Global Sourcing and Quality Recalls: An Empirical Study of Outsourcing-Supplier Concentration-Product Recalls Linkages

Abstract

This paper investigates how supply chain sourcing strategies are associated with product quality recalls. In particular, the research examines how the make or buy decision (i.e., outsourcing), the use of foreign suppliers (i.e., offshore outsourcing), the relocation of production to offshore markets (i.e., offshoring) and the decision to consolidate the supply base (i.e., use few vs. several suppliers) are related to product recalls. Product recalls are serious quality failures in the supply chain that have significant and negative impact on firm performance. Product recalls are frequently connected to the increasing trend of supply chain globalization where quality control and quality standards may be less than consistent, leading to quality problems and failures. Data across multiple industries, where recalls have been widely reported, are collected and analyzed using negative binomial regression techniques. Our findings indicate that offshore outsourcing has a greater impact on recalls than offshoring, and outsourcing domestically has the least influence. Interestingly, we find that outsourcing to a smaller supplier base may lead to fewer recalls at low levels of outsourcing but can exacerbate the impact of outsourcing on recalls at high levels of outsourcing.

Key words: Product recalls, global sourcing, empirical research, outsourcing, offshoring
1. Introduction

In this paper, we investigate the relationship between outsourcing and product quality as assessed through product recalls. We look at the different forms of outsourcing and the subsequent supply chain nuances and hypothesize relationships linking individual supply chain structural measures relating to outsourcing and product quality as measured by product recalls of individual firms. Further, we examine the interactions between some of these granular attributes of outsourcing and their joint effects on product quality. Many or almost all industries, ranging from business processes and information technology (example Corbett, 2005) to production and manufacturing (Wilhelmsson 2004), have seen an increase in outsourcing and offshoring activities. While both outsourcing and offshoring can be motivated by a variety of reasons, cost savings are most often the driving force (e.g., Landis et al., 2005; Insinga and Werle, 2000; Kakabadse and Kakabadse 2003; Cecere, 2005). However, these strategies may have unintended consequences, such as increased exposure to quality risks resulting from reduced control and visibility in the supply chain (e.g., Doig et al. 2001, Landis et al. 2005, Robinson et al., 2008).

Outsourcing involves changes in supply chain governance, but research has been rare in examining the role of supply chain governance in managing product quality and in the frequency of quality failures, in particular. In a broader perspective, Leiblein et al., (2002) suggest an examination of how governance strategies affect not only profits but risks as well. Risks may be higher under outsourcing because, as indicated in Marucheck et al., (2011), outsourcing and offshoring makes supply chains longer and more complex, with increased numbers of hands touching products as they move across the supply chain nodes and across international boundaries.
In spite of the common belief that connects outsourcing and offshoring with quality failures such as product recalls, only limited rigorous analysis has been conducted to provide concrete evidence of the existence of this link. Further, accompanying the outsourcing/offshoring decisions, are additional choices with ramifications affecting the structure of the supply chain. Choices, including the extent of supply base diversification or concentration may be also related to quality risks resulting from complexity in the supply chain, reduced control, and visibility. These considerations lead to important research questions: are quality recalls associated with outsourcing and offshoring in supply chains? Which of the three outsourcing dimensions affect product recalls most; outsourcing, offshore outsourcing, or offshoring? This paper contributes to this stream of literature by suggesting and empirically investigating linkages between these fine grain offshoots of outsourcing and product recalls.

Product recalls are quality failures of supply chains because the finished products’ quality is the agglomeration of the individual quality control efforts of each member in the supply chain. While quality management has garnered substantial interest among researchers (see for example Sousa and Voss, 2002 for a review), quality failures have been understudied from the supply chain perspective. This research empirically investigates whether product recalls are associated with a firm’s global sourcing decisions, the consequent supply base structure, and its cultural ramifications. Specifically, we examine the relationships between recalls and the extent to which a firm’s supply chain is outsourced, offshore outsourced, and offshored. In addition, we examine the concentration (diversification) of the supply base and how it relates to recalls. Furthermore, we also investigate whether the cultural difference across recipient countries of offshoring activities and their distances from the headquarter locations of the parent firms affect product recalls. Offshoring may include shifting manufacturing to offshore locations within the same
parent company or to different offshore companies. In context, shifting manufacturing to offshore locations within the same company is termed offshoring and sourcing from offshore firms is referred to as offshore outsourcing. Research has shown that outsourcing may lead to poor quality performance (Hsieh et al. 2002) and offshoring production may be linked to lower quality ratings (Gray et al. 2011). However, no empirical comparative connection has been established between outsourcing, offshore outsourcing, and offshoring and quality failures.

This paper contributes to the academic literature in several ways. First, drawing upon quality management and outsourcing literature, we propose and empirically investigate simultaneously the link between outsourcing, offshore outsourcing, and offshoring and quality failures as assessed through product recalls. The distinction between outsourcing, offshore outsourcing, and offshoring in our paper makes a point that significantly contributes to theory: interest misalignments and outsourcing complexities results in high quality failure risks when manufacturing is outsourced and the risk is higher when the outsourced activity is offshored. Second, a model is developed based on this theory that examines the linkages between consolidation or diversification of the supply base and product recalls. We suggest two different relationships between supply base concentration and recalls: a direct effect through reduced exposure to risks and a moderating effect through diminished transactional complexity and coordination challenges. This provides contingencies for our theory. Our findings indicate that both outsourcing and offshore outsourcing have significant and positive impact on product recalls. Interestingly, offshoring appears to have less effect on recalls relative to offshore outsourcing and domestic outsourcing has the least effect. We also find that outsourcing to a smaller supplier base may actually lead to fewer recalls for firms on the low side of outsourcing.
Moreover, diversifying the supply base across international boundaries appears to ameliorate the positive association between offshoring and product recalls.

The rest of this work is organized as follows. A review of literature is presented in the next section, followed by hypotheses developed from the literature and discussed in Section 3, data and research methodologies are outlined in Section 4. The results are presented and discussed in section 5 with conclusion in the last section.

2. Literature review

To develop the theoretical underpinnings for the research hypotheses, we draw upon literature on strategic sourcing and quality management, under the framework of the agency theory.

2.1. Quality management and product recalls

Quality management (QM) research has focused on quality programs within a firm or facility (Sousa & Voss, 2002). While it has been well developed, there is a dearth of QM literature focusing on quality issues in a supply chain setting (for example, Robinson & Malhotra, 2005). Notable exceptions include analytical and a few empirical studies that have examined relative effectiveness of different forms of managing quality at a contract manufacturer or a supplier (example Hart et al., 1997; Economides, 1999; Hwang et al. 2006; Forker 1997, Trent and Monczka 1999; Handley and Gray, 2013). Empirical studies have looked at among other things, how buyer-supplier collaboration may affect supplier quality (Trent and Monczka 1999), the effect on supplier quality of the interaction between buyers’ quality management practices and supplier efficiency and power (Forker, 1997), and the effect on quality performance from the use of contractual incentives and monitoring mechanisms (example Handley and Gray, 2013). A few
studies have indicated that offshore locations, on average, perform worse in quality (Gray et al., 2011).

Anecdotal evidence has indicated that well-known quality failures associated with product recalls are often linked to outsourced manufacturing. Recently, there has been an increase in empirical research in operations management on product recalls. Marucheck et al. (2011), in an editorial note, summarized the issues and outlined research opportunities in product safety research. They indicated industries that are prone to recalls and areas that have potential for academic research, such as supplier relationship management. Thirumalai and Sinha (2011) conducted an empirical investigation of the causes of recalls in the medical devices industry. They found that research firms are more likely to make recalls and that product diversification and past recall experience are negatively correlated with future recalls. Earlier studies also found a negative relationship between learning experience and recalls. Haunschild and Rhee (2004) found that past voluntary recalls had a negative effect on future recalls. Beamish and Bapuji (2008) suggested that outsourcing to China has not primarily contributed to recalls, but rather most recalls are due to design flaws created by issues in the home country.

Much of the research regarding product recalls has been on the impact of recalls, rather than on the sources or causes of recalls. For example, researchers have examined the effects of recalls on demand (Crafton et al., 1981; Reilly and Hofer, 1983), on brand equity (Dawar et al., 2000), on marketing effectiveness (Herde et al., 2007), and on wealth of sellers (e.g., Jarrell and Peltzman, 1985; Hoffer et al., 1988; Thirumalai and Sinha, 2011). This paper contributes to the QM literature by linking explicitly the granularities of outsourcing/offshoring decision and product recalls. Specifically, this paper investigates the extent to which outsourcing, offshored
outsourcing, offshoring, and concentration of a firm’s supply base are associated with quality failures as measured through recalls.

2.2. Outsourcing and Offshoring

Outsourcing decisions involve the choice between activities firms conduct themselves and activities firms buy from other firms (outsource) (Stukey and White, 1993). Studies have pointed out that outsourcing creates competitive advantages (e.g., Narasimhan and Das, 1999) and strategic benefits for firms (Kakabadse and Kakabadse, 2003, Holcomb and Hilt, 2007, Kroes and Gosh 2010). A major theoretical framework behind outsourcing is based on agency theory, which explains the motivation of outsourcing as a strategic move to delegate responsibility to another firm in order to, among other goals, lower costs for the outsourcer (Kroes and Ghosh, 2010).

While offshoring can be broadly defined as the relocation of some of the manufacturing and production stages to a foreign country, it is comparable and more relevant to quality recalls when it involves international outsourcing. Albeit the focus of the paper is on the outsourcing-recall nexus, a distinction is made between domestic and offshore outsourcing. This delineation further advances the understanding of the outsourcing-recall relationship through the agency theory lens.

Considerable research has examined outsourcing and offshoring. In summarizing the literature on outsourcing, Lacity et al. (2010) reported that the empirical findings are conflicting. Results from outsourcing and offshoring research studies have been found to be negative, positive, or insignificant. Some scholars have found a negative curvilinear relationship between outsourcing and firm performance, using measures such as market share (e.g. Katobe et al.,
2012) and financial performance (e.g., Grimpe and Kaiser 2010, Kotabe and Mole 2004, Kotabe et al., 2008, Rothermel et al., 2006). While some empirical studies have found that outsourcing leads to lower operational costs (e.g., Jiang et al. 2006) or higher firm value (Hays et al, 2000), others have found no relation to profitability (Jiang et al. 2006, Kimura 2002). In addition, opportunistic provider behavior has been noted in the literature as a concern with outsourcing (e.g., Halcomb and Hitt, 2007, McIvor, 2009).

While these theories and the empirical literature testing the efficacies of outsourcing as a strategy are well espoused, albeit with mixed findings, the literature so far has not looked deeply into the quality implications involved in lengthening and complicating the supply chain through outsourcing and offshoring. Our paper is well positioned to fill this void by linking outsourcing and offshoring to product recalls that emanate from quality failures. Further, as indicated earlier, we are linking the concentration of the suppliers and international diversification of the supply base to quality failures.

2.3 Supply base concentration

Literature has shown concentrated supply bases, as compared with more disperse supplier bases, have superior financial performance (Lanier et al., 2010), reduced inventory costs (Trevelen, 1987, Guimaraes et al., 2002), and benefits from scale economies through volume orders (Hahn et al., 1986).

Literature on the relationship between supply chain complexity and performance indicated a linkage between supply base concentration and quality management. Complexity of supply chains involves both supply base concentration and geographic diversification of suppliers. The number of suppliers has been identified as a complexity driver (Choi et al., 2001;
Wu and Choi, 2005; Goffin et al., 2006; Bozarth et al., 2009) as well as the extent of globalization of the supply base (Cho and Kang, 2001; Nellore et al., 2001; Bozarth et al., 2009). Supply chain complexity has been shown to have a negative impact on service quality (Milgate, 2001; Vachon and Klassen, 2002) and manufacturing performance (example Bozarth et al., 2009).

Even though these studies have linked complexity to performance, linkages between supply base complexity and quality performance in the product industry has not been established empirically to the best of our knowledge.

3. Theoretical background hypotheses development

We draw upon agency theory and the theory of transactions cost to develop our hypotheses in this research. Agency theory suggests that a combination of information acquisition, interest misalignment, moral hazard, and adverse selection (Fleisher, 1991) drives agency costs such as specifying, rewarding, monitoring, and policing the agent’s behavior. Agency theory considers situations where information asymmetry and interest misalignment exists between a principal and an agent (Eisenhardt, 1989). Under this situation, the theory suggests that the agent would try to optimize its own interests at the expense of the principal which often may be suboptimal for the principal (Laffont and Martimort, 2002). In this study, the manufacturer or brand owning firm is usually the principal and the suppliers are the agents. The brand owning firms delegate business functions to contract manufacturers or suppliers and the firms’ management interests need to be aligned.

There is an extensive work on the principal-agent dilemma in supply chain management, a situation that arises when existence of information asymmetries, moral hazard and/or adverse
selection risk, affect the actions of the agents causing the equilibrium to be inefficient (Eisenhardt, 1989; Jensen and Meckling, 1976). The theory has been used in supply chain settings to explain the relationships between suppliers and buyers. Product quality is one scenario where the agency problem becomes an important issue for an organization. Issues relating to agency problems are in most cases divided into moral hazards (Whipple and Roh, 2010; Zu and Kaynak, 2011; Mishra, Heide and Cort, 1998; Lassar and Kerr, 1996) and adverse selection (Zsidisin and Ellram, 2003). Moral hazard problems refer to information asymmetries about the agent’s effort and adverse selection relates to information asymmetries about the agent’s capabilities.

The moral hazard problem arises when it is difficult or costly to monitor the agent’s effort and, therefore, it poses an incentive for the agent to provide a lower quality than requested or expected. This leads to an information disadvantage for the buyers (Whipple and Roh, 2010), which provides a setting where the supplier has both the ability and the incentives to cheat (Mishra, Heide and Cort, 1998). One of the major consequences from this dilemma is a willfully dishonest effort to give the supplier a higher profit at the buyer’s expense, through self-induced quality fade (Whipple and Roh 2010). It has been suggested that China product recalls might be associated with this type of quality fade.

The adverse selection problem, on the other hand, arises during the supplier selection process. It relates to lack of full knowledge on the part of the buyer about the capabilities of a supplier. The wrong supplier selected may lead to quality and safety compromises that may lead to product recalls.
A secondary theory that lends credence to the hypotheses in this research is Transactions Cost Economics (TCE). TCE suggests that uncertainty, bounded rationality and opportunistic behavior creates transaction costs and the primary objective of organizing trade is to minimize such costs (Ketchen and Hult, 2007). Transactions costs include searching, contracting, monitoring, enforcement and coordination costs. Traditionally, in its primary form, the theory suggests instances in which one of the two extreme governance forms, make or buy, is optimal. The theory has also been used in explaining intermediate governance structures, such as contractual relationships (e.g., Rabinovich et al., 2007). Recently however, application of the normative nature of TCE, which suggests that high transactions costs would be associated with low performance levels, has been used in studying the relationship between supply chain structures and performance (example Lanier et al., 2010). Specifically, as it applies to our study, concentrating a supply base which may reduce supply base complexity, could reduce upstream search, contracting, monitoring, and enforcement costs (Zhao et al., 2007; Das et al., 2006; Choi and Krause, 2006; Corsten and Kumar, 2005) as well as coordination costs and transactions risks (Lanier et al., 2010). Choi and Krause (2006) suggest that the number of suppliers and, consequently, supply base complexity increases the total transaction costs of the focal manufacturing firm. In contrast, reducing the number of suppliers would reduce supply base transactions costs. Using this reasoning, Lanier et al., (2010), for instance, find that concentrated supply chains are associated with higher performance defined in terms of financial measures.

3.1. Outsourcing relationship with product recalls

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1 Particularly hypotheses 3 through 4.
A firm’s quality management practices alone may not be enough to entirely avoid quality and safety failures that result in recalls. While quality improvement efforts are critical for best quality performance, there are many other factors that may affect success in quality excellence (Soussa and Voss, 2002; Nair, 2006). The Mattel toy recall in 2007, is an instance of a supplier compromising quality by using excessive lead base paint in children’s toys.

Agency theory, through the moral hazard lens, suggests that the presence of information asymmetry and misaligned interest may result in suboptimal outcomes for the buyer, the manufacturer in this context. Both information asymmetry and interest misalignment may be present in an outsourcing environment. One of the factors involves the firm’s lack of visibility of quality efforts and actions of its suppliers. In most cases, the suppliers manufacture their products in the absence of the manufacturer (Handley and Gray, 2013). Consequently, a supplier’s quality improvement activities or its quality efforts can be difficult to observe by the buyer or manufacturer. Even though the buyer can monitor a supplier in a number of ways with advanced information technologies, complete visibility and control of the supplier’s production and procurement processes under outsourcing is almost impossible, given the fact that the buyer is absent during the supplier’s manufacturing process. In fact, loss of control due to information asymmetry is inevitable when a firm delegates authority to another organization (Laffont and Martimort, 2002), which encourages supplier moral hazard when the opportunistic supplier shirks its responsibilities. Even though less obvious, there is incentive misalignment that may hinder quality efforts in an outsourcing environment. As demonstrated in the Mattel toy recall in 2007, a supplier, knowing that compromising quality costs the supplier little in terms of reputation while allowing for immediate gains, could have an incentive to deviate from the required quality standards, leading to inefficiency associated with moral hazard. Compounding
this situation is the difficulty in measuring quality performance as it may often be a composite of multiple individual performance measures. Where there are many outcomes, effort can be funneled to the outcomes that are easily measurable, such as (Holstrom and Milgrom, 1991; Parker and Anderson, 2002) cost or on-time delivery.

These arguments suggest that both information asymmetry and interest misalignment are present in an outsourcing environment and, consequently from the agency theory, quality may be lower with outsourced production as compared to in-house manufacturing. In a concluding remark in their work based on the “Supply Chain game,” Amaral and Tsay (2009, p. 632) put this more assertively: “Hidden actions, hidden information, and misaligned incentives are ubiquitous, and outsourcing only exacerbates their impact.”

**Hypothesis 1a.** Product recalls are positively associated with a firm’s outsourcing intensity.

When outsourcing moves manufacturing offshore to other countries, as firms have increasingly done to take advantage of low costs in labor and other resources, additional issues may exacerbate the moral hazard problem, if the problem is present under outsourcing as we have suggested. Cultural issues, such as different perceptions on governance and legal infrastructural weaknesses in the enforcement of contractual terms, endemic in developing countries that are beneficiaries of most of the foreign outsourcing, are enabling environments for opportunistic behaviors of suppliers (Lyles et al., 2008; Lou 2008). Being far from the market may also protect the suppliers from being recognized and blamed when there is a quality failure. Therefore, moral hazard may lead to more quality concerns when the supplier is located in a foreign country. Further, effective communication is hindered between the manufacturer
(principal) and the suppliers (agents) in an offshore outsourcing situation. Geographic distance, travel distance, language distance, and cultural distance each or together may inhibit information flow between the manufacturer and the suppliers increasing information asymmetry (Stringfellow et al., 2007). This increases risks associated with moral hazards. Moreover, in investigating the US pharmaceutical industry, Gray et al., (2011) found that quality risk varies by the location of the manufacturing facility. They found that products manufactured in offshore locations pose higher quality risks than their counterparts produced within the United States, even after controlling for distance and learning effects.

Adverse selection risks may also be higher in an offshore environment than in a local market. Most of the recipient markets of offshore outsourcing and offshoring are developing countries who offer low manufacturing costs. However, as evident in China, these markets have very deep supply chains and many little known about or underground firms (Lyles et al., 2008). This increases the cost of searching quality partners and thus increases the risks of adverse selection. The wrong supplier selected may lead to quality and safety compromises that may lead to product recalls as was seen in the Mattel case when a supplier’s supplier used excessive lead base paints in children’s toys in 2007 (Beamish and Bapuji, 2008).

**Hypothesis 1b. The positive relationship between product recalls and outsourcing is stronger when outsourcing is offshored.**

3.2. Offshoring and product recalls

Offshoring, by itself, may also be related to product recalls. Governing of offshore locations by manufacturers within the realm of maintaining quality and safety standards that obviate recalls, can be characterized by the agency theory similar to outsourcing to secondary firms.
First, the offshore locations act as agents on behalf of the brand owner. Arguably, these locations or plants are different entities and govern themselves semi-autonomously albeit with objectives that are guarded by the parent company. They have their independent governing and business systems influenced by their local economies and cultures and are often subjected to monitoring and evaluations from the foreign principal. Further, the physical as well and cultural distances between the parent firm and its subsidiary located in a different country hinders communication flow and knowledge transfers between the two entities (Gray et al., 2011; Cummings and Teng, 2003; Lester and McCabe, 1993; Galbraith, 1990). These suggest that there is some level of information asymmetry present between the principal and the subsidiary which sets the bases for agency problems. It is logical, therefore, to suggest a link between offshoring and quality failures that results in recalls. A few studies have even pointed to this direction.

We suggest, however that, on average, the two forms of outsourcing, domestic and offshore outsourcing, may have a stronger relationship with quality problems than offshoring. In any of these three cases, there is some level of information asymmetry. Arguably though, there may be a higher level of information asymmetry between the principal and the agents in an outsourcing environment than in an offshore situation within the same firm. In an offshore environment, the manufacturer may be involved in decisions regarding personnel, procedures, and investments. In other words, there is comparably high level of visibility of the actions of the subsidiary. Also, the manufacturer can monitor the operations of its subsidiaries often as it desires with no restrictions on access. In contrast, the suppliers in an outsourcing environment independently hires, trains, sources and maintain control over their internal procedures. Visibility is consequently lower. Monitoring is also on regularly defined time intervals and the suppliers are noticed in advance of such audits and inspections. These arguments support our supposition
that information asymmetry will be greater between the principal and the agent in outsourcing relative to offshoring.

There can be higher levels of incentive misalignment between the manufacturer and the agents in outsourcing environment relative to an in-house offshore situation as well. Compromising quality may cost the supplier little both in monetary and in terms of reputation as argued earlier, but the same cannot be said of an offshore subsidiary. The allocation of costs of quality failures to a supplier may be more difficult than an internal subsidiary. Also, coverage on quality recalls often mentions only the brand owner and not the supplier.

These arguments put together suggest that governance structure (outsourced, offshore outsourced, and offshored) can affect quality recalls at different levels. Processes are more visible within an organization, less visible between an organization and a subsidiary and least visible between the organization and its suppliers. Similarly, information flows can be more effective within a firm than between loosely connected independent firms. Therefore, coordination, collaboration, and subsequent incentive alignment that ensures high quality standards, may be more effective when business units are organizationally internalized and less effective in a buyer-supplier relationship.

**Hypothesis 2:** There is a positive relationship between product recalls and offshoring. This relationship is weaker relative to recall-outsourcing relationship, which in turn is weaker relative to recall-offshore outsourcing relationship.

### 3.3. Supply base concentration and product recalls

The complex and globalized supply chains may involve a large number of suppliers. Mattel had 37 certified suppliers and hundreds of others in China alone in 2007 (Bapuji and Beamish 2008). However, a large and diversified supply base may suffer from “upstream complexity” in the
Supply chain complexity can lead to high costs of coordination (Denis et al., 2002), make monitoring much more difficult and costly (Bodnar et al., 1999), and increase information asymmetry (Harris et al., 1982; Myerson 1982). Supply base complexity may also increase supplier risks and reduce supplier responsiveness (Choi and Krause, 2006). Furthermore, supply base complexity may implicitly increase the costs of identifying quality problems, contracting for quality performance, monitoring quality standards, and enforcing quality control programs. When sourcing is widely distributed across a large number of suppliers, individual suppliers may expect higher uncertainties in their supply relationships with the buyer and more likely develop opportunistic behavior in quality improvement efforts. In addition, a concentrated supply chain should enable visibility and traceability, leading to early detection of production and supply chain issues.

Another potential driver of product recalls is supplier diversification across geographic regions. Geographic diversification of the supply base contributes to the upstream supply chain complexity (Bozarth et al., 2009) leading to higher transaction costs. Further, nationally diversifying the supply base, in effect, would inhibit inventory visibility and traceability and, consequently, supply chains would be more exposed to disruptions (e.g. Rice and Caniato, 2003; Stauffer 2003; Chopra and Sodhi 2004; Tang 2006; Deloitte Consulting, 2007). In addition, the effects of such complexity can be compounded through geographic and cultural distances among the member countries. Knowledge transfer needed to attain quality levels across the supply chain; for example, from a parent company to suppliers or subsidiaries, can be hindered by both physical and cultural distances (Gray et al., 2011). On the other hand, focusing suppliers to one geographic location (e.g. in China) can increase cultural distance between the focal firm (e.g. in
the US) and the supplier, which can lead to a different form of complexity and in turn increase product recalls. However, given that transactional difficulties would be reduced through lower supply base complexity, national concentration may be associated with lower recalls.

These arguments also apply to offshoring situations in which a company locates manufacturing plants across many countries. In many firms, different locations are tasked with handling different activities, i.e., manufacturing components which are pooled together at an assembly plant, in again, a different location. This creates coordination complexities that may result in compromise of product quality.

**Hypothesis 3a.** Product recalls are negatively associated with the degree of concentration among a firm’s suppliers.

**Hypothesis 3b.** Product recalls are negatively associated with the degree of geographical/national concentration of a firm’s suppliers.

**Hypothesis 3c.** Product recalls are negatively associated with the degree of geographical/national concentration of a firm’s subsidiaries

The relationship between supplier concentration and recall is similar to that between outsourcing and product recalls, as both are developed from the agency theory with regard to uncertainties and moral hazard. The overlap of the relationships may lead to secondary effects on product recalls. Specifically, a more concentrated supplier base under outsourcing may ease a firm’s effort in coordination, monitoring, and enforcement of the quality improving activities conducted by the suppliers, leading to lower costs and higher efficiency of such effort. Consequently, supplier concentration may mitigate the negative relationship between outsourcing intensity and quality performance. As Bozarth et al., (2009) argued, the number of
suppliers is associated with increased information and physical flows and greater numbers of relationships involved. The intense information and physical flows necessary in a more diverse supply base increase the risk of misinformation (information asymmetry) as well as exposure of the product to supply chain disturbances that may compromise quality and safety. Furthermore, the distribution of the suppliers directly affects the visibility of the supply chains, as a large number of small suppliers may make communication and information sharing in the supply chains more difficult, further aggravating the moral hazard problem.

Geographic concentration of suppliers may also moderate how offshoring is associated with product recalls. A supply chain that spans several international boundaries can be more complex than a chain concentrated in one country, for a given number of suppliers (Bozarth et al. 2009; Craighead et al., 2007). Supply base complexity can also lead to high costs of coordination (Denis et al., 2002), making monitoring much more difficult and costly (Bodnar et al., 1999) with greater information asymmetry (Harris et al., 1982; Myerson 1982). Consequently, geographic diversification (concentration) may strengthen (weaken) the negative relationship between offshoring and quality due to higher degree of complexity in business transactions and coordination among suppliers across geographic boundaries.

These arguments suggest that transactional complexities associated with diversifying the supply and operational bases exacerbates the agency problems associated with outsourcing and offshoring.

**Hypothesis 4a.** The positive relationship between outsourcing and product recalls is weaker when the supply base is more concentrated.
**Hypothesis 4b.** The positive relationship between offshore outsourcing and product recall announcements is weaker when the supply base is more concentrated nationally.

**Hypothesis 4c.** The positive relationship between offshoring and product recall announcements is weaker when offshoring is more concentrated nationally.

4. Model development and Data

In this section, we develop econometric models to test the above hypotheses. The modeling framework is based on the relationships between product recalls and outsourcing intensity, offshoring intensity, sourcing concentration by suppliers and by geographic locations. Furthermore, additional moderating effects are also examined between supplier concentration, outsourcing, and offshoring. Outsourcing both domestic and offshore, and offshoring intensity are expected to be positively related to the number of recalls (H1b and H1b) and concentration in both suppliers and geographic locations are expected to be negatively related to recalls (H3a, H2b and H3c). Also, supply base concentration and national concentration are expected to mitigate the positive relationship between outsourcing/offshoring and product recalls (H4a, H4b and H3c). Figure 1 illustrates this modeling framework.

(Insert Fig. 1 about here)

4.1. Data and data sources

Our setting is the consumer products industry. To test the hypotheses, we make use of a three-year panel data on publicly traded manufacturing firms, including information on their relationships with suppliers and buyers, the strength of these relationships, and the recalls made
by each firm. By using archival data in this analysis, the information gathered is not dependent on survey respondents’ perceptions and or attitudes (Goffin et al. 2006).

This investigation is limited to public firms within the US manufacturing sector. The sample uses these firms for a number of reasons. First, the research is about “make or buy” decisions and the sector that faces that decision most often is the manufacturing sector. Other sectors, such as retail, almost always depend on secondary firms for their production needs. No doubt, large retailers, such as Walmart, Target, and Babies R Us, play a critical role in the US economy, for instance, and possess and exercise significant power over supply chain members. However, they are not faced with decisions to make or to buy and, therefore, are not appropriate for this analysis. A second reason is the availability of data on public firms. Since public firms are required to make many disclosures, data are available only for these firms.

We focused on the broad consumer products sector because of the recall data recorded by the US Consumer Product Safety Commission (CPSC). The CPSC record all recall announcements, of all consumer products with detail description of the cause of the recall, type of hazard and incidents associated with the recall. This detailed information which is lacking in the recalls of foods and drugs and vehicles, enables the delineation between recalls that are associated with manufacturing errors and those that are due to design errors. This distinction is important because it is logical to argue that manufacturing defaults will be more associated with outsourcing relative to design problems (Beamish and Bapuji, 2008).

Data for this analysis are gathered from three different sources. The main hypotheses revolve around outsourcing impacts on firm quality performance as measured by the number of recalls. The recall data are collected from the US Consumer Product Safety Commission’s
(CPSC) recall announcements as suggested earlier. These data are utilized to obtain the number of recalls each firm makes within our period of observation.

To account for firms with zero recalls, we started by collecting information on all recalls made in 2010 through 2012 from the CPSC recall data. The recall firms are then separated into public and private firms by manually and individually checking them. Only recalls by public firms are kept for our study. These firms are then linked with their respective six digit primary NAICS codes. The NAICS codes are then used to gather information on all corresponding firms from the Compustat data, including both firms with recalls and those without. Since our explanatory variables are collected from the Bloomberg database (explained further below), the analysis is limited and applicable to only 2010 through 2012, a three year period. Data are collected on all 6-digit NAICS codes ranging from 3111112 to 339999. These data are then matched with the Bloomberg data by company name to get a unique dataset of 433 firm-year observations of 165 unique firms. We are, therefore, able to have firms that made zero recalls within our study period, as well as firms with as many as five independent recalls. Descriptive data analysis is given in the next section.

The data for the four explanatory variables capturing outsourcing intensity, offshore outsourcing intensity, and supplier and national concentration are compiled from the Bloomberg database. Bloomberg offers data on many public firms’ supply chain relationships. The data map a company to its suppliers, customers, and competitors and give an indication of the strength of the relationship between any two firms in a dyad. The supply chain data provided by Bloomberg reveal money flows between companies on both a customer (revenue) and supplier (cost) basis. Estimates are provided of the percentage of a supplier’s revenue that comes from a given buyer, and the percentage of a buyer’s cost of goods sold that is spent on a given supplier.
Bloomberg uses three different methods to compile this dataset. The first, termed as the “mathematical method”, derives the supply chain relationship from public data as well as from information collected from the companies directly. In the second method, Bloomberg has its own algorithm that is used to quantify relationships based on content analysis such as announcements from manufacturers or their suppliers. Third, Bloomberg also purchases propriety data from other sources.

Finally, data on offshoring intensity are collected from the Compustat segment data base accessed through the Wharton Research Data Services (WRDS) for the three observation years. Information on individual firm’s annual assets, plants, property and equipment (PPE) by geographic regions are collected. These annual measures of foreign PPE are used as effective proxies for a firm’s in-house offshore activities. Data on the control variables are also collected from the Compustat database.

The data was collected using five graduate students at two different universities and at two different times. The first set of data was collected in the winter of 2011 using four graduate students and the lead author and the final batch was collected by another graduate student and the lead author during the fall of 2013.

4.2. The empirical model

The dependent variable in the model is the number of recalls of a firm over the study period, and the main explanatory variables are the firm’s outsourcing and offshore outsourcing and offshoring intensity, and its supplier and national concentration levels. Given that recalls are infrequent for firms and the number of recalls is a count data, the dependent variable may follow a Poisson or Negative Binomial distribution.

The regression equation is given below:
Based on the hypotheses, $\beta_1$, $\beta_2$ and $\beta_3$ are expected to have positive signs while $\beta_4$ through $\beta_9$ are expected to have negative signs.

Where:

- **Recall** is the dependent variable measured by the number of recall announcements per firm per year.
- **Outsourcing** is one of the key independent variables. It measures the extent to which firms source from outside their firms as oppose to making products in-house.
- **Offshore outsourcing** is the second explanatory variable of interest. It measures the extent to which a firm sources internationally; i.e., offshores their outsourcing activities.
- **Supplier concentration** is supplier concentration which measures the extent to which a firm’s suppliers are concentrated (or diversified).
- **National concentration of suppliers** is concentration of the suppliers of a firm within national boundaries. It captures both the number of suppliers residing in a country as well as the share of costs expended on them by the manufacturing company.
- **National concentration offshore** is concentration of offshore subsidiaries of a firm within national boundaries.

\[
\text{Recall} = \beta_0 + \beta_1 \text{outsourcing}(\text{domestic}) + \beta_2 \text{offshoreoutsourcing} + \beta_3 \text{offshoring} \\
+ \beta_4 \text{supplier concentration} + \beta_5 \text{national concentration of suppliers} + \beta_6 \text{national concentration offshore} \\
+ \beta_7 \text{outsourcing} \times \text{supplier concentration} + \beta_8 \text{offshoreoutsourcing} \times \text{national concentration suppliers} \\
+ \beta_9 \text{offshoring} \times \text{national concentration offshore} + \beta_{10} \text{prior recall} + \beta_{11} \text{R & D intensity} \\
+ \beta_{12} \text{size} + \beta_{13} \text{capital intensity} + \text{Industry effects} + \text{firm effects} + \text{year} + \varepsilon
\]
**R&D intensity** is a measure of R&D intensity and is a control variable in the model which reflects a firm’s innovative capability and may be associated with a firm’s quality performance. R&D efforts of a firm may reduce the chances of a quality failure, and, hence, lead to lower recalls. On the other hand, higher R&D intensity may also indicate the firm’s focus on innovation and new product development, which may increase the likelihood of errors and thus positively affects recalls.

**Prior recall** is a control variable aimed at capturing the effect of learning from quality and safety failures. Recall events may “trigger renewed attention to the weak links in the process and foster research toward improving the existing operations by bringing new information and resources” (Thirumalai and Sinha, 2011, p. 381). As such, prior recalls made by firms may lead to efforts that mitigate future recalls. On the other hand, prior recalls may just represent poor supply chain management, in which case, one would expect them to be positively related to future recalls.

**Firm size** is used as a control variable. Firm size may be positively associated with recalls as larger firms usually have a more diversified product base and are, therefore, more complex.

**Capital intensity** is a control variable that may be associated with firm quality performance. Capital investments include investments in information technology which may improve visibility of inventory and, thus, increase the chances of detecting and correcting defects before products reach the market. Capital intensity is therefore expected to be negatively related to product recalls.
- **Firm** effects are included as control variables in the model. There are other factors that may affect recalls besides the aforementioned variables. Therefore, firm effects are included in the analysis to control for other omitted firm specific variables.

- **Industry** effects are included as control variables in the model. Three-digit North American Industrial Classification System (NAICS) codes are used to classify industry sectors. In North America, industry sectors are classified primarily based on production processes and technologies, both of which may affect product quality and recalls. It is very possible that the nature of activities of an industry will be associated with supply chain disruptions. We include these industry-specific dummy variables to control for otherwise omitted industry-specific attributes that influence product quality and recalls.

4.3. **Measures of variables and descriptive statistics**

Outsourcing intensity is measured as the percentage of a firm’s cost of goods sold (COGS) that are incurred from its suppliers as provided in the Bloomberg database. The larger this percentage, the more intense is a firm’s outsourcing activity.

\[
\text{Outsourcing intensity} (\text{Outsour}) = \frac{\sum \text{expenditure to secondary firms}}{\text{Cost of goods sold}}
\]

Offshore outsourcing intensity is measured as the percentage of a firm’s COGS that is expended on foreign firms. Foreign firms mean firms that are registered or headquartered in foreign countries.

\[
\text{offshore outsourcing intensity} = \frac{\sum \text{Expenditure to foreign firms}}{\text{cost of goods sold}}
\]
Both variables measure the extent of relationships with other firms relative to cost of goods sold.

Offshore intensity is measured by the ratio of the value of a firm’s foreign plants, property and equipment (PPE) to the total PPE value. It is therefore given in percentage terms. This measure is an effective proxy for offshoring because it is straight forward logical that plants and equipment are owned and used for productive activity particularly manufacturing and assembling. An alternative measure of the total number of foreign subsidiaries is also used as offshoring variable.

\[
\text{offshore penetration intensity} = \frac{\sum \text{foreign PPE}}{\text{total PPE}}
\]

Supplier concentration is measured as the sum of the squares of shares of cost of goods sold expended on each supplier following the Herfindahl-Hirschman Index (HHI).

\[
\text{supplier concentration} = \sum_{i=1}^{N} S_i
\]

Where \( S_i \) is the share of COGS expended on firm \( i \) and \( N \) is the total number of suppliers. A value of 1 indicates that a firm has only one supplier and the value of the variable approaches zero as the number of suppliers approach infinity.

National concentration is calculated as the sum of the squares of shares of cost of goods sold by domicile country of the suppliers.

\[
\text{National concentration of suppliers} = \sum_{j=1}^{M} X_j
\]
Where $X_j$ is the total share of COGS expended on suppliers in country $j$ and $M$ is the total number of countries in which the firm has suppliers. Similarly, a value of 1 implies that all of a firm’s suppliers are domiciled in 1 country.

Offshore concentration is calculated as sum of squares of shares of PPE by foreign country.

$$Offshore\text{concentration} = \sum_{k=1}^{q} Z_k$$

Where $Z_k$ is the total share of PPE in country $k$ and $q$ is the total number of countries in which the firm has Plants property or equipment. Similarly, a value of 1 implies that all of a firm’s subsidiaries are in one country.

R & D intensity is measured by a firm’s research and development expenditure normalized by sales.

$$RD\text{intensity} = \frac{R & D\text{expenditure}}{sales}$$

Capital intensity is measured by a firm’s capital expenditure normalized by sales.

$$RD\text{intensity} = \frac{capital\text{expenditure}}{sales}$$

Prior recalls is a cumulative measure of recalls prior to the study year.

The natural log of sales is used as the size measure.

4.3.1. Descriptive statistics
Firm sourcing characteristics and the distribution of firms by industry are given in Table 1 and overall descriptive statistics are provided in Table 2.

(Insert Table 1 about here)

Table 1 shows that firms from the computer and electronics manufacturing sector account for about 25 percent of the firm-year observations, while firms from the paper and related products manufacturing industry is least represented with less than 5 percent of the observations each. In terms of outsourcing, firms with operations in computer and electronics manufacturing outsource the most (29 percent of COGS), followed by transportation equipment (23 percent). The highest average recalls are in the furniture industry with an average of 0.5 recalls per firm over the year period, followed by the paper, chemical and machinery industries respectively.

The mean outsourcing intensity for all firms is 15% of cost of goods sold (Table 2) with a mean of 0.217 recalls per firm year and a maximum recalls per firm year of 5.

(Insert Table 2 about here)

5. Results

Table 3 provides the correlations between the variable pairs. Unsurprisingly, the strongest correlation between the independent variables are between the various concentration measures and offshore outsourcing and outsourcing. However, since neither of these variables is used together in the analysis, multi-collinearity will not be an issue. Further, the estimated variance inflation factor (VIF) of the models suggests that the effects of multi-collinearity are limited. Each model has a VIF estimate of less than 10 which is deemed acceptable.
To reduce heteroscedasticity, all variables, except the dependent variable, are standardized. To control for both industry and firm level effects, the models are run using a nested random coefficients model because firm effects are nested in industry effects. To limit the effects of outliers, the data are trimmed of possible outliers by eliminating all data points above and below 95% and 5% percentiles respectively. The estimations using fixed and random effects provide very similar results, so only the random effects model results are presented. As suggested earlier, because of the discrete nature of the dependent variable, the estimation is best characterized by either a Poisson or a negative binomial distribution. However, the variance of recalls far exceeds the mean. As a result, the model is estimated with the negative binomial distribution.

The regression results are presented in Tables 4a and 4b, which include a total of eight different models. In Model 1, coefficients of the control variables and the outsourcing measure are estimated. In Model 2, outsourcing is split into domestic and offshore outsourcing and only domestic outsourcing is added in Model 2 and offshore outsourcing is added in Model 3. Offshoring is estimated in Model 4 and in Model 5, all three outsourcing measures are simultaneously estimated. The interaction of outsourcing and supply base concentration, of offshore outsourcing and national concentration, and offshoring and offshore concentration are respectively estimated in Models 6 through 8 to limit the effects of multi-collinearity. Overall, all the models have significant Wald Chi-squared statistics. For the model that includes the hypothesized relationships, but excludes the interaction terms, the Chi-Squared statistic is 46.95 and highly significant at p<0.001. However, all analyses are based on Model 1 for Hypothesis
Hypotheses 1a and 1b suggest a relationship between outsourcing and recalls. The coefficient for outsourcing is positive and significant as seen in Model 1. This result supports the first hypothesis that recalls are positively associated with outsourcing intensive firms. When the outsourcing variable is split to focus on offshore outsourcing (Model 3), the offshoring variable has a positive coefficient and is significant. Hypothesis 1b however, suggests that the coefficient for offshore outsourcing would be greater than the coefficient for domestic outsourcing. When both sub variables of outsourcing, that is offshore outsourcing and domestic outsourcing, are included and simultaneously estimated, offshore outsourcing’s coefficient is larger. In fact, domestic outsourcing becomes insignificant. This, by itself supports Hypothesis 1b that offshore outsourcing has a bigger effect on recalls. A significance test of differences between coefficients also supports that the two are different (at t-stat>3.0).

Offshoring on the other, has a more complex relationship with product recalls. When offshoring is estimated alone together with the controls, the offshoring coefficient is insignificant suggesting that there is not enough evidence to support a relationship (Model 4). However, when the outsourcing variables are included, offshoring becomes significant albeit weakly (Model 5). The correlation between offshoring and the outsourcing variables are low enough to rule out multi-collinearity as a big issue. A plausible explanation, therefore, would be that outsourcing has a very strong effect on recalls and without controlling for it, unexplained variability is large and the weak effects of offshoring cannot be seen. But after adding the outsourcing variables, the weak effect of offshoring becomes significant compared to the
unexplained variability. Further, when offshoring is interacted with the offshore concentration variable, the interaction term has a positive significant coefficient. These two supports the hypothesis that offshoring is positively related to product recalls. Hypothesis 2 suggests that outsourcing both domestic and offshore will have a stronger effect on recalls relative to offshoring. Since the variables are standardized, a direct comparison can be made. Clearly, offshore outsourcing has a stronger positive effect on recalls in comparison to offshoring. There is not enough evidence, however, to suggest that domestic outsourcing has a stronger effect on recalls relative to offshoring. In fact, the opposite is suggested by the regression results. Hypothesis 2, is therefore only partially supported.

Among the concentration variables, only supplier concentration has a significant negative coefficient. Only Hypothesis 3a is, therefore, supported with both national concentration of suppliers and offshore concentration variables having insignificant coefficients. As suggested earlier, because of the high correlation between the concentration measures, their interaction variables are separately investigated. The supplier concentration-outsourcing interaction is significant but positive contrary to expectation. Hypothesis 4a is, therefore, not supported. This indicates that supply base concentration does not weaken the positive relationship between outsourcing and recall. The offshore outsourcing and national concentration of suppliers’ interaction variable has an insignificant coefficient. Hypothesis 4b is, therefore, not supported. The offshoring-offshore concentration interaction variable surprisingly, has a significant and positive coefficient. Hypothesis 4c is, therefore, not supported.

(Insert Table 4a and 4b about here)

There are some interesting results from the control variables as well. R&D intensity, after controlling for firm and industry effects, appears to have no association with recalls, as indicated
by the insignificant coefficients. Higher R&D intensity is an indication of a firm’s focus on innovation and new product development. This may increase the likelihood of errors and, thus, positively affects recalls. Alternatively, a firm with significant expenditures in R&D may more likely monitor and discover product defects that lead to recalls. Since our database does not differentiate between exploitative and explorative R&D, this confounding effect may be a possible reason why this variable is insignificant. The coefficient for capital intensity is weakly significant and negative in some of the models. This is expected as capital expenditure includes expenses on information technology, which may enhance information flow between organizations and also increase supply chain visibility. Larger firms are associated with more recalls as given by the positive and significant coefficient on the size variable. Contrary to expectation, the prior recall coefficient is positive and significant. This contradicts prior findings that previous recalls are negatively related to future recalls.

As shown in Table 5, the association between outsourcing and recalls vary across industries. Within industry estimations and, therefore, across industry comparisons are only possible for few industries, however, because of data limitations. Of the five industry level estimations, three industries, chemical products, computer and electronics, and miscellaneous durables manufacturing all exhibit positive coefficients of outsourcing. In these industries, outsourcing appears to be associated with higher recalls. In the transportation equipment industry on the other hand, the coefficient of outsourcing is negative suggesting that outsourcing is associated with lower recalls in this industry. In the machinery industry, outsourcing appears to have no relation with recalls.

5.1. Sensitivity analyses
There are three issues that may undermine our results if not addressed. First, outsourcing itself may be affected by the other firm level variables used in the analyses and, therefore, may be endogenous. This definitely would undermine the findings of this paper. Second, the dependent variable is obviously left truncated. Even though the negative binomial very well characterizes the dependent variable, censored data regression models such as Tobit regression would provide a robust check of the validity of our results. Third, it is arguable that recalls may be more associated with manufacturing problems relative to design errors that results in quality failures. Ignoring this distinction would lead to erroneous conclusions.

To rule out endogeneity as an issue, we reran the regression (Model 1) using instrumental variable technique using some of the explanatory variables as instruments. The insignificance of the R&D intensity variable in explaining recalls provides an opportunity for this variable to be used as an effective identification variable. As seen in Table 6, the outsourcing-recall relationship is supported.

To account for the truncated nature of the data, we then use the Tobit model in rerunning the two stage regression (Model 1). Results of the endogenous Tobit regression model is given in Table 7. Again the results are robust to the estimation technique.

(Insert table 6 and Table 7 about here)

To test for sensitivity against the type of problem and its relation to outsourcing, we divide the data into two by recall problem type; that is either manufacturing or design problems. The classification followed the work of Beamish and Bapuji (2008) and Hora et al., (2011). Each individual recall is classified first as either a design or manufacturing error and then by NAICS code, added to zero recall firms. This results in two sets of data and each is estimated independently. The expectation here is that outsourcing would affect only manufacturing
problems since product design and development is usually done in-house (Beamish and Bapuji, 2008). As seen in Table 8, both design and manufacturing problems are positively associated with recalls. This shows that outsourcing is related to both design and manufacturing errors which strengthens our research. The manufacturing coefficient however, is stronger than and statistically different from the design coefficient as would be expected.  

(Insert Table 8 about here)

6. Conclusions, discussions and implications

6.1. Research implications

6.1.1. Direct relationships

A major contribution of this paper is the focus on both outsourcing and offshore outsourcing, distinguishing between them and hypothesizing their effects separately in comparison to offshoring. The separation of outsourcing from offshore outsourcing helps in identifying the sources of quality issues in an outsourcing environment. This distinction separates this study from a number of other studies on vertical integration and manufacturing outsourcing. This is a theoretical contribution as it implicitly suggests that the moral hazard problem is exacerbated by transactions across international borders. Our findings that most of the quality issues emanating from outsourcing are driven by offshore-outsourcing (offshoring) provides an interesting insight and an important contribution to the research stream.

Second, our empirical results show that outsourcing is associated with lower quality performance. This finding is in line with well-known operation management theories, such as, knowledge transfer, transactions cost economics, and agency theory. Knowledge transfer indicates difficulties in transferring knowledge across firm boundaries. There may be difficulties
in alignment among firms in the supply chain resulting in quality failures. Transactions cost economics indicates supply chain complexity will increase with extensive globalization. This will result in difficulties in managing over the entire supply chain and lead to quality failures. Agency theory links opportunistic behavior with the delegation of authority (example outsourcing) leading to quality failures that result in recalls. Offshore outsourcing, as expected, is positively associated with product recalls and has a stronger effect on recalls relative to domestic outsourcing. As argued in the hypotheses development, outsourcing to offshore suppliers engenders the moral hazard problem that may follow outsourcing. In fact, when the variable is split to account for offshoring, it appears that most of the negative quality performance is generated by outsourcing to offshore suppliers. The quality problems in outsourcing, are, therefore, more driven by outsourcing to offshore locations than just outsourcing.

In comparison to offshoring, offshore outsourcing has a stronger effect on recalls. This is clearly in line with agency theory as offshore outsourcing involves crossing firm boundaries. Offshoring, on the other hand, appears to have a stronger effect on recalls than domestic outsourcing contrary to our expectations. Domestic outsourcing involves crossing firm boundaries and, therefore, has agency problems implications. Offshoring keeps production in-house but across national borders and, therefore, has distance, cultural, and other institutional implications that may negatively influence quality. Our results suggest that the cultural and the other problems associated with offshore locations outweigh the agency problems associated with outsourcing to domestic partners. This finding is clearly a significant contribution to the literature stream as no other research, to our knowledge has suggested this relationship.

A second motivation of the research was to investigate the association between supply base concentration, offshore concentration, and recalls. Relying on the agency theory and
referencing the theory of transactions cost economics and literature on supply chain complexity, we hypothesized that diversifying a firm’s supply base may be associated with greater numbers of product recalls. The relationship between supply base concentration and recalls turns out to be more complex than hypothesized. To clearly illustrate this complex relationship, we look at the marginal effects of changes in supply base concentration on recalls. From the Model 6 results, the equations below can be used to obtain the effect of concentration on recalls at the mean levels of all other variables.

At the mean levels of outsourcing for instance (that is outsourcing = 0), the marginal effect of supply base concentration on recalls is -0.023. This means that a standard deviation change in concentration levels is negatively associated with 0.023 recalls.

At high outsourcing level (outsourcing = 1; one standard deviation above the mean)

\[ Recall = -0.023 + 0.350 = 0.327 \text{ recalls}\]

At low outsourcing level (outsourcing = -1; one standard deviation below the mean)

\[ Recall = -0.023 - 0.350 = -0.373 \text{ recalls}\]

Concentrating the supply base, therefore, affects quality performance in opposing ways depending on the outsourcing levels. The results imply that for firms operating at the mean levels of outsourcing or at lower levels, concentrating the supply base is associated with better quality performance. This finding reinforces prior research showing that concentration within a supply chain may be associated with superior firm performance as measured by other metrics as cost,
profits, and inventory (example Lanier et al., 2010; Trevelen, 1987; Guimaraes et al., 2002) and extends current knowledge by linking concentration to quality performance for the first time. However, at high outsourcing levels, concentrating the supply base compounds the negative association between outsourcing and recalls. An explanation for this finding could be related to the power in supply chains literature stream. High levels of outsourcing to very few suppliers increase dependency on those suppliers. Diversifying the supply base therefore, may introduce competition among competing suppliers. This reduces dependency and thus reduce the risk of opportunistic behavior.

Offshore diversification, unexpectedly, was found to be associated with improved quality performance as measured through recalls. Though surprising, there is a logical reason for this finding. Having a concentrated offshore base in one region can give rise to several regulatory or trade risks (Westphal et al., 2006) which could impact quality negatively. Further, concentration in a single region could increase cultural distance which may introduce different coordination challenges such as language barriers leading to quality failures that result in recalls.

There are a number of important future research directions emanating from this study. Outsourcing may have both direct and indirect effects on firm performance. The direct effect is through cost savings, as has been pointed out in the literature. Indirectly however, outsourcing may be associated with product recalls and, thus, counteract the direct cost savings. Perhaps, this is one explanation as to why research on outsourcing-performance relationships has inconsistent findings. There is potential for future research in this direction. The literature has pointed out cost savings as the main driver of outsourcing. It may be possible to attain the cost savings resulting from outsourcing whilst maintaining good quality, if certain conditions are present. For instance, firms may take actions that keep recalls at a minimum, but still rely on secondary firms
for their manufacturing. The investigation of such moderating relationships on the outsourcing-recall relationship is a future direction of this research stream. As it relates to the findings associating offshore outsourcing and offshoring to recalls, future research should look at attributes of specific offshore locations to determine what is responsible for the difference in quality. Such attributes include geographic locations of the suppliers; physical as well as cultural distances; and physical, institutional, and infrastructural development of the suppliers’ foreign bases.

This study also only looked at supply base concentration ignoring the length of the supply chain. There is the potential that the length of the supply chain also adds to its complexity and, therefore, may compound the negative quality effects of outsourcing. Additional work in this area could be an important contribution to the research stream.

Furthermore, there are interesting complexities to a firm’s outsourcing/offshoring/supplier concentration decision process and the relationship of those decisions to overall production quality that remain to be explored in additional studies. It would be interesting, for example, to disaggregate the outsourcing/offshoring variable to account for the number of individual offshore locations used and the geographical dispersion of activities. Examining the impact of these factors on quality would provide an opportunity to offer a finer grain level of managerial implications.

6.2. Managerial implications

One important managerial implication of our study is that both outsourcing and offshoring may be associated with unintended consequences, such as product non-conformance with standards that may lead to recalls. This consideration should, therefore, be taken into account with any cost
saving decisions that result from outsourcing. Moreover, the study pointed out that offshore outsourcing has a stronger positive effect on recalls than does offshoring. Outsourcing locally however, is associated with the least less risk in terms of quality failures than either offshore outsourcing or offshoring by itself. Thus, managers deciding to outsource in offshore locations must be particularly aware that such a strategy entails particularly risks and take necessary preventive actions to limit any breakdowns that might lead ultimately to costly product recalls.

A second finding in this paper is the complex relationship between supply base concentration and product recalls and overall outsourcing strategy. This finding also has an important managerial implication. Recently, large firms have been diversifying their supply bases as a risk mitigation strategy. For example, Flextronics was the sole EMS supplier for the Xbox. However, Microsoft added Wistron and Celestica as suppliers in 2004 (Lee et al., 2006) in order to diversify supply risk. Given the fact that Microsoft is on the high side in terms of outsourcing, the company may also benefit through the reduction of recall risks. However, firms on the low side of outsourcing may increase the risks of quality failures by diversifying their supply base.

Clearly, our results highlight the relationship between a firm’s supplier diversification strategy and its overall outsourcing strategy. Our results should direct firms with a predominant outsourcing strategy, to diversify their outsourcing among multiple firms and not to become overly dependent on a single outsourcing partner. On the other hand, firms with a limited outsourcing strategy should be sure to limit outsourcing partners in order to gain leverage over their activities. This is important because not only does concentration of the supply base reduce the exposure of the supply chain to disturbances, but also limits difficulties associated with transactions and coordination needed for effective relationship management in an outsourcing
environment. Thus, firms with a limited outsourcing strategy may be able to reap the cost benefits associated with outsourcing and be able to limit the quality effects by concentrating their outsourcing behavior among few suppliers.

6.3. Limitations

There are a few limitations to the study. First, data limitations restrict the study to only a three-year time period. A study using a panel dataset of more years may better allow for the investigation of causal factors. Second, our study is limited to publicly traded firms. A study that can include private firms is desired to add further insights to the subject area since a reasonable number of recalls are made by private firms. Third, the Bloomberg database, which is the source for the explanatory variables, has data mainly on large firms. Adding small firms to the analysis may improve the generalization of the findings.

6.4. Conclusions

This study provided insight into fundamental managerial decisions regarding outsourcing, offshoring, and supplier concentration and the impacts on production quality breakdowns leading to recalls. We tapped a recently developed supply chain database with detailed quantitative assessment of the supplier base of individual firms in terms of their locations and direct business activities. Thus, we were able to assess the impact of outsourcing, offshoring, and supplier concentration on product quality breakdowns. We were able to identify both firms with product recalls and those without recalls which facilitated the construction of a multivariate model to assess the contribution of outsourcing, offshoring, and supplier concentration to increased likelihood of a product recall.
We concluded that there is a direct positive contribution of outsourcing, particularly offshore outsourcing to product recalls. We also concluded that there is a complex relationship between supplier concentration and the increased likelihood of product recalls that must account for a firm’s overall level of outsourcing. We believe that our results provide a strong signal of the importance of these considerations on overall product quality and the need to continue the investigation of these relationships with additional research.

References


Wilhelmsson, M. 2004. Outsourcing patterns in the pharmaceutical industry. IMD Case Study. IMD-6-0263. IMD, Lausanne, Switzerland.


Tables and Figures

Figure 1: Research Model

Table 1: Distribution of firms by industry

<table>
<thead>
<tr>
<th>NAICS</th>
<th>Industry Description</th>
<th>Number of observations</th>
<th>Outsourcing</th>
<th>Offshore outsourcing</th>
<th>recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>322</td>
<td>Paper manufacturing</td>
<td>17</td>
<td>0.063</td>
<td>0.014</td>
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<tr>
<td>325</td>
<td>Chemical manufacturing</td>
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<td>0.137</td>
<td>0.070</td>
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<td>332</td>
<td>Fabricated metal products</td>
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<tr>
<td>333</td>
<td>Machinery manufacturing</td>
<td>44</td>
<td>0.102</td>
<td>0.049</td>
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<tr>
<td>334</td>
<td>Computer and electronic</td>
<td>165</td>
<td>0.290</td>
<td>0.192</td>
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<tr>
<td>335</td>
<td>Electrical equipment</td>
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<td>0.033</td>
<td>0.053</td>
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<td>Transportation equipment</td>
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<td>Miscellaneous manufacturing</td>
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<td>Total</td>
<td></td>
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### Table 2: Descriptive statistics

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<td>National concentration of suppliers</td>
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<td>1.000</td>
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<tr>
<td>Supplier concentration</td>
<td>0.510</td>
<td>0.338</td>
<td>0.000</td>
<td>1.000</td>
</tr>
<tr>
<td>Offshore concentration</td>
<td>0.170</td>
<td>0.209</td>
<td>0.015</td>
<td>1.000</td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0.099</td>
<td>0.218</td>
<td>0.000</td>
<td>0.350</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>0.045</td>
<td>0.044</td>
<td>0.000</td>
<td>0.308</td>
</tr>
<tr>
<td>Size(sales)</td>
<td>9237</td>
<td>17201</td>
<td>0</td>
<td>156508</td>
</tr>
</tbody>
</table>

### Table 3: Correlation between variables

<table>
<thead>
<tr>
<th>outsourcing</th>
<th>Offshore outsourcing</th>
<th>R&amp;D intensity</th>
<th>Capital intensity</th>
<th>Sales</th>
<th>Prior recalls</th>
<th>Offshoring</th>
<th>offshore concentration</th>
<th>National concentration of suppliers</th>
<th>Supplier concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>outsourcing</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshore outsourcing</td>
<td>0.89</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0.153</td>
<td>0.194</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital intensity</td>
<td>0.079</td>
<td>0.074</td>
<td>0.087</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td>0.453</td>
<td>0.332</td>
<td>-0.081</td>
<td>-0.006</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior recalls</td>
<td>0.129</td>
<td>0.142</td>
<td>-0.069</td>
<td>-0.051</td>
<td>0.16</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshoring</td>
<td>0.039</td>
<td>0.012</td>
<td>-0.118</td>
<td>-0.007</td>
<td>0.418</td>
<td>0.128</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshore concentration</td>
<td>-0.061</td>
<td>0.001</td>
<td>0.258</td>
<td>-0.051</td>
<td>-0.173</td>
<td>-0.054</td>
<td>-0.339</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National concentration of suppliers</td>
<td>-0.441</td>
<td>-0.391</td>
<td>0.059</td>
<td>-0.057</td>
<td>-0.438</td>
<td>-0.137</td>
<td>-0.297</td>
<td>0.267</td>
<td>1</td>
</tr>
<tr>
<td>Supplier concentration</td>
<td>-0.444</td>
<td>-0.262</td>
<td>0.029</td>
<td>0.008</td>
<td>-0.449</td>
<td>-0.081</td>
<td>-0.258</td>
<td>0.247</td>
<td>0.736</td>
</tr>
</tbody>
</table>
Table 4a: Regression results for negative binomial random effects model

<table>
<thead>
<tr>
<th>recall</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Standard error)</td>
<td>(Standard error)</td>
<td>(Standard error)</td>
<td>(Standard error)</td>
<td>(Standard error)</td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>-0.033(0.124)</td>
<td>0.153(0.101)</td>
<td>-0.061(0.122)</td>
<td>0.163(0.109)</td>
<td>-0.014(0.125)</td>
</tr>
<tr>
<td>Firm size (sales)</td>
<td>0.178***(0.073)</td>
<td>0.240***(0.078)</td>
<td>0.235***(0.074)</td>
<td>0.292***(0.084)</td>
<td>0.257***(0.093)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.351*(0.180)</td>
<td>-0.184(0.158)</td>
<td>-0.301*(0.172)</td>
<td>-0.166(0.156)</td>
<td>-0.273(0.175)</td>
</tr>
<tr>
<td>Prior recalls</td>
<td>0.050**(0.019)</td>
<td>0.059***(0.016)</td>
<td>0.050***(0.019)</td>
<td>0.060****(0.017)</td>
<td>0.050***(0.019)</td>
</tr>
<tr>
<td>Outsourcing</td>
<td>0.520***(0.012)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Domestic outsourcing</td>
<td>-</td>
<td>0.109*(0.065)</td>
<td>-</td>
<td>-</td>
<td>0.099(0.142)</td>
</tr>
<tr>
<td>Offshore outsourcing</td>
<td>-</td>
<td>0.485****(0.090)</td>
<td>-</td>
<td>-</td>
<td>0.503****(0.096)</td>
</tr>
<tr>
<td>Offshoring</td>
<td>-</td>
<td>-0.067(0.124)</td>
<td>0.006* (0.004)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.325(2.123)</td>
<td>-1.847* (1.06)</td>
<td>-0.381(2.162)</td>
<td>2.206** (1.099)</td>
<td>-0.515(2.313)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>433</td>
<td>433</td>
<td>433</td>
<td>433</td>
<td>433</td>
</tr>
<tr>
<td>Number of Industries</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Wald</td>
<td>44.43</td>
<td>28.64</td>
<td>47</td>
<td>27.09</td>
<td>46.95</td>
</tr>
<tr>
<td>Model Probability (&gt;chi-squared)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively
Table 4b: Regression results for negative binomial random effects model – Interaction effects

<table>
<thead>
<tr>
<th>recall</th>
<th>Model 6 (Standard error)</th>
<th>Model 7 (Standard error)</th>
<th>Model 8 (Standard error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Intensity</td>
<td>-0.023(0.126)</td>
<td>-0.053(0.101)</td>
<td>-0.063(0.122)</td>
</tr>
<tr>
<td>Firm size (sales)</td>
<td>0.202**(0.081)</td>
<td>0.229**(0.083)</td>
<td>0.296***(0.090)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.229(0.166)</td>
<td>-0.228(0.161)</td>
<td>-0.155(0.155)</td>
</tr>
<tr>
<td>Prior recalls</td>
<td>0.050**(0.017)</td>
<td>0.044**(0.018)</td>
<td>0.061***(0.017)</td>
</tr>
<tr>
<td>Outsourcing</td>
<td>0.665***(0.106)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Domestic outsourcing</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offshore outsourcing</td>
<td>0.559*** (0.106)</td>
<td>-</td>
<td>0.282 (0.220)</td>
</tr>
<tr>
<td>Offshoring</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Supplier concentration</td>
<td>-0.023**(0.011)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Outsourcing*supplier concentration</td>
<td>0.350*** (0.110)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>National concentration of suppliers</td>
<td>-0.083 (0.155)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offshore outsourcing*National concentration of suppliers</td>
<td>-0.103 (0.086)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Offshore concentration</td>
<td>-0.696(1.495)</td>
<td>-0.324(2.293)</td>
<td>0.634*(0.342)</td>
</tr>
<tr>
<td>Offshoring*Offshore concentration</td>
<td>-0.134*(0.077)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Intercept</td>
<td>433</td>
<td>433</td>
<td>433</td>
</tr>
<tr>
<td>Number of Industries</td>
<td>9</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Wald</td>
<td>62.41</td>
<td>57.45</td>
<td>29.09</td>
</tr>
<tr>
<td>Model Probability (&gt;chi-squared)</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively

Table 5: Industry level intercepts and coefficients of outsourcing relationship with recalls

<table>
<thead>
<tr>
<th>NAICS</th>
<th>Industry level intercept</th>
<th>Industry level coefficient of outsourcing</th>
</tr>
</thead>
<tbody>
<tr>
<td>325 Chemical products</td>
<td>-1.92(1.286)</td>
<td>0.030*** (0.005)</td>
</tr>
<tr>
<td>333 Machinery</td>
<td>-1.048(1.473)</td>
<td>0.015 (0.022)</td>
</tr>
<tr>
<td>334 Computer and electronics</td>
<td>-4.380*** (1.031)</td>
<td>0.031*** (0.007)</td>
</tr>
<tr>
<td>336 Transportation equipment</td>
<td>-1.955* (1.112)</td>
<td>-0.134* (0.077)</td>
</tr>
<tr>
<td>339 Miscellaneous (Other durable)</td>
<td>-1.193* (1.10)</td>
<td>0.022* (0.012)</td>
</tr>
</tbody>
</table>

*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively
### Table 6: Two stage estimation results

<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsourcing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>0.285***</td>
<td>0.036</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>0.076</td>
<td>0.063</td>
</tr>
<tr>
<td>Firm size (sales)</td>
<td>0.170***</td>
<td>0.023</td>
</tr>
<tr>
<td>Labor intensity</td>
<td>-0.087</td>
<td>0.066</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.418**</td>
<td>0.191</td>
</tr>
<tr>
<td>recall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsourcing</td>
<td>0.147**</td>
<td>0.073</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.039</td>
<td>0.027</td>
</tr>
<tr>
<td>Firm size (sales)</td>
<td>0.030*</td>
<td>0.016</td>
</tr>
<tr>
<td>prior</td>
<td>0.033***</td>
<td>0.009</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.055</td>
<td>0.126</td>
</tr>
</tbody>
</table>

Firm, industry and time dummies included.
*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively

### Table 7: Results of the panel tobit regression

<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>Std. Err.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsourcing</td>
<td>0.586**</td>
<td>0.289</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.398*</td>
<td>0.226</td>
</tr>
<tr>
<td>Firm size (sales)</td>
<td>0.208**</td>
<td>0.096</td>
</tr>
<tr>
<td>Prior recall</td>
<td>0.107**</td>
<td>0.036</td>
</tr>
<tr>
<td>Intercept</td>
<td>-4.085***</td>
<td>0.906</td>
</tr>
<tr>
<td>Number of observations</td>
<td>433</td>
<td></td>
</tr>
<tr>
<td>Number of Industries</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Wald</td>
<td>29.41</td>
<td></td>
</tr>
<tr>
<td>Model Probability (&gt;chi-squared)</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Instrumented: Outsourcing
Instruments: Capital intensity, Sales, Prior recalls, R&D intensity
*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively
Table 8: Regression results by problem type

<table>
<thead>
<tr>
<th></th>
<th>Design related problems (Std error)</th>
<th>Manufacturing related problems (Std. error)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsourcing</td>
<td>0.459**(0.218)</td>
<td>0.549*** (0.086)</td>
</tr>
<tr>
<td>Prior recalls</td>
<td>0.073 (0.062)</td>
<td>0.065*** (0.017)</td>
</tr>
<tr>
<td>Capital intensity</td>
<td>-0.242 (0.267)</td>
<td>-0.340** (0.194)</td>
</tr>
<tr>
<td>Firm size(sales)</td>
<td>0.319** (0.130)</td>
<td>0.144* (0.085)</td>
</tr>
<tr>
<td>R&amp;D intensity</td>
<td>0.011 (0.270)</td>
<td>0.014 (0.295)</td>
</tr>
<tr>
<td>Intercept</td>
<td>10.417 (717.382)</td>
<td>-0.507 (2.041)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>226</td>
<td>219</td>
</tr>
<tr>
<td>Number of Industries</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Wald</td>
<td>19.23</td>
<td>51.55</td>
</tr>
<tr>
<td>Model Probability (&gt;chi-squared)</td>
<td>0.002</td>
<td>0</td>
</tr>
</tbody>
</table>

*, **, and *** denote 10%, 5% and 1% significance levels for two-tailed tests, respectively.