product failures. The managers commented that a product recall system should be able to identify the source of defects and reduce the negative effects of recalls. The case companies have established tracking and tracing

systems throughout the supply chains. The managers commented that there are standardized procedures that allow them to effectively identify the source of all raw materials and parts for each unit of output and the source of quality problems. For example, Auto can trace back to each unit of components (e.g. single wire) to its suppliers and the flow of each car to the final consumers. The nation-wide information system built by State Food and Drug Administration (SFDA) allows Pharm to register the ingredients and the source of each ingredient of the drugs and record the movement of the drugs, which help Pharm to trace the source of raw materials. Food also uses ear tags of each cow to track the drugs and feeds the cow taken and to keep records of all sample-testing results from milking to production. When a quality problem is detected, Food can trace back to each cow. Therefore, we find that the case companies can access the information that allows them to identify and trace each unit of its output from production to delivery and to track the source of quality problems in the supply chains. The managers commented that process management is very important for them to mitigate the negative effects of a recall and to recover promptly from a crisis. Evidence reveals that the case companies have established processes and procedures for coordinating product recall activities and have developed strict guidelines for determining when they will recall a defective product. They are proactive in monitoring and handling the quality problems and will initiate a product recall if there are any concerns about consumer safety. For example, Auto collects information about quality complaints through multiple channels and the company once recalled products after it found complaints from the internet. Auto replaces and repairs the defective parts for free and provides spare cars for affected customers. Pharm and Food will recall products when they become aware of potential hazards to customers through internal inspections and before any customer reports safety incidents. Process management thus helps the companies to respond to consumer complaints early and issue speedy recalls. Therefore, the case evidence suggests that a company's product recall systems include both tracking and traceability and process management.

We find that the multifunctional teams with representatives from different internal departments play critical roles for the case companies to manage quality across the supply chains and product recall. Led by the quality departments, the case companies arrange their quality-related practices and procedures across various internal functions into synchronized and collaborative processes. The managers commented that cross-functional collaboration and quality management teamwork enable them to control quality throughout the supply chains. Multi-functional teams are formed to solve quality problems. Procedures have been developed for the communication of quality-related information and joint decision making on quality improvement among all team members. The case evidence reveals that multiple departments are required to work together to solve quality problems and handle recalls. The quality departments in the three case companies also lead teams to manage almost all the activities related to supply chain quality control, such as selecting and auditing suppliers, incoming inspection, supplier evaluation and product development. One manager commended that teamwork in quality management enables it to improve "the influence on my suppliers to improve my quality" (Auto). Quality management teamwork facilitates the case companies to integrate internal functions or processes and enable them to have a systematic and global control on the supply chains. Therefore, teamwork in quality management can improve the information flows and increase the transparency of the supply chain processes, facilitating the companies to trace materials and products and identify the sources of quality problems. It breaks down functional barriers and employees from different functions can work together to analyse and respond to

customer complaints. Quality management teamwork allows various departments to evaluate the impacts of product collaboratively and make joint decisions. In this way, companies can reduce the negative impacts of product recalls on their operations and develop reaction plans for potential quality issues quickly. Therefore, we propose the following hypothesis.

H1: Quality management teamwork is positively associated with product recall system.

We find that supplier selection and supplier involvement are two key practices the case companies adopted to manage suppliers to support product recall. Quality related criteria such as quality management system and qualifications play critical roles in selecting and evaluating suppliers. When designing supply networks, the case companies all believe that the capabilities on quality control significantly influence the decisions on the location and number of the suppliers. For example, Auto adopts a multiple sourcing strategy for each component to reduce quality risks. Pharm only selects suppliers with GMP (Good Manufacturing practices) certificate, and on-site visits are required before placing orders with suppliers. Food tends to collaborate with large farms who have more resources and are more capable in managing quality. Regular quality audits are conducted at suppliers' sites (Auto and Pharm). Established guidelines and procedures are used to evaluate and assess suppliers' quality performance. For example, Food develops a "one hundred points" management system to rate suppliers. The suppliers with low points will be disqualified and removed from the supply base. In addition, the case companies invest resources to maintain long-term relationships with selected suppliers. Collaborating with suppliers with high quality performance and reliable quality management system allows the case companies to establish systems and procedures to manage product recalls. Suppliers with high quality management capabilities also allow them to respond to quality issues quickly. In addition, frequent on-site audits and quality performance evaluation help case companies to promptly identify potential quality problems. Established quality management systems and procedures facilitate the information flows in supply chains which enable the case companies to trace the movement of raw materials and track the sources of quality issues. Therefore, we propose the following hypothesis.

H2: Supplier selection is positively associated with product recall system.

Involving suppliers in the product design and development processes has been viewed as an important method to achieve high quality by the three case companies. Supplier involvement allows them to acquire new knowledge and information and develop core quality competencies derived from coordination with critical suppliers. We find that Auto partners with suppliers in the product and process design and involves some suppliers, such as exhaust system and horn suppliers, into product development teams. Pharm argues that intellectual property issues can be concerns when involving suppliers directly and it collaborates with suppliers informally in the design stage through frequent communications. The managers commented that supplier involvement enables the case companies to control product quality from the source and reduce the quality problems caused by the mismatches among different components. The knowledge and capabilities learned from suppliers can generate opportunities that enable the case companies to design and produce high quality products. Managers commented that supplier involvement allows them to leverage suppliers' resources to design innovative products, which can reduce design and manufacturing errors. Supplier involvement can break down the barriers between companies and suppliers, allowing companies to respond quickly to quality problems. The frequent communications and supplier involvement in the design processes also improve the transparency and the information flows of the supply chains, which facilitate the companies to trace the

movement of materials and products and to identify the sources of quality problems. In addition, the collaboration with suppliers helps companies to develop procedures to manage product recalls. Therefore, we propose the following hypothesis.

H3: Supplier involvement is positively associated with product recall system.

The managers also commented that supplier selection and involvement are not independent. Involving suppliers in new product development affects the processes and criteria used in supplier selection. For example, Auto views research and development (R&D) capability as an important criterion in selecting suppliers. Food tends to collaborate with large suppliers because they have more resources and capabilities that can contribute to its product development. Suppliers' R&D capability is also a key component in the "one hundred points" management system. Pharm selects suppliers with compatible value on quality and have advanced production environment and quality control practices to ensure that suppliers can contribute to its product design. To improve the quality of the products, partnering with suppliers in product design motivates the case companies to select suppliers with reliable quality management system and high capabilities on quality management, which affects the procedures for supplier qualification and performance evaluation. Therefore, we propose the following hypothesis.

H4: Supplier involvement is positively associated with supplier selection.

The case evidence suggests that quality management teamwork plays crucial roles in supplier selection and involvement. For example, Auto uses multi-functional teams in supplier selection. The quality departments in Auto and Pharm actively participate in the product design processes, which is conducted by a team including representatives from other departments such as manufacturing, marketing and purchasing. In the three case companies, the on-site supplier visits and quality audits are performed by multi-functional teams. Using teams to solve quality problems and in quality improvement projects allow companies to develop a holistic understanding on the requirements and expectations on suppliers. Quality management teamwork facilitates companies to conduct on-site supplier auditing and evaluate suppliers' capabilities and performance. Intensive communications and collaboration within the team also help companies develop supplier selection procedures and guidelines incorporating opinions from various departments. In addition, quality management teamwork provides an integrated interface which facilitates the communications between suppliers and companies and the involvement of suppliers in the product design teams. Therefore, we propose the following hypotheses.

H5: Quality management teamwork is positively associated with supplier selection.

H6: Quality management teamwork is positively associated with supplier involvement.

Phase 2: Quantitative survey

Based on the relevant literature and case study, a survey instrument was designed to measure a company's quality management teamwork, supplier selection, supplier involvement and product recall system. A multiple-item, 7-point Likert-type scale (1= "strongly disagree"; 7= "strongly agree") was used for all constructs. In addition, the questionnaire included questions related to the demographic profile of the companies (e.g. industry, ownership, number of employees and total sales). To test the hypotheses, manufacturing firms were randomly selected from three major areas (i.e. Pearl River Delta, Yangtze River Delta, and Bohai Sea Economic Area) that represent the national economy of China. Beside the three industries for case study (food, automobile, and pharmaceutical), we also collected data from the toy industry. The Chinese toy industry is export oriented and has a high rate of recalls, most of which were issued in the

foreign market. For example, in the U.S., 90% of toys sold in the market are imported from China, and among all the toy recalls, about 80% were related to Chinese-made toys. The manufacturing company list of China Statistical Bureau is used as the sampling frame. The manufacturing companies were contacted by phone and were invited to participate in this project. To make sure the appropriateness of the informants, we asked them some questions before the invitation to ensure that the company and the informant is our target. Then we made an appointment with the appropriate respondents to conduct an on-site interview, so that we can give the questionnaire to them face-to-face, and ask them to fill in the questionnaire immediately. Key informants included general managers, presidents, directors, quality manager, and supply chain managers. Questionnaires were sent to 1,623 randomly selected manufacturers. The research team finally collected 400 usable questionnaires. Hence, the response rate is 24.6%.

Reliability was assessed in terms of composite reliability and Cronbach's Alpha. The values of composite reliability and Cronbach's Alpha range from 0.708 to 0.829 and from 0.848 to 0.880 respectively. All of the average variance extracted (AVE) values are above the recommended value of 0.50 (ranging from 0.542 to 0.667), which demonstrate adequate convergent validity. Comparisons of all the correlations and square roots of the AVEs indicate adequate discriminant validity for all constructs. A second-order measurement model was constructed using confirmatory factor analysis to further assess convergent validity. In the model, the items for were linked first to the constructs of tracking and traceability and process management, which then loaded onto the second-order construct product recall system, and the items for quality management teamwork, supplier selection and supplier involvement were directly linked to corresponding constructs. The resulting model fit indices are $\chi^2(161)=281.236$, CFI=0.956, TLI=0.948 and RMSEA=0.043, which are better than the threshold values. The factor loadings range from 0.633 to 0.863 and the t-statistics of the factor loadings are all significant at the $p < 0.01$ level.

Structural equation modelling (SEM) is used to test the research hypotheses. SEM estimates are generated using the AMOS program with the maximum likelihood estimation method. We have controlled the effects of industry, ownership and total sales in the analysis. The model fit indices are $\chi^2(215) =372.113$, CFI=0.944, TLI=0.934 and RMSEA=0.043, indicating that the model can be accepted. We find that quality management teamwork ($b=0.437$, $p<0.01$) and supplier selection ($b=0.368$, $p<0.01$) improve product recall system. Hence, H1 and H2 are supported. However, the direct effect of supplier involvement on product recall system is not significant. Hence, H3 is not supported. The results also show that supplier involvement is positively associated with supplier selection ($b=0.238$, $p<0.01$) and quality management teamwork enhances both supplier selection ($b=0.414$, $p<0.01$) and supplier involvement ($b=0.342$, $p<0.01$). Therefore, H4, H5 and H6 are all supported. In addition, the findings reveal that the impact of industry is significant ($b=0.135$, $p<0.01$) whereas ownership and total sales do not significantly affect product recall systems.

We further examine the joint effects of quality management teamwork, supplier selection and supplier involvement on product recall system using the bias-corrected bootstrapping method with a 95% confidence level and 5000 samples. The results show that the indirect effect of supplier involvement on product recall system through supplier selection is 0.060 and the bias-corrected 95% confidence interval of the indirect effect is (0.036, 0.096). The indirect effect of quality management teamwork on product recall system through supplier selection is 0.125 and the bias-corrected 95% confidence interval of the indirect effect is (0.077, 0.189). We also find that quality management teamwork improves supplier selection indirectly through supplier involvement

(b=0.060) and the bias-corrected 95% confidence interval is (0.027, 0.109). Therefore, the impact of supplier involvement on product recall system is fully mediated by supplier selection and supplier selection also partially mediates the effect of quality management teamwork on supplier selection. In addition, supplier involvement partially mediates the impact of quality management teamwork on supplier selection.

Discussion and conclusions

This study contributes to the quality management literature in two ways. Frist, the study enhances existing knowledge on the components of a product recall system and how a company can effectively manage product recalls. Researchers have provided empirical evidence on the negative impacts of product recalls on firm performances and how the impacts are influenced by the companies' strategies, operations and environments (Chen et al., 2009, Steven et al., 2014, Davidson III and Worrell, 1992, Ni et al., 2016, Zhao et al., 2013, Hora et al., 2011, Steven and Britto, 2016). Few studies have taken an operational perspective to investigate the processes and practices companies used to manage product recalls. Using a case study method, we find that a company's product recall systems include both tracking and traceability and process management. We also develop a measurement scale for product recall systems which have been tested for validity and reliability using a quantitative survey. The results build a foundation for researchers to empirically investigate the contingencies affecting the impact of product recalls (Steven and Britto, 2016, Hora et al., 2011). The findings improve current understandings on how Chinese manufacturers manage product recalls and develop an effective product recall system. This study also sheds light on how Western companies can manage the negative impacts of product quality problems in globalized supply chains by selecting Chinese patterns with advanced product recall systems (Lyles et al., 2008, Roth et al., 2008). Second, this study provides empirical evidence on the mechanisms through which SCQM affects product recall systems and how to develop product recall systems. The findings enhance existing knowledge on the antecedents of product recall systems by linking SCQM with product recalls (Foster, 2008, Steven and Britto, 2016). In addition, extant studies have shown that SCQM improves companies' quality performance and competitiveness. We extend literature by revealing that SCQM can also help companies to manage product recalls. This study finds that a company can develop a system to manage product recalls by applying both internal and supply quality management practices. The results also show that quality management teamwork improves both supplier selection and involvement and that both quality management teamwork and supplier involvement improve product recall systems indirectly through supplier selection. Therefore, we suggest researchers consider the interrelationships among the SCQM practices and their joint effects when investigating the performance outcomes of SCQM. The findings also provide insights on how companies can improve product recalls by developing Chinese partners' quality management capabilities. Moreover, using a multi-methodological approach allows us to explore the multiple perspective and gain an accurate picture on how product recalls are managed, which increase the scientific merit of the study (Boyer and Swink, 2008, Choi et al., 2016).

This study also provides managerial guidelines for managing product recalls and quality in globalized supply chains. First, we suggest companies develop a system that includes both tracking and traceability and process management to manage product recalls. Companies should develop an information system that allows them to trace the raw materials, parts the products and track the source of quality problems across supply chains. Standardized procedures should be created for identifying the source of quality problems. Systems and procedures should be created for coordinating product recall

activities and strict guidelines should be developed for determining when to recall a product. Second, we suggest companies adopt quality management teamwork to integrate internal quality management efforts. Companies should form multifunctional teams to solve quality problems and conduct quality improvement projects. Tools should be provided to facilitate the communications and interactions among team members and procedures should be developed to integrate team members' opinions in decision making. Third, we suggest companies adopt supplier selection and involvement practices to cooperate with suppliers in managing quality. Companies should regularly conduct quality audits of suppliers' sites and use established guidelines and procedures to qualify and evaluate the quality performance of our suppliers. We also suggest companies select suppliers with reliable quality management systems. In addition, we suggest companies partner with suppliers in new product development and involve them in the new product design teams. Managers should be aware that frequent communications with suppliers in the product design are also critical for managing product quality. Managers should be aware that supplier involvement only enhances product recall systems indirectly through supplier selection and hence we suggest managers implement the two practices together to capture their joint effects. Moreover, we suggest companies apply the quality management teamwork and supplier selection and involvement simultaneously to fully reap the benefits of SCQM on product recall systems. When designing a supply chain and choosing Chinese partners, we suggest Western companies collaborate suppliers that high capability on tracking and traceability and process management to develop a product recall system. Moreover, Western companies' supplier development investments should focus on improving Chinese partners' capabilities on quality management teamwork and supplier selection and involvement.

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