Improving Supplier Performance in New Product Development:
The Role of Supplier Development

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Forthcoming in *Journal of Product Innovation Management* (2015), Vol 32 (5).

DOI: 10.1111/jpim.12231

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Acknowledgement:
This research was funded by a grant from the Engineering and Physical Sciences Research Council, UK (Grant Number: EP/E003990/l)

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Abstract

Suppliers play an increasingly central role in helping firms achieve their new product development (NPD) goals. Although much attention has focused on managing the buyer-supplier interface, we know little about how firms can enhance a supplier's ability to contribute to an NPD effort. Thus, we propose a theoretical model that conceptualizes supplier development activities within inter-organizational NPD projects as bilateral knowledge-sharing processes. Antecedents (supplier responsibility, skills similarity, and single sourcing strategy) and consequences of supplier development activities (on supplier, product and project performance) are examined using a sample of 153 inter-organizational NPD projects conducted within UK manufacturers. We find broad support for our hypotheses. In particular, we show that the relational rents, in the form of improved product and project performance, attained from supplier development activities in new product development are not achieved directly, but rather indirectly via improvements in the supplier's creative and technological capabilities. Our results emphasize the importance of adopting a strategic view of the potential returns available from investing in the NPD capabilities of key suppliers, and provide clues about underlying reasons for the suboptimal experiences of many firms' collaborative NPD projects.

Keywords: supplier development, new product development, buyer-supplier relationships, survey research

Introduction

A growing body of research indicates that involving suppliers in new product development (NPD) can generate substantial improvements in operational, product, and project performance (Petersen, Handfield, and Ragatz, 2005; Lawson, Petersen, Cousins, and Handfield, 2009; Wynstra, von Corswant, and Wetzels, 2010). This involvement may range from simple technical consultation to full design responsibility for components, sub-assemblies, or systems. However, findings in the literature have been somewhat mixed. While the preponderance of evidence suggests that supplier involvement in new product development is generally beneficial (Song and Di Benedetto, 2008; Johnsen, 2009), others have raised doubts regarding its effectiveness (e.g. Hartley, Meredith, McCutcheon, and Kamath, 1997). The Airbus A380 and Boeing 787 Dreamliner programs, for example, highlight the many challenges and trade-offs in managing suppliers' participation in new product development.

Given that the involvement of key suppliers is important to NPD performance, one logical question is to what extent can a firm positively influence a supplier's performance during NPD? The literature has typically assumed that suppliers meet or exceed the quality standards and technological expectations of the firm. But, what if suppliers do not possess the required specialist component knowledge or technological capabilities? Or they bring a strong technology focus, but lack the architectural knowledge necessary to integrate new technologies into the firm's end product? In such situations the firm may need to work to develop their suppliers' product development capabilities, before, during, and after they are involved in new product development. To our knowledge, the literature is largely silent on these issues. Our study thus addresses two key research questions: (1) what are the antecedents that influence the extent to which firms invest to develop their suppliers' NPD capabilities? and (2) what are the outcomes of these investments during NPD for the supplier, the NPD project, and the performance of the new product?

From a theoretical perspective, Dyer and Singh's (1998) relational view holds that firms and their suppliers can accrue benefits in the form of relational rents when they combine knowledge in novel ways that jointly benefit both parties. For example, a firm may outsource to a supplier a specific aspect of a product or component design, and expect, in return, the supplier to develop creative innovations and new technologies that can be integrated into the new product. However, this depiction of supplier involvement is primarily unilateral knowledge sharing of design recommendations, technical specifications, and new technology from the supplier to the firm (Kotabe, Martin, and Domoto, 2003; Song and Di Benedetto, 2008; Lawson et al., 2009). In the present study, we incorporate the flow of knowledge sharing from the firm to the supplier – in the form of supplier development activities that aim to upgrade the supplier's creative and technological contributions to NPD (Modi and Mabert, 2006; Wagner and Krause, 2009). Thus, we investigate the nomological network of factors that may encourage firms to actively manage the performance of suppliers during new product development.

In doing so, a number of gaps in the extant literature are addressed. First, to date, the literatures on supplier development and supplier involvement have evolved largely in parallel, and there is a deficiency of research with respect to supplier development activities in new product development (Johnsen, 2009; Wagner and Krause, 2009). To address this gap, we propose a model in which the supplier's engineering responsibility in the NPD project, skill similarity between the firm and supplier, and the use of a single supplier are associated with supplier development activities in NPD. Second, research on supplier development has primarily been concerned with improving a supplier's operational performance in areas such as quality, cost, delivery, and flexibility (Krause, Handfield, and Tyler, 2007; Wagner and Krause, 2009). By contrast, conducting an NPD project across inter-organizational boundaries differs from typical day-to-day operational requirements between supply chain parties as the most important supplier tasks revolve around creative and technological contributions (Ragatz, Handfield, and Scannell, 1997; Carson, 2007; Loch and Kavadias, 2008). Exploring the relationship between a firm's efforts to improve a supplier's NPD capabilities and subsequent supplier task performance (their creativity and technology contributions) is a key focus of the paper.

Third, we examine the inter-relations among performance outcomes, explicitly considering the effect of supplier development in new product development (SD-NPD) on supplier's task performance (in terms of creativity and technology contributions), project performance, and new product advantage. Finally, this is one of the first studies to take a holistic view of the relational dynamics between the firm's effort directed at developing its suppliers' technological capabilities, and in turn, the supplier's creative and technological contribution to the NPD project.

The remainder of the paper is structured as follows. First, we examine the literature relating to supplier involvement and supplier development in the context of inter-organizational NPD. Subsequently, we develop hypotheses, and describe our methodology, and analysis. Finally, we discuss the results of our analysis and provide implications for decision makers and future research.

Literature Review

Supplier Involvement in New Product Development

Many well-known firms such as Honda, Chrysler, and Toyota have implemented supplier involvement practices that have transformed their operations and supply chains (Sobrero and Roberts, 2002; Hult, Tomas, and Swan, 2003; Van Echtelt, Wynstra, Van Weele, and Duysters, 2008). In particular, supplier involvement is regarded as one of the reasons why Toyota was able to launch new products faster, with shorter development times, and lower development costs (Dyer and Ouchi, 1993; Liker, Kamath, Wasti, and Nagamachi, 1996). Over the past twenty years a large number of studies have examined the antecedents, characteristics, moderators, and performance outcomes associated with supplier involvement in product innovation (Clark and Fujimoto, 1991; Eisenhardt and Tabrizi, 1995; Ragatz et al., 1997; Swink, 1999; Petersen et al., 2005; Lawson et al., 2009). Various dimensions of supplier involvement have been investigated, such as supplier selection (Petersen et al., 2005; Emden, Calantone, and Droge, 2006), joint problem solving cycles (Clark and Fujimoto, 1991), timing of involvement (Swink, 1999), decision making (Petersen, Handfield, and Ragatz, 2003), team structures (Ragatz et al., 1997) knowledge sharing (Lawson et al., 2009), and supplier engineering responsibility (Liker et al., 1996). Supplier involvement has been found to have a positive effect across a range of different performance outcomes, including reduced material costs, improved material quality, shorter development times, lower project costs, enhanced product functionality, improved product manufacturability, lower manufacturing costs, and access to supplier technology (Ragatz et al., 1997; Handfield, Ragatz, Petersen, and Monczka, 1999; Lau, Tang, and Yam, 2010).

However, there is also evidence that supplier involvement has a number of disadvantages (Primo and Amundson, 2002; Johnsen, 2009), including greater bureaucracy (King and Penleskey, 1992), additional coordination time (Eisenhardt and Tabrizi, 1995), and lower efficiency (Littler, Leverick, and Bruce, 1995). In particular, debate remains over whether supplier involvement helps to shorten or lengthen the development time of a new product (Ragatz et al., 1997); and whether supplier involvement helps to decrease or increase product development costs (von Corswant and Fredriksson, 2002). Consequently, recent research attention has focused on determining which management capabilities decision-makers within the firm should utilize in order to successfully integrate suppliers into their NPD project and achieve superior product innovation outcomes.

Capabilities may be regarded as the "…*complex bundles of skills and collective learning, exercised through organizational processes that ensure superior coordination of functional activities"* (Day, 1994: 38). For example, the ability to effectively manage business-to-business relationships has been identified as a critical capability (Jarratt, 2004). In the present paper, we identify two distinct organizational-level capabilities in supplier involvement: first, the capabilities of suppliers to contribute knowledge, technology and various skillsets to the NPD process, and second, the capability of firms to integrate suppliers into the NPD process. The former includes the suppliers' ability to provide technical and production expertise, to move quickly from providing a prototype to volume production, and to incorporate new technologies into the components and sub-assemblies they make and deliver to their customer (Terwiesch and Bohn, 2001). The latter includes the ability of the firm to manage the quality of their suppliers' NPD performance and to step in to help suppliers when needed (Chaudhuri, Mohanty, and Singh, 2013). For example, suppliers and their representatives often lack the project management skills required to be effective contributors to NPD teams. Working as part of an inter-organizational NPD team with people from different companies and skillsets, while meeting challenging technical- and time-related deadlines, can be difficult for the supplier, and so may form part of the supplier development effort.

Developing a Supplier's New Product Development Capabilities

The Ford Motor Company undertook supplier development as far back as the early 1900s (Seltzer, 1928), though it wasn't until the 1980s and 1990s that greater attention was paid to developing the operational capabilities of suppliers (Leenders, 1966; Krause, Handfield, and Scannell, 1998). Krause et al. (1998: 40) define supplier development as *"an effort by an industrial buying firm to improve the performance or capabilities of its suppliers."* Previous research has focused on the antecedents of supplier development (Krause, 1999), supplier development goals (Wagner and Krause, 2009), the process of supplier development (Hartley and Choi, 1996), reactive and proactive supplier development (Krause et al., 1998), supplier development practices (Modi and Mabert, 2006), and the performance outcomes associated with supplier development (Dyer and Hatch, 2006). Other research identified four different supplier development strategies including competitive pressure, evaluation and certification systems, incentives and direct supplier development (Krause, Scannell, and Calantone, 2000).

Greater involvement of suppliers in NPD in recent years has led firms to consider how to rectify deficiencies and develop further their suppliers' capabilities in product design. A firm may undertake direct supplier development with the intention of developing a supplier's new product development capabilities within a particular NPD project by sharing technological knowledge and organization routines (Modi and Mabert, 2006), helping design production processes for the new product, and sending employees to the suppliers' facilities. Such activities are often required because design errors, quality defects and technical glitches are built into the new product during the early phases of the NPD cycle, and frequently originate from the suppliers that are involved in the NPD project (Hoopes, 2001; Rauniar, Doll, Rawskic, and

Hong, 2008; Koufteros, Rawski, and Rupak, 2010). A proactive approach to upgrading suppliers during product development can prevent such quality defects occurring within the supply chain before the new product is launched into the market (Wagner, 2006; Krause et al., 2007), as well as facilitate joint problem solving, knowledge sharing, commitment, and relational trust (Dyer and Nobeoka, 2000).

While firms increasingly educate and develop suppliers selected for involvement in their NPD projects, empirical evidence on the effectiveness of such practices is sparse. One reason for the mixed results for the effects of supplier involvement in NPD may be that research has not fully investigated the development activities that take place between a firm and supplier during NPD. More specifically, research has yet to explore the extent to which firms allocate resources to supplier development efforts before or during the involvement of suppliers in NPD. Furthermore, firms may not be synchronising their supplier development and supplier involvement practices, and in particular, may not be focused on supplier creativity and innovation as important determinants of NPD success. For example, many firms involve suppliers in NPD without thinking proactively about how to improve supplier capabilities to solve technical glitches that frequently occur during NPD (Rauniar et al., 2008; Koufteros et al., 2010). Instead, firms often rely on a reactive supplier development approach – *after* the start of production – once they find their supplier's performance lacking. This effort may be necessary especially when there are few alternative suppliers to switch to and the supplier provides a strategic item. The experience of Boeing's 787 Dreamliner program would seem indicative of just such an approach.

Theoretical Framework

Dyer and Singh (1998) argue that the primary sources of relational rent reside in inter-firm knowledge-sharing, relation-specific assets, complementary resource endowments, and effective governance. The relational view provides a useful lens regarding how and why firms and their key suppliers share knowledge, routines, and resources during a collaborative NPD effort. Given that supplier involvement efforts vary in terms of their success in meeting NPD goals, the present research focuses on the efforts of firms to increase the capabilities of suppliers during NPD and the effects on performance. Our model first examines the antecedents of supplier development activities during NPD. Specifically, does the level of supplier responsibility, supplier skills similarity, and the use of a single sourcing strategy influence firm decisions to proactively develop suppliers? These factors are among the key strategic decisions as part of a supplier NPD sourcing strategy (Handfield et al., 1999; Van Echtelt et al., 2008; Roy and Sivakumar, 2012). Second, we investigate the effect of supplier development activities on different elements of NPD performance. Each party may bring complementary capabilities to NPD. For example, the supplier may bring technical expertise, and the firm may bring project management expertise and other technical knowledge (Dyer and Singh, 1998). However, the majority of the extant literature does not differentiate between the impact of supplier development activities during NPD on different organizational outcomes (Krause et al., 2007). As shown in Figure 1, we propose that supplier development during NPD is positively related to supplier task performance, in the form of the supplier's creative and technological contributions, which in turn enhances project performance and new product advantage.

Insert Figure 1 Here

Supplier Responsibility

Previous studies have found that project and product performance can be enhanced when suppliers are given more engineering responsibility within collaborative NPD projects (Liker, Kamath, and Wasti, 1998; Wynstra, Anderson, Narus, and Wouters, 2012). Japanese automotive firms, for example, delegated significantly more responsibility to their suppliers than US and European producers (Clark and Fujimoto, 1991). The general consensus is that NPD projects can experience superior performance when greater responsibility for NPD activities and decision making is devolved to suppliers (Bonaccorsi and Lipparini, 1994; Swink, 1999; Hobday, Davies, and Prencipe, 2005). From a managerial perspective, one of the primary motivations for allowing suppliers to take on greater responsibility is to reduce the cost, development time and risk of NPD (Liker et al., 1998; Koufteros et al., 2010). Such motivations underlie recent examples of outsourcing responsibilities for product and process design to suppliers, such as the Boeing 787 Dreamliner, the Airbus A380 and the F22 joint strike fighter.

However, suppliers that have been allocated the greatest NPD responsibility must meet quality, technical, design, time, and managerial expectations. Therefore, firms that are convinced that supplier development activities during NPD are a good investment will carefully consider how to allocate those resources to increase the probability of NPD success. Dyer and Singh (1998) note that a firm transferring know-how to another firm must have incentives to incur the cost of making such a transfer (Mesquita, Anand, and Brush, 2008). In this case, the firm is incentivized to invest in supplier development because of the significance of the supplier's role in the NPD project and to increase NPD success (Wynstra et al., 2012). Investing in supplier development helps ensure that standards, procedures, and performance outcomes within NPD are high, and that the supplier's sub-assemblies, modular and systems are successfully integrated together within the NPD project (Hobday et al., 2005).

H1. There is a positive relationship between the proportion of engineering responsibility delegated to the supplier, and the level of supplier development undertaken during the NPD project.

Skills Similarity

Within a firm's supply base, there is likely to be a portfolio of technical skills: some suppliers will have compatible technical skills with the firm, while other suppliers will be specialists in different skills and knowledge pools (Bensaou and Anderson, 1999). Dyer and Singh (1998) note that firms generate relational rent by leveraging the distinct resources of each party (Mesquita et al., 2008). In many cases, these different or distinctive supplier resources can provide the potential for greater relational rent, and in turn, provide the firm with an incentive to invest in supplier development for NPD (Dyer and Singh, 1998; Mesquita et al., 2008). In the context of collaborative NPD, skills similarity occurs when the supplier's technical work shares similarities with the firm's activities, when employees of the two firms have similar training and technical backgrounds, and when the firm is successful in the same technological field as the supplier (Carson, 2007). Knowledge sharing and the transfer of technological routines across inter-organizational boundaries are often facilitated when the supplier and firm share similar technological capabilities and skills (Handfield et al., 1999; Kotabe et al., 2003). Hence, as a firm and its supplier have increasing overlap in their respective skillsets, the need for supplier development activities is likely to decrease. As internal resource constraints limit the ability of a firm to develop all their suppliers, they therefore target supplier development at dissimilar suppliers that represent the greatest strategic risk. Following Dyer and Singh (1998), we propose that in recognizing the distinct and similar resources of each party (Mesquita et al., 2008), firms will be less likely to invest in supplier development activities for suppliers with skillsets similar to their own.

H2: There is a negative relationship between skills similarity and the level of supplier development activities undertaken during the NPD project.

Single Sourcing

An important way in which decision makers manage collaborative NPD projects is via the type of sourcing strategy used (Liker et al., 1996). Single sourcing involves the deliberate selection of one supplier, even though multiple suppliers are available. Using a single supplier to provide a technological solution or to develop a subassembly for an NPD project may be more efficient in terms of managing the relationship and minimizing project complexity. In contrast, using two or more suppliers may force a design competition, with a goal of finding the best design solution (Kraljic, 1983; Costantino and Pellegrino, 2010). However, relying upon market governance may also constrain the ability of both parties to conduct joint activities in collaborative NPD (Krause et al., 2000). Further, developing the capabilities of multiple suppliers, instead of a single supplier, of a particular item can be costly and has the potential to increase complexity, development times, and costs (Primo and Amundson, 2002).

To improve product quality and lower costs, Deming (1986) argues that firms should build long-term collaborative relationships with a single supplier for an item and invest in supplier development (Richardson and Roumasset, 1995). However, single sourcing can also increase the firm's dependence on the supplier, raise the risk of supplier opportunism, increase switching costs and lock-in obsolete technologies (Ramsay and Wilson, 1990; Richardson and Roumasset, 1995). Thus, given the multi-faceted importance of a single-source supplier's position in an NPD project, firms may engage in supplier development activities to achieve transparency and manage supply chain risks (Chaudhuri et al., 2013). Following Dyer and Singh's (1998) relational view, we propose:

H3. There is a positive relationship between the use of a single supplier strategy and the level of supplier development activities undertaken during the NPD project.

Supplier Development Activities in NPD and Performance Effects

When a firm develops a supplier during the process of NPD it enhances the ability of the supplier to generate creative innovations tailored to the firm's needs. That is, making relation-specific investments through supplier development and thus combining resources in unique ways may create idiosyncratic inter-firm linkages that produce relational rents and, ultimately, competitive advantage (Dyer and Singh, 1998). During the process of supplier development in NPD, managers may conduct site visits, provide technological and project management knowledge, and train supplier's employees, aimed at improving the supplier's creativity and innovation capabilities, that is, the supplier's task performance (Carson, 2007). When firms develop their suppliers they increase the stock of new knowledge within the supplier's NPD team, which may lead to greater creativity and technological innovation by the supplier (Amabile, 1998). For example, if the firm provides project management know-how of the most effective and efficient ways to develop creative innovations, then the supplier will become more capable at product development.

H4: There is a positive relationship between supplier development activities undertaken during the NPD project and the supplier's task performance.

Supplier Task Performance

As each firm specializes on its own core competency along a supply chain, its NPD activities also become specialized in a niche product group, market, industry, technology, sub-assembly, or system (Loch and Kavadias, 2008). This trend has seen many firms outsource specific NPD activities and build integrated problem solving cycles in order to access suppliers' unique skills and creativity (Atuahene-Gima and Wei, 2011). Consequently, firms have become increasingly reliant on their suppliers to generate innovations and creative solutions, which must then be integrated into the new product (Leonard-Barton, 1995). As Grant (1996) argues, firms can therefore generate a new product advantage by being more successful at knowledge integration with suppliers, especially if they can access creative innovations that lead to a first mover advantage (Lieberman and Montgomery, 1988). When suppliers have higher levels of creativity and tailored innovation, they can develop novel solutions to be incorporated into the end product and ultimately attain a unique market advantage (Song and Di Benedetto, 2008). Kibbeling, Bij and Weele (2013), for example, identified that a supplier's innovativeness can have a significant positive effect on the focal firm's level of innovativeness arguing that "…the more innovative the supplier, the more potential new ideas, opportunities, and innovations are created and flow from the supplier to the focal firm" (p. 505). Based upon these arguments, the following hypothesis is proposed:

H5: There is a positive relationship between a supplier's task performance (creativity and technological contribution) and new product advantage.

Little research has explored the impact of supplier task performance – conceptualized in terms of creativity and technological contribution - on project performance when suppliers are involved in NPD. Previous research has shown that supplier's technological capabilities are an important determinant of project effectiveness and product success (Hoopes and Postrel, 1999; Takeishi, 2001). By upgrading a supplier's creative and innovative performance, firms are likely to find that the supplier can generate novel solutions to technical errors, design defects, and glitches which enable the technical goals, quality targets, schedules, and costs for the project to be met (Koufteros et al., 2010). Hoopes and Postrel (1999), for instance, argue that supplier involvement and inter-firm knowledge sharing can help to solve technical glitches within NPD, which are an important source of project delays and cost overruns.

H6: There is a positive relationship between a supplier's task performance (creativity and technological contribution) and NPD project performance.

Research Design

Sample Characteristics

A sample of 1700 medium-to-large manufacturing firms was developed from databases held by Department of Trade & Industry (United Kingdom) and other publicly available sources. Respondents were selected on the basis of Standard Industrial Classification (SIC) industry code (top five industries on R&D intensity), job function (purchasing manager or equivalent), and plant size (at least 100 employees). To ensure that the firms met our selection criteria, telephone calls were made to the managers of each of the manufacturing firms prior to distribution of the survey. These preliminary telephone conversations confirmed the difficulties in identifying key respondents with knowledge of a supplier's role in an NPD project. Often several referrals within a firm occurred before we identified the single most-knowledgeable respondent.

After data screening, 204 firms did not meet the selection criteria for our research and were removed, resulting in a final sample of 1,496 firms. Ultimately, 160 questionnaires were received, of which seven were unusable due to missing data. The effective response rate is thus 10.3% (153/1496). Of the responding firms, industries represented were electrical (35.3%), aerospace (14.4%), chemicals (11.8%), pharmaceutical (10.4%), automotive (8.5%), and general manufacturing (11.1%). The final eleven percent of firms had no response to industry classification. The response by position held within the firm was Purchasing Manager (38.5%), Operations Manager (19.6%), R&D Manager (17.0%), and Procurement Director (15.6%). No significant mean differences were detected between these groups, or across functional departments. The average experience in the industry was 9.56 years, providing support that our informants were also knowledgeable about the issues under investigation. Table 1 presents further sample characteristics.

Insert Table 1 Here

Survey Administration

The unit of analysis is a single dyadic relationship between the firm and a supplier that had been involved in a collaborative NPD project completed within the last three years. Respondents were further instructed to select a supplier that had provided a critical component or sub-assembly into the firm's end product. As an additional validation check, we also asked respondents their level of knowledge of the supplier relationship and NPD project, using a Likert scale of 1 to 7, where

7 represented “extensive knowledge”. A mean response of 5.8 (out of 7) provides confidence that respondents were knowledgeable regarding the items under investigation.

Ten semi-structured interviews were conducted with purchasing managers, project managers, and design engineers to develop and refine the focus of the survey. The completed instrument was then pilot-tested with ten additional managers, and six expert academics who were asked to critically evaluate and comment on the design, content, clarity, and scaling of the survey. Minor modifications were made based on this feedback. Each respondent was mailed a copy of the survey, together with an accompanying cover letter that explained the purpose of the research. A number of procedures were followed in an attempt to enhance the response rate (Dillman, 2000). Respondents could respond via return post, or internet, and were offered a composite summary of results (Forza, 2002). Also, a reminder postcard was sent to each respondent two weeks after the initial mailing. Finally, follow-up phone calls were made after six weeks.

A number of tests were conducted to detect the presence of response bias, especially for any differences between early and late responders (Armstrong and Overton, 1977). Results indicated no statistically significant differences. Second, representative checks were conducted using Pearson’s chi-square tests to determine whether particular types of firms were over or under represented within the sample compared to the population (Greene, 2002). While our analysis does not rule out the possibility of response bias, it suggests that the sample is broadly representative.

Operationalization of Variables

All constructs were drawn from the extant literature. Items were assessed on a Likert scale ranging from 1 “strongly disagree”, to 7 “strongly agree”. Further details of these measures are provided in Appendix A.

New product advantage. The scale developed by Song and Parry (1997) was adopted, with respondents asked to assess their firm’s new product compared to those of competitors’ products in terms of unique features, technical performance, quality, enabling customers’ to do something they could not presently do, and meeting customers’ needs.

Project performance. A modified version of Petersen et al. (2003) was used to assess the performance of the NPD project. The five-item construct examined whether, relative to the firm’s internal goals, the project had met quality standards, technical objectives, schedule targets, budgeted cost targets, and project goals. A seven-point Likert scale anchored at 1= “much worse’’ to 7= “much better” was used.

Supplier task performance. Following Carson (2007), this factor was broken into two sub-factors assessing supplier creativity and technology contribution. The creativity sub-factor asked about the supplier’s contribution in terms of providing new knowledge, new discoveries, and the level of creativity. The technology contribution sub-factor asked respondents to characterize the supplier’s anticipated technology contribution to the NPD project in terms of its effect on competitiveness, functionality, and profitability of the new product. This ensures the construct reflects both the creativity and the broader value of the technology provided by the supplier.

Supplier development activities in NPD. A scale previously developed by Krause (2000) was adapted to an NPD context. Five items measured the degree to which firms were directly involved in the supplier's product development activities, visited the supplier's facilities to help them improve their product development performance, provided technological know-how, aided in the design of production processes for the new item, and provided project management know-how during product development.

Supplier responsibility. The approach of Clark and Fujimoto (1989) and Liker et al. (1996) was adopted asking respondents to indicate the percentage of total engineering hours for the new product attributable to this specific supplier.

Skills similarity. A four-item scale was adapted from Carson (2007), with respondents asked to consider the similarity of the firm's task-related skills to those of the supplier at the outset of the project (to avoid confounding effects of skills learned during the project). Items assessed the competencies embedded at the firm unit-level with regards to the similarity of the supplier's technical work to: that regularly done by the firm, to the firm's most important products, to the firm's technical background, and to the firm's ability to successful perform the type of work the supplier was doing.

Single supplier sourcing. The approach of Richardson and Roumasset (1995) was used to assess whether the firm utilized a single supplier, or multiple suppliers for the particular component or input. Respondents were asked to quantify the percentage of their total purchases of the particular item provided by the supplier; and then how many suppliers in total were used. The variable was binary coded as single supplier sourcing set to 1, otherwise 0.

Control variables. Relationship length was controlled for due to its likely influence on the extent of supplier development activities conducted by the firm due to familiarity with the supplier. Component importance was also included, coded as 1 or 0, depending on whether the supplier provided a sub-assembly to the firm (Liker et al., 1996). Finally, a binary variable of technological newness controlled for the need to undertake supplier development activities and the extent of product advantage gained due to the degree of 'radicalness' of the end new product.

Data Analysis

Confirmatory Factor Analysis

A two-step process of analysis using AMOS 19.0 was employed to test our hypotheses (Anderson and Gerbing, 1988). Confirmatory Factor Analysis (CFA) was used to test for construct validity and unidimensionality using latent and manifest variables. Within each construct, one of the loadings was fixed to the value of one. Low factor loadings, high residual values, and modification indices were examined. Three items, one each from new product advantage, project performance and supplier development were removed from the analysis due to low loadings. Table 2 presents the details of the loadings and error terms of the manifest variables onto each latent variable. One and two-factor solutions for supplier task performance were also examined, with a chi-square difference test indicating that the second-order factor produced significantly better fit to the data than a one-factor solution ($\Delta\chi^2(2) = 42.6$, $p<0.01$).

Insert Table 2 Here

Harman's one-factor test was used to examine potential common methods bias (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). A principal component factor analysis was conducted on all constructs, with factor 1 (largest factor) accounting for 24 per cent of the variance. No single factor emerged, nor did one factor account for most of the variance, indicating that common methods bias may not be a serious problem in the data.

Model fit was examined using four measures: the chi-square test, the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root-mean-square error of approximation index (RMSEA) (Gerbing and Anderson, 1992). The fit of the CFA to the data was satisfactory [$\chi^2(177)=320.36$, $p=0.00$; CFI = 0.92; TLI = 0.91; and RMSEA = 0.07]. A number of procedures were then followed to check for convergent validity (Bagozzi and Yi, 1988) and discriminant validity (Fornell and Larcker, 1981; Anderson and Gerbing, 1988). The convergent validity of the scales (extent to which the measurement items reflect a common underlying construct) was supported, with estimated coefficients of all indicators being significant ($t > 2.0$). The average variance extracted (AVE), which measures the variance captured by the indicators relative to measurement error, was also greater than the 0.50 minimum necessary to justify the use of a construct (Hair, Anderson, Tatham, and Black, 1998). Composite reliability values also provide a further assessment of internal consistency. A minimum value of 0.70 is recommended as it indicates that around 0.50 of the variance (the squared loading) can be attributed to the construct of interest (Fornell and Larcker, 1981). The composite reliabilities, which ranged from .85 to .92, each met the required level.

All tests of discriminant validity were supportive. That is, no confidence intervals of the correlations for the constructs (ϕ values) included 1.0 ($p < .05$) (Anderson and Gerbing, 1988), and the square of the intercorrelations between two constructs, ϕ^2, was less than the AVE estimates of the two constructs. This was true for all pairs of constructs (Fornell and Larcker, 1981). Inter-item correlations, Cronbach's alpha, composite reliabilities (CR), and average variance extracted (AVE) values are shown in Table 3.

Insert Table 3 Here

Structural Model

The structural model was tested using maximum likelihood estimation. The structural model indicates an acceptable fit to the data [$\chi^2(274) = 430.3$, p=0.00; CFI = 0.92; TLI = 0.90; and

RMSEA = 0.061]. Figure 2 presents the results from the structural model, indicating that four out of the six research hypotheses were supported.

Insert Figure 2 Here

Results

The results show a significant positive relationship between supplier responsibility and supplier development (β= .23, $p<0.01$), providing support for H1. However, H2 is not supported, with results indicating that skills similarity is not significantly associated with supplier development (β= .09, p=n.s.), while contrary to expectations in H3, single supplier is significantly negatively related to supplier development (β= -.19, $p<0.05$). Supplier development for NPD is positively related to supplier task performance (β= .20, $p<0.05$) (H4), and in turn, supplier task performance was shown to have a significant positive impact on new product advantage (β= .31, $p<0.001$) and project performance (β= .36, $p<0.001$) providing support for H5 and H6, respectively.

A nested model was also used to identify the presence of direct effects between supplier task performance, and new product advantage and project performance. Results indicate that each direct effect was non-significant and a chi-square difference test against the hypothesized model showed no significant improvement in model fit to new product advantage ($\Delta\chi^2(1)$ = .04, n.s) or project performance ($\Delta\chi^2(1)$ = .10, n.s). These results indicate that the hypothesized model is the most parsimonious representation of the data. A Sobel test (1982) further indicates that supplier development in NPD has a significant indirect effect on new product advantage (t=1.66, p=0.05), and project performance (t=1.68, p=0.05), operating through supplier task performance.

With regard to control variables, the results indicate that relationship length is positively related to supplier development in NPD (β= .17, $p<0.05$) and to new product advantage (β= .16, p<0.05). Technological newness of the firm's end product (β= .08, p=n.s.) and component importance (β= .13, p=n.s.) were both found to have no significant relation to supplier development in NPD, but were significant associated with new product advantage at β= .19 (p<0.01) and β= .24 (p<0.001), respectively. In addition, the components of technological contribution and supplier creativity both loaded at high levels on the second-order supplier task performance factor. These loadings (β= .83, p<0.001 and β= .94, p<0.001, respectively) provide an indication of the relative contribution of the components to overall supplier task performance.

Discussion

During case study visits to firms undertaken prior to administration of the survey research reported in this paper, we were provided with many in-depth descriptions of the involvement of suppliers in NPD. In virtually every description, there were problems, many of which originated from suppliers or interfaces with suppliers. These NPD experts talked about suppliers who lied about their NPD progress, about planned technologies that never made it into the new products, about problems with technical glitches that originated from suppliers, and about missed NPD time deadlines and cost targets. In most cases, managers held debriefing sessions after their NPD projects, wherein they attempted to diagnose what had happened, both good and bad, and how to improve for the next NPD effort. Many of these improvements included the need to improve the customer-supplier interface, and to help suppliers improve the quality, delivery and technical specifications of their NPD deliverables.

Overall, the results of the present study support the notion that firms' supplier development efforts during NPD can play an important role in instigating creativity and innovativeness in key suppliers, and can ultimately enhance the performance of NPD projects.

The results also provide support for Dyer and Singh's (1998) relational view, where knowledge-sharing routines, and complementary resources and capabilities are among the sources of competitive advantage that span organizational boundaries.

Consistent with Hypothesis 1, suppliers with greater responsibility for NPD activities, measured as the percentage of engineering hours contributed to the end product, were more likely to receive support from the firm to upgrade their NPD capabilities. These findings are consistent with prior research where firms proactively implement supplier development with critical suppliers to maintain *operational* performance imperatives such as quality, delivery, and technological standards in their supply bases (Krause et al., 1998). However, our results indicate that managers should also consider designating resources for supplier development *during* NPD. While supplier development is a time and resource-intensive process, managers can act strategically by deciding to focus their supplier development on key suppliers of strategic items that significantly affect product success, and ultimately product advantage in the marketplace. The results of H1 further reinforce the importance of complementary resource endowments and distinctive resources brought by each party to NPD (Dyer and Singh, 1998). H1 proposed that suppliers making the most significant contributions to NPD were the most likely recipients of supplier development efforts. In such cases, a supplier may have significant engineering expertise but, for example, limited project management skills. Thus, a firm should be aware of their suppliers' abilities and limitations so as to decide when and where supplier development should occur.

Hypothesis 2 proposed that a firm would be less likely to invest in supplier development in NPD as buyer-supplier skills increasingly overlap. H2 was justified through Dyer and Singh's (1998) notion that competitive advantage was most likely to result from relationships where the parties brought complementary resource endowments, that is, distinctive resources that when combined, yielded relational rent (Mesquita et al, 2008). However, we did not find support for this relationship. A possible explanation for the insignificant finding is that the relationship between skills similarity and supplier development is highly context-specific to different collaborative NPD projects. For some NPD projects, similar pools of knowledge between firm and supplier facilitate the sharing of R&D and technological know-how necessary for successful performance, and supplier development is not required as the supplier already meets or exceeds the firm's technological standards. For other projects, firms may involve suppliers with a different set of technical skills, and use supplier development to align the supplier's technological capabilities and product development routines to their needs (Wagner and Krause, 2009). Moreover, there may be suppliers that are niche technological providers that do not require development by the firm because they are already technical leaders in their specific field (Prahalad and Hamel, 1990). Our sample may include NPD projects that fall into each of these scenarios, thus emphasizing the need for future research to explore the complex relationships between skills similarity and supplier development in NPD.

Previous research suggests that firms focus their development efforts on single suppliers due to the risks arising from their monopoly position, technological lock-in, and limited competition (Deming, 1986; Richardson and Roumasset, 1995). Contrary to expectations, our results in testing H3 indicated a significant, but negative relationship between a single sourcing strategy and the level of supplier development in new product development. A number of factors may help explain this counter-intuitive finding. First, firms are likely to implement a more intensive supplier selection and monitoring process with their single suppliers in comparison to multiple suppliers (Ramsay, 1990). Thus, there may be a temporal aspect to this question not captured with our current data. Consequently, the single suppliers selected for involvement in NPD may be less likely to require further technological development from the firm. Second, the supplier may be a technological leader within the supplier market, and have developed a new component that competitors find difficult to imitate (Barney, 1991). These suppliers are likely to have established technological capabilities and do not require the firm to develop their NPD capabilities. Single suppliers with a first mover advantage may also be less receptive to supplier development efforts undertaken by firms for fear of knowledge leakages to rivals, the erosion of their bargaining power, or the firm acting opportunistically (Costantino and Pellegrino, 2010).

Attention now turns to the impact of supplier development on NPD performance outcomes, and our analysis of the bilateral exchange between supplier development efforts by the firm and the supplier's reciprocal contribution to the NPD project. Our results indicate that supplier development during NPD results in improved supplier task performance, in terms of the creativity of the supplier solution and its potential technological contribution to the firm's end product (H4). Improved supplier creativity and innovation is a key motivation for involving suppliers in NPD, and our results show that engaging in supplier development activities is an effective route to achieving this goal. Consistent with the literature on creativity (e.g. Amabile, Conti, Coon, Lazenby, and Herron, 1996; Carson, 2007), the results of the present study suggest that supplier development activities serve to increase the stock of new knowledge and routine-building within the supplier's NPD function, facilitating, amongst others, the ability to generate creative solutions to technical problems. This idiosyncratic knowledge transferred from firm to supplier may range from component and architectural knowledge, to technical and managerial know-how required to boost creativity and innovation (Modi and Mabert, 2006).

Support was found for the positive relationships between supplier task performance and both project performance (H5) and new product advantage (H6). The results support the existence of a significant, positive indirect effect on both project performance and new product advantage, operating through supplier task performance. In other words, firms are able to appropriate relational rents, in the form of improved project performance (on-time, to budget, meeting required technical objectives) and product performance (market advantage), when they focus development efforts on enhancing their supplier's creativity and technological contributions to NPD.

Overall, our results point to the importance of relationship-specific, bilateral exchanges as a source of competitive advantage. Investments in upgrading a supplier's NPD capabilities do not specifically influence typical NPD performance metrics related to project or product performance. However, the returns from their development efforts arises indirectly through access to more technologically savvy suppliers, who are better able to undertake creative problem-solving activities and contribute valuable technology to the firm. These results hold after controlling for the influence of component importance, length of the relationship and technological newness of the end product on both the extent of supplier development activities, as well as the new product advantage achieved, relative to competitors. Thus, our results illustrate the value derived from investing in supplier development during NPD, as a partner-specific routine, which leads to gains deployable only within the relationship.

Managerial Implications

One of the primary managerial recommendations from this study is to recognize the potential contribution that supplier development can make in NPD, and to extend traditional supplier development programs to focus proactively on developing suppliers that are chosen for involvement in NPD. This effort may include adapting supplier development goals, programs and initiatives undertaken by the firm with a greater emphasis given to developing the supplier's creativity and technological capabilities (Wagner and Krause, 2009). For larger firms, these efforts may also require the formation of dedicated cross-functional teams to manage the development and involvement of suppliers throughout the NPD project. Our findings highlight the importance of considering *proactive* supplier development before, during, and after suppliers are involved in NPD, especially for key suppliers with design responsibility (Liker et al., 1998).

Toyota serves as an example of a firm that has recently emphasized the use of a single supplier strategy for many of its component parts (Economist, 2010). Spurred on by an effort to increase its market share, the firm integrated many of these suppliers into its NPD projects. However, transparency of these suppliers' actions and capabilities apparently slipped as the firm's monitoring efforts lagged behind its dramatic growth. Ironically, Toyota has clearly documented supplier development capabilities (Liker and Choi, 2004). Our results suggest that better monitoring of these suppliers might have identified the need for supplier development as an important concurrent activity to the involvement of these suppliers in the various NPD projects.

Our results also indicate a need to re-examine the metrics against which supplier development programs are assessed. Operational performance criteria typically used to evaluate such programs (e.g., lead times, cost savings, schedule targets, quality defects, etc), are unlikely to detect the beneficial impact supplier development activities have on supplier creativity and technological contribution within inter-organizational NPD projects. However, we encourage managers to broaden their perspective, recognizing that investments in building a supplier's NPD capabilities will ultimately be reflected in improved product and project performance, and reflect relational-specific rents unavailable to competitors.

Limitations and Future Research

A number of limitations should to be taken into consideration when interpreting the results from this study. First, although our study focuses on cross-sectional data collected from a large sample of industries, it is based upon firms within the United Kingdom manufacturing sector, which may limit generalizability. The practicalities of collecting detailed data on a single key supplier involved in a single NPD project limited the size of our sample and meant that many contingent factors could not be examined in detail. In addition, case study research could help identify how firms synchronize their supplier development programs and supplier involvement initiatives over time and how the relational rents from supplier development are shared between the two parties. Moreover, future research efforts could include the collection of data from multiple respondents on both sides of the dyadic relationship (Nyaga, Whipple, and Lynch, 2010).

Broadly speaking, our results lend support for Dyer and Singh's (1998) relational view of the firm by illustrating that the sources of value, in part, lie in the relationships between firms (Mesquita et al., 2008). Building on Dyer and Singh (1998), future research could explore each of the four potential sources of value or relational rent. For example, researchers might examine the value of different inter-firm relationship-specific assets to NPD, which may be site, physical asset, or human asset specific (Williamson, 1985). Further, researchers could examine the timing and nature of supplier development in NPD, as well as investigate the enablers, barriers, and complexities of two-way knowledge sharing during collaborative NPD.

The outcomes of NPD, as measured in the present study, point to greater relational rents obtained by collaborative supplier development and involvement in the NPD project. Future research could explore the extent to which these gains are captured by the buyer-supplier dyad, or are also potentially re-deployable by the supplier to other customers as a form of market spillover. Finally, while the present study did not include measures of governance, which includes formal safeguards (such as legal contracts) and informal safeguards (such as trust or embeddedness), future research could explore which governance mechanisms foster supplier development in NPD, and how firms can successfully develop their suppliers' creativity and technological contributions.

Conclusion

A theoretical model to investigate the antecedents and consequences of supplier development in inter-organizational NPD projects was proposed, investigating the bilateral interactions between firms and their suppliers, with supplier development primarily representing a flow of knowledge and resources toward the supplier, and supplier involvement in NPD representing a flow of knowledge and technology toward the firm. Where previous studies of supplier development have framed the benefits primarily in terms of operational performance improvements, we show that supplier development influences firm NPD outcomes indirectly via improvements in a supplier's creative problem-solving capabilities. In other words, firms appropriate relational rents from their supplier development activities by integrating their supplier's creative ideas and new technologies into their NPD projects. Overall, these findings provide evidence of the importance of developing suppliers' creative and innovative capabilities to improve the performance of inter-organizational new product development. Our findings may also provide clues about underlying reasons for many firms' suboptimal experiences in NPD projects, and we hope our study incites further research in this area.

REFERENCES

Amabile, T.M. 1998. How to kill creativity. *Harvard Business Review* 76 (5):76-87.

Amabile, T.M., R. Conti, H. Coon, J. Lazenby, and M. Herron. 1996. Assessing the work environment for creativity. *Academy of Management Journal* 39 (5):1154-1184.

Anderson, J.C., and D.W. Gerbing. 1988. Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin* 103:411-423.

Armstrong, S.J., and T.S. Overton. 1977. Estimating non-response bias in mail surveys. *Journal of Marketing Research* 14 (3):396-402.

Atuahene-Gima, K., and Y. Wei. 2011. The vital role of problem-solving competence new product success. *Journal of Product Innovation Management* 28 (1):81-98.

Bagozzi, R.P., and Y. Yi. 1988. On the evaluation of structural models. *Journal of the Academy of Marketing Science* 16 (1):74-94.

Barney, J. 1991. Firm resources and sustained competitive advantage. *Journal of Management* 17 (1):99-120.

Bensaou, M., and E. Anderson. 1999. Buyer-supplier relations in industrial markets: when do buyers risk making idiosyncratic investments? *Organization Science* 10 (4):460-481.

Bonaccorsi, A., and A. Lipparini. 1994. Strategic partnerships in new product development: An Italian case study. *Journal of Product Innovation Management* 11 (2):134-145.

Carson, S.J. 2007. When to give up control of outsourced new product development. *Journal of Marketing* 71 (1):49-66.

Chaudhuri, A., B.K. Mohanty, and K.N. Singh. 2013. Supply chain risk assessment during new product development: a group decision making approach using numeric and linguistic data. *International Journal of Production Research* 51 (10):2790-2804.

Clark, K.B. 1989. Project scope and project performance: the effect of parts strategy and supplier involvement on product development. *Management Science* 35 (10):1247-1263.

Clark, K.B., and T. Fujimoto. 1991. *Product development performance*. Boston, MA: Harvard Business School Press.

Costantino, N., and R. Pellegrino. 2010. Choosing between single and multiple sourcing based on supplier default risk: A real options approach. *Journal of Purchasing and Supply Management* 16 (1):27-40.

Day, G.S. 1994. The capabilities of market-driven organizations. *Journal of Marketing* 58 (4):37-53.

Deming, W.E. 1986. *Out of crisis*. Cambridge, MA: MIT Center for Advanced Engineering Study.

Dillman, D.A. 2000. *Mail and Internet surveys: the tailored design method*. 2nd ed. New York, Chichester: John Wiley.

Dyer, J.H., and N.W. Hatch. 2006. Relation-specific capabilities and barriers to knowledge transfers: creating advantage through network relationships. *Strategic Management Journal* 27:701-719.

Dyer, J.H., and K. Nobeoka. 2000. Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal* 21 (3):345-367.

Dyer, J.H., and W.G. Ouchi. 1993. Japanese-style partnerships: giving companies a competitive edge. *Sloan Management Review* 35 (1):51-63.

Dyer, J.H., and H. Singh. 1998. The relational view: cooperative strategy and sources of interorganizational competitive advantage. *Academy of Management Review* 23 (4):660-679.

Economist. 2010. Toyota's overstretched supply chain: The machine that ran too hot. *The Economist*, Feb 24, 74.

Eisenhardt, K.M., and B.N. Tabrizi. 1995. Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly* 40:84-110.

Emden, Z., R. Calantone, and C. Droge. 2006. Collaborating for new product development: selecting the partner with maximum potential to create value. *Journal of Product Innovation Management* 23 (4):330-341.

Fornell, C., and D.F. Larcker. 1981. Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research* 18 (1):39-50.

Forza, C. 2002. Survey research in operations management: a process-based perspective. *International Journal of Operations & Production Management* 22 (2):152-194.

Gerbing, D.W., and J.C. Anderson. 1992. Monte Carlo evaluations of goodness of fit indices for structural equation models. *Sociological Methods and Research* 21 (2):132-160.

Grant, R.M. 1996. Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science* 7 (4):375-387.

Greene, W.H. 2002. *Econometric analysis*. 5th ed. New Jersey: Prentice Hall.

Hair, J.F., R.E. Anderson, R.L. Tatham, and W.C. Black. 1998. *Multivariate data analysis*. 5th ed. New Jersey, USA: Prentice-Hall.

Handfield, R.B., G.L. Ragatz, K.J. Petersen, and R.M. Monczka. 1999. Involving suppliers in new product development. *California Management Review* 42 (1):59-82.

Hartley, J.L., and T.Y. Choi. 1996. Supplier development: Customers as a catalyst of process change. *Business Horizons* 39 (4):37.

Hartley, J.L., J.R. Meredith, D. McCutcheon, and R.R. Kamath. 1997. Suppliers' contributions to product development: An exploratory study. *IEEE Transactions on Engineering Management* 44 (3):258-267.

Hobday, M., A. Davies, and A. Prencipe. 2005. Systems integration: a core capability of the modern corporation. *Industrial and Corporate Change* 14:1109-1143.

Hoopes, D.G. 2001. Why are there glitches in product development? *R&D Management* 31 (4):381-389.

Hoopes, D.G., and S. Postrel. 1999. Shared knowledge, "glitches," and product development performance. *Strategic Management Journal* 20:837-865.

Hult, G., M. Tomas, and S.K. Swan. 2003. From the special issue guest editor: A research agenda for the nexus of product development and supply chain management processes. *The Journal of Product Innovation Management* 20 (5):333-336.

Jarratt, D.G. 2004. Conceptualizing a relationship management capability. *Marketing Theory* 4:287-309.

Johnsen, T.E. 2009. Supplier involvement in new product development and innovation: taking stock and looking to the future. *Journal of Purchasing and Supply Management* 15 (3):187-197.

Kibbeling, M., H. van der Bij, and A. van Weele. 2013. Market orientation and innovativeness in supply chains: Supplier's impact on customer satisfaction. *Journal of Product Innovation Management* 30 (3):500-515.

King, B.E., and R.J. Penleskey. 1992. Impediments to timely delivery of new products at an industrial product firm. *International Journal of Operations and Production Management* 12:56-65.

Kotabe, M., X. Martin, and H. Domoto. 2003. Gaining from vertical partnerships: knowledge transfer, relationship duration, and supplier performance improvement in the U.S. and Japanese automotive industries. *Strategic Management Journal* 24 (4):293-316.

Koufteros, X.A., G.E. Rawski, and R. Rupak. 2010. Organizational integration for product development: The effects on glitches, on-time execution of engineering change orders, and market success. *Decision Sciences* 41 (1):49-80.

Kraljic, P. 1983. Purchasing must become supply management. *Harvard Business Review* 61 (5):110-117.

Krause, D.R. 1999. The antecedents of buying firms' efforts to improve suppliers. *Journal of operations management* 17 (2):205-224.

Krause, D.R., R.B. Handfield, and T.V. Scannell. 1998. An empirical investigation of supplier development: reactive and strategic processes. *Journal of Operations Management* 17 (1):39-58.

Krause, D.R., R.B. Handfield, and B.B. Tyler. 2007. The relationships between supplier development, commitment, social capital accumulation and performance improvement. *Journal of Operations Management* 25 (2):528-545.

Krause, D.R., T.V. Scannell, and R.J. Calantone. 2000. A structural analysis of the effectiveness of buying firms' strategies to improve supplier performance. *Decision Sciences* 31 (1):33-55.

Lau, A.K.W., E. Tang, and R.C.M. Yam. 2010. Effects of supplier and customer integration on product innovation and performance: Empirical evidence in Hong Kong manufacturers. *Journal of Product Innovation Management* 27 (5):761-777.

Lawson, B., K.J. Petersen, P.D. Cousins, and R.B. Handfield. 2009. Knowledge sharing in interorganizational product development teams: the effect of formal and informal socialization mechanisms. *Journal of Product Innovation Management* 26 (2):156-172.

Leenders, M.R. 1966. Supplier development. *Journal of Purchasing* 2 (4):47-62.

Leonard-Barton, D. 1995. *Wellsprings of knowledge: building and sustaining the sources of innovation*. Boston, Mass.: Harvard Business School Press.

Lieberman, M.B., and D.B. Montgomery. 1988. First-mover advantages. *Strategic Management Journal* 9 (Special Issue: Strategy Content Research):41-58.

Liker, J.K., and T.Y. Choi. 2004. Building deep supplier relationships. *Harvard Business Review* December 1.

Liker, J.K., R.R. Kamath, and S.N. Wasti. 1998. Supplier involvement in design: a comparative survey of automotive suppliers in the USA, UK and Japan. *International Journal of Quality Science* 3 (3):214-238.

Liker, J.K., R.R. Kamath, S.N. Wasti, and M. Nagamachi. 1996. Supplier involvement in automotive component design: are there really large US Japan differences? *Research Policy* 25:59-89.

Littler, D., F. Leverick, and M. Bruce. 1995. Factors affecting the process of collaborative product development: A study of UK manufacturers of information and communications technology products. *Journal of Product Innovation Management* 12 (1):16-32.

Loch, C.H., and S. Kavadias. 2008. *Handbook of new product development management*. Burlington, MA.: Butterworth Heinemann-Elsevier.

Mesquita, L.F., J. Anand, and T.H. Brush. 2008. Comparing the resource-based and relational views: knowledge transfer and spillover in vertical alliances. *Strategic Management Journal* 29 (9):913-941.
Modi, S.B., and V.A. Mabert. 2006. Supplier development: Improving supplier performance through knowledge transfer. *Journal of Operations Management* 25 (1):42-64.
Nyaga, G.N., J.M. Whipple, and D.F. Lynch. 2010. Examining supply chain relationships: Do buyer and supplier perspectives on collaborative relationships differ? *Journal of Operations Management* 28 (2):101-114.
Petersen, K.J., R.B. Handfield, and G.L. Ragatz. 2003. A model of supplier integration into new product development. *Journal of Product Innovation Management* 20 (4):284-299.
———. 2005. Supplier integration into new product development: Coordinating product, process and supply chain design. *Journal of Operations Management* 23 (4):371-388.
Podsakoff, P.M., S.B. MacKenzie, J.Y. Lee, and N.P. Podsakoff. 2003. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology* 88:879-903.
Prahalad, C.K., and G. Hamel. 1990. The core competencies of the corporation. *Harvard Business Review* 68 (3):79-91.
Primo, M.A.M., and S.D. Amundson. 2002. An exploratory study of the effects of supplier relationships on new product development outcomes. *Journal of Operations Management* 20 (1):33-52.
Ragatz, G.L., R.B. Handfield, and T.V. Scannell. 1997. Success factors for integrating suppliers into new product development. *Journal of Product Innovation Management* 14 (3):190-202.
Ramsay, J. 1990. The myth of the cooperative single source. *International Journal of Purchasing and Materials Management* 26 (1):2-5.
Ramsay, J., and I. Wilson. 1990. Sourcing/contracting strategy selection. *International Journal of Operations & Production Management* 10 (8):19-28.
Rauniar, R., W.J. Doll, G.E. Rawskic, and P. Hong. 2008. Shared knowledge and product design glitches in integrated product development. *International Journal of Production Economics* 114 (2):723-736.
Richardson, J., and J. Roumasset. 1995. Sole sourcing, competitive sourcing, parallel sourcing: mechanism for supplier performance. *Managerial and Decision Economics* 16 (1):71-84.
Roy, S., and K. Sivakumar. 2012. Global outsourcing relationships and innovation: A conceptual framework and research propositions. *Journal of Product Innovation Management* 29 (4):513-530.
Seltzer, L. 1928. *A financial history of the American automobile industry*. Boston.
Sobel, M.E. 1982. Asymptotic confidence intervals for indirect effects in structural equations models. In *Sociological Methodology*, edited by S. Leinhart. San Francisco: Jossey-Bass.
Sobrero, M., and E.B. Roberts. 2002. Strategic management of supplier-manufacturer relations in new product development. *Research Policy* 31:159-182.
Song, M., and C.A. Di Benedetto. 2008. Supplier's involvement and success of radical new product development in new ventures. *Journal of Operations Management* 26 (1):1-22.
Song, M., and M.E. Parry. 1997. The determinants of Japanese new product successes. *Journal of Marketing Research* 34 (1):64.
Swink, M. 1999. Threats to new product manufacturability and the effects of development team integration processes. *Journal of Operations Management* 17 (6):691-709.

Takeishi, A. 2001. Bridging inter- and intra-firm boundaries: management of supplier involvement in automobile product development. *Strategic Management Journal* 22:403-433.

Terwiesch, C., and R.E. Bohn. 2001. Learning and process improvement during production ramp-up. *International Journal of Production Economics* 70 (1):1-19.

Van Echtelt, F.E.A., F. Wynstra, A.J. Van Weele, and G. Duysters. 2008. Managing supplier involvement in new product development: A multiple-case study. *Journal of Product Innovation Management* 25 (2):180-201.

von Corswant, F., and P. Fredriksson. 2002. Sourcing trends in the car industry: A survey of car manufacturers' and suppliers' strategies and relations. *International Journal of Operations & Production Management* 22 (7):741-758.

Wagner, S.M. 2006. Supplier development practices: an exploratory study. *European Journal of Marketing* 40 (5/6):554-571.

Wagner, S.M., and D.R. Krause. 2009. Supplier development: communication approaches, activities and goals. *International Journal of Production Research* 47 (2):3161-3177.

Williamson, O.E. 1985. *The economic institutions of capitalism: Firms, markets, relational contracting*. New York: Free Press.

Wynstra, F., J.C. Anderson, J.A. Narus, and M. Wouters. 2012. Supplier development responsibility and NPD project outcomes: The roles of monetary quantification of differences and supporting-detail gathering. *Journal of Product Innovation Management* 29 (S1):103-123.

Wynstra, F., F. von Corswant, and M. Wetzels. 2010. In chains? An empirical study of antecedents of supplier product development activity in the automotive industry. *Journal of Product Innovation Management* 27 (5):625-639.

Appendix A: Constructs and Items

New product advantage
NA1: Offered unique features or attributes to the customer
NA2: Was clearly superior in terms of meeting customers' needs
NA3: Had superior technical performance
NA4: Offered higher quality – tighter specs, stronger, lasted longer, or more reliable [a]
NA5: Permitted the customer to do a job or do something he could not presently do [a]

Project performance
PP1: Met quality standards
PP2: Met technical objectives
PP3: Achieved schedule targets
PP4: Achieved project goals
PP5: Budgeted cost targets [a]

Supplier task performance
CR1: The supplier exhibited a great deal of creativity in its work
CR2: The supplier's technology incorporated a great deal of new knowledge and discovery
CR3: The supplier's technology was very innovative
CO4: The technology will contribute a great deal to the competitiveness of our products
CO5: The technology will contribute a great deal to the functionality of our products
CO6: The technology will contribute a great deal to the profitability of our products

Supplier development activities in new product development (SD-NPD)
SD1: We were directly involved in this supplier's product development activities
SD2: We used site visits to this supplier's premises to help improve their product development performance
SD3: We aided in the design of production processes for this supplier's new item
SD4: We provided project management know-how to this supplier during product development
SD5: We provided technological know-how to this supplier during product development [a]

Skills similarity
SS1: The supplier's technical work was very similar to work regularly done throughout our firm
SS2: The technical work for our most important products is very similar to the work the supplier was doing
SS3: Most people in our firm had the same training and technical background as the supplier's people on the project
SS4: Our firm was known for successful performance of the type of work the supplier was doing

Supplier responsibility
Approximately, what percent of the total engineering hours for your end product were attributable to this specific supplier?

Single supplier sourcing
How many suppliers were involved in the design of this component on the project?

[a] Item was dropped during scale purification.

Table 1: Sample characteristics

(1) Industry		Frequency	%
Aerospace		22	14.4
Automotive		13	8.5
Chemicals and chemical products		18	11.8
Electronic and industrial equipment		54	35.3
General manufacturing		17	11.1
Pharmaceutical		16	10.4
Not reported		13	8.5
	Total	*153*	*100*

(2) Business Units' Annual Sales		Frequency	%
Under £25M		52	34.0
£25 - £50M		18	11.8
£50 - £100M		15	9.8
£100 - £250M		17	11.1
£250 - £500M		15	9.8
Over £500M		20	13.1
Missing		16	10.5
	Total	*153*	*100.0*

(3) Titles		Frequency	%
Operations Manager		30	19.6
R&D Manager		26	17.0
Purchasing Manager		59	38.5
Procurement Director		24	15.7
Missing		14	9.1
	Total	*153*	*100.0*

Table 2: Confirmatory factor analysis

Factors and Items	Standardized loading	Error Term	*t*-value
New product advantage			
NA1	0.91	-	-
NA2	0.93	0.06	16.91
NA3	0.83	0.06	14.04
Project performance			
PP1	0.90	0.14	9.40
PP2	0.84	0.12	9.06
PP3	0.61	0.16	6.91
PP4	0.69	-	-
Supplier task performance (Creativity & Contribution)			
CR1	0.73	-	-
CR2	0.89	0.11	11.10
CR3	0.93	0.12	11.50
CO4	0.87	-	-
CO5	0.72	0.08	9.17
CO6	0.69	0.09	8.62
Supplier development in new product development			
SD1	0.76	-	-
SD2	0.87	0.11	10.33
SD3	0.80	0.11	9.73
SD4	0.68	0.11	8.28
Skills similarity			
SS1	0.86	0.11	9.75
SS2	0.85	0.11	9.69
SS3	0.70	0.10	7.99
SS4	0.73	-	-

Table 3: Descriptive statistics

Variable [a,b]		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1.	New product advantage	**.92**									
2.	Project performance	.23	**.83**								
3.	Supplier task performance	.29	.30	**.88**							
4.	Supplier development in NPD	.09	.05	.16	**.86**						
5.	Skills similarity	.06	.20	.12	.15	**.87**					
6.	Supplier responsibility	-.09	-.09	.16	.18	.00	-				
7.	Single supplier sourcing	.13	.02	-.02	-.19	-.21	.00	-			
8.	Relationship length	.18	.11	.09	.14	.12	-.13	-.05	-		
9.	Component importance	.26	-.01	.02	.12	-.03	.03	.12	-.07	-	
10.	Technological newness	.30	-.11	.02	.04	-.16	-.20	.08	.03	.15	-
	Mean	5.42	5.02	4.35	4.02	3.50	0.30	0.59	79.62	0.42	0.59
	Standard deviation	1.42	1.01	1.24	1.58	1.62	0.28	0.49	69.44	0.50	0.49
	Average Variance Extracted	0.79	0.59	0.82	0.61	0.62	-	-	-	-	-
	Compositie Reliability	0.92	0.86	0.90	0.85	0.87	-	-	-	-	-

[a] For N=153, r has to be 0.161 or higher to be significant (p<0.05)

[b] Cronbach's alpha shown on the diagonal

Figure 1: Theoretical framework

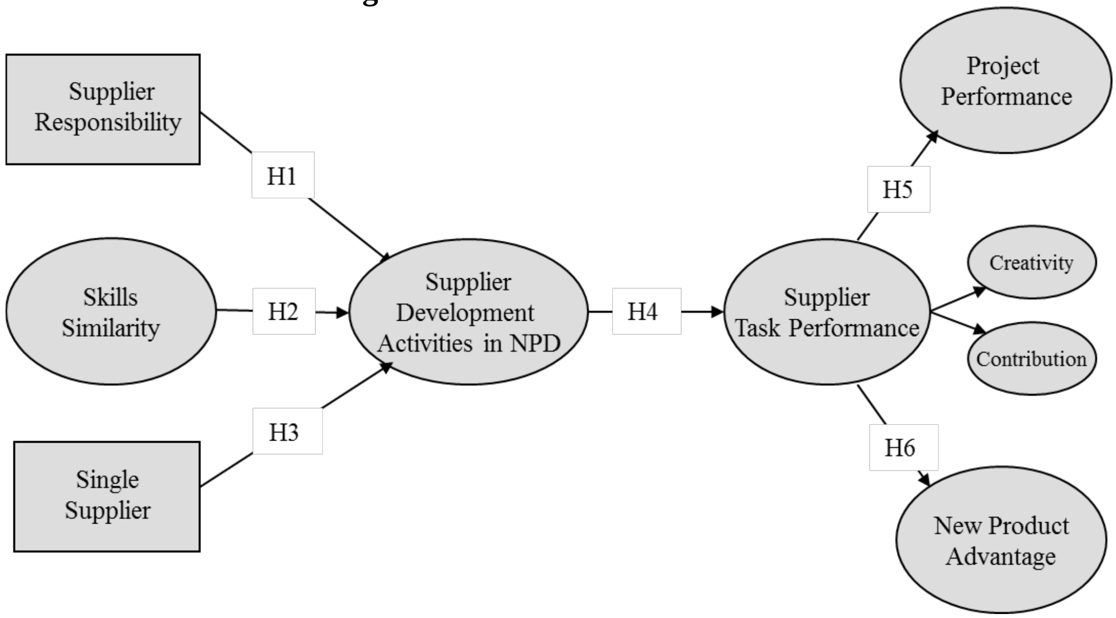

Figure 2: Structural model