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Determinants of knowledge transfer in inter-firm new product development projects

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Abstract

Purpose – The purpose of this paper is to explore the factors which determine the degree of knowledge transfer in inter-firm new product development (NPD) projects. The authors test a theoretical model exploring how inter-firm knowledge transfer is enabled or hindered by a buyer's learning intent, the degree of supplier protectiveness, inter-firm knowledge ambiguity, and absorptive capacity.

Design/methodology/approach – A sample of 153 R&D intensive manufacturing firms in the UK automotive, aerospace, pharmaceutical, electrical, chemical, and general manufacturing industries was used to test the framework. To analyse the data, two-step structural equation modeling in AMOS 7.0 was used.

Findings – The results indicate that a buyer's learning intent increases inter-firm knowledge transfer, but also acts as an incentive for suppliers to protect their knowledge. Such defensive measures increase the degree of inter-firm knowledge ambiguity, encouraging buyer firms to invest in absorptive capacity as a means to interpret supplier knowledge, but also increase the degree of knowledge transfer.

Practical implications – The paper illustrates the effects of focusing on acquisition, rather than accessing supplier technological knowledge. The paper shows that an overt learning strategy can be detrimental to knowledge transfer between buyer-supplier, as suppliers react by restricting the flow of information. Organisations are encouraged to consider this dynamic when engaging in multi-organisational, NPD projects.

Originality/value – The paper examines the dynamics of knowledge transfer within inter-firm NPD projects, showing how transfer is influenced by the buyer firm's learning intention, supplier's response, characteristics of the relationship and knowledge to be transferred.

Keywords New products, Product development, Knowledge management, Knowledge transfer, Supplier involvement, New product development, Causal ambiguity

Paper type Research paper

1. Introduction

Research in new product development (NPD) has increasingly shifted its attention beyond the boundaries of individual firms. Indeed, a growing body of literature examines how firms learn and develop new products through collaboration with their key suppliers (Athaide and Klink, 2009; Dowlatshahi, 1998; Knudsen, 2007; Lawson *et al.*, 2009; Petersen *et al.*, 2005). Early and extensive involvement of suppliers in the design

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and development stages of NPD has been associated with improvements across a range of dimensions, including product quality, project cost and development cycle time (Carr *et al.*, 2008; Handfield *et al.*, 1999; Spina *et al.*, 2002). These benefits persist across a range of industries, including automotive (Clark and Fujimoto, 1991), electronics (Iansiti, 1995), and pharmaceuticals (Henderson and Cockburn, 1994).

Involving suppliers in product development is a knowledge-intensive process, with the ability to share knowledge between the two organisations critical to the success of the new product, the project as a whole, and the firm itself (Lawson *et al.*, 2009; Petersen *et al.*, 2003). However, this research also demonstrates that successfully transferring new knowledge from supplier to buyer can be difficult to achieve, particularly within the context of a NPD project. The process of NPD often relies upon close and frequent interaction with organisations external to the firm, and especially the transfer of “sticky knowledge” (Szulanski, 1996; von Hippel, 1994). Inter-organisational boundaries, relationships, routines, and management control systems all add complexity to the knowledge transfer process (Dekker, 2004; Easterby-Smith *et al.*, 2008; Hong *et al.*, 2009). Despite numerous papers on inter-firm knowledge transfer (Dyer and Hatch, 2006; Easterby-Smith *et al.*, 2008; Simonin, 2004), little previous work has examined the issue in an inter-firm NPD context.

The knowledge based view (KBV) of the firm holds that knowledge is a strategically important resource that provides firms with a sustainable competitive advantage due to its valuable, rare, non-substitutable, socially complex, and heterogeneous nature (Grant, 1996b; Liebeskind, 1996). Building on this theory, our study explores the factors which determine the degree of knowledge transfer in inter-firm NPDs. Knowledge derived through inter-organisational relationships is difficult to imitate, and may be a source of competitive advantage (Lawson *et al.*, 2009). Specifically, we propose that three factors influence knowledge transfer between firms: the characteristics of the knowledge transferred (Zander and Kogut, 1995); the motivation of source and recipient firms (Szulanski, 1996); and the absorptive capacity of the focal firm (Cohen and Levinthal, 1990). However, to date, these factors have been examined separately, with little consideration given to the complex interactions between them (Easterby-Smith *et al.*, 2008; Szulanski, 1996). Consequently, we develop and test a conceptual model that explores the determinants of inter-firm knowledge transfer and the relationships between these factors. This question is tested on a sample of 153 R&D intensive manufacturing firms from the UK. We identify various organisational mechanisms that either enable or hinder inter-firm knowledge transfer. Specifically, we attempt to unravel how inter-firm knowledge transfer is influenced by learning intent, supplier protectiveness, absorptive capacity, and causal ambiguity.

Our study offers several contributions. First, many papers examining knowledge transfer in collaborative relationships focus implicitly on buyer's intent to access, rather than acquire, supplier's knowledge. By examining the effects of buyer's intent to internalise supplier knowledge, our study presents an additional perspective of the knowledge transfer process. Second, we shed light on the interaction between buyer's motivation to learn and a supplier's willingness to share. The literature has typically assumed that suppliers are willing participants in knowledge sharing, yet comparatively little research has focused on how suppliers respond to buyer's efforts to acquire their valuable technological knowledge. Third, previous research has often examined knowledge transfer within the context of lateral strategic or technology alliances.

Our paper extends this perspective to the examination of technology transfer within vertical industry relationships.

The remainder of the paper proceeds as follows. We first review the literature on supplier involvement and the determinants of inter-firm knowledge transfer, before developing our conceptual model and hypotheses. The structural equation modeling (SEM) approach to analysing the survey data is then discussed, and results provided. The paper concludes with a discussion of results, managerial implications and future directions for research.

2. Literature review

There is growing recognition that many strategic resources and new sources of knowledge lie beyond the traditional boundaries of the firm (Das and Teng, 2000). In particular, a large body of empirical research suggests that one of the most frequent and important sources of new knowledge are a firm's suppliers (Hult *et al.*, 2006; Song and Di Benedetto, 2008). New knowledge from suppliers can bring a number of benefits to the firm, such as enabling individuals to learn from best practice, increasing the stock of knowledge held within the firm, speeding up the process of NPD, and promoting the development of new products (Henderson and Cockburn, 1996; Kogut and Zander, 1992). In addition, an interconnected supply network of innovative suppliers can also be a vital source of competitive advantage (Mathews, 2003). Similarly, firms can draw on their supplier's knowledge to improve product development activities, with collaborative relationships helping overcome the difficulties of transferring knowledge across inter-organisational boundaries (Clark and Fujimoto, 1991; Lawson *et al.*, 2009; Liker *et al.*, 1996).

While inter-firm knowledge transfers are important to the success of NPD, transferring this knowledge is notoriously difficult to achieve (Inkpen and Tsang, 2005; Szulanski, 1996). The KBV contends that one of the firm's key tasks is to integrate efficiently the specialist knowledge they receive from multiple sources, a process known as knowledge integration (Grant, 1996a). In particular, one of the challenges is determining the "best way of utilizing knowledge initially dispersed among all people" (von Hayek, 1945, p. 520). For instance, when firms specialise in developing a particular product, they may also lose the capability to generate knowledge in other areas. Thus, as firms increasingly focus on their core competencies, they rely more heavily on the integration of inter-firm knowledge transfers in order to access "islands of knowledge" developed by suppliers who specialise in different products, production processes, markets and industries (Postrel, 2002).

In a business environment that contains multiple pools of specialist knowledge, firms develop a competitive advantage by generating new knowledge through internal R&D, and by being more capable at integrating knowledge from external sources (Grant, 1996a). In other words, the integration of supplier's into the firm's activities and the transfer of knowledge across organisational boundaries is vital to the success of the firm and its products (Handfield *et al.*, 1999; Ragatz *et al.*, 1997). Evidence suggests that firms that are able to transfer knowledge effectively are more likely to survive and generate a competitive advantage, compared to those firms that are less adept at knowledge transfer (Argote *et al.*, 2000; Darr *et al.*, 1995). Research on inter-firm knowledge transfer has identified a number of different determinants (Easterby-Smith *et al.*, 2008; Grant, 1996a; Szulanski, 1996), including the motivation

of source and recipient firms (Szulanski, 1996); the characteristics of the knowledge transferred (e.g. causal ambiguity) (Zander and Kogut, 1995); and the absorptive capacity of the focal firm (Cohen and Levinthal, 1990). We now develop the literature with respect to each of these variables.

2.1 *Motivation of knowledge transfer*

Although buyer firms have numerous reasons for collaborating in NPD, a desire to learn from their supplier's knowledge is often one of the major motives (Handfield *et al.*, 1999). Hamel (1991) argues that the learning intent of a firm is a key determinant of inter-firm learning because the stronger the intention to learn, the higher the chance that knowledge will be transferred and the firm will learn from the supplier's technology (Inkpen, 2000; Tsang, 2002). In the context of supplier involvement, we define a buyer's learning intent as the desire and will of the focal firm to learn new knowledge from its supplier. Whilst a large body of empirical research supports the view that learning intent by the buyer increases inter-firm knowledge transfer, the supplier's motivation to transmit knowledge is an equally important factor (Simonin, 2004). Indeed, the two are likely to be related, since when firms have a strong intention to learn new knowledge from the supplier this may dampen the enthusiasm of the supplier to provide such knowledge (Easterby-Smith *et al.*, 2008). Comparatively little research has focused on how suppliers adapt when firms have a strong intention to learn their knowledge.

From a transaction cost economics perspective, suppliers often protect their knowledge in order to maintain their competitive advantage, and to decrease the likelihood of a buyer firm using their knowledge in an opportunistic manner (Williamson, 1975). A key task for the supplier is thus to accumulate and protect its valuable knowledge and capabilities (Nickerson and Zenger, 2004). In the context of a dyadic buyer-supplier relationship, it is common for some partners to be less open and transparent with their knowledge (Hamel, 1991; Simonin, 2004). In other words, a duality frequently exists between the ability and the willingness of suppliers to transfer knowledge, which is likely to be an important determinant of the degree of inter-firm knowledge transfer (Mowery *et al.*, 1996). Simonin (1999) refers to this as the degree of "supplier protectiveness". Types of protective mechanisms can range from formal contractual obligations, and patent protection, to using informal shielding practices aimed at protecting a supplier's core competencies (Inkpen and Beamish, 1997). As Baughn *et al.* (1997) note, firms often "wall off" their proprietary knowledge by using gatekeepers to filter external information, partition different NPD activities, and by physically separating expert scientists within the NPD project. In other words, the extent of knowledge transfer depends to a large extent on the willingness of the supplier to share their knowledge with external organisations (Pisano, 1990).

2.2 *Characteristics of knowledge*

Alongside the motivations of each party to transfer knowledge, an additional determinant is the ability of the focal firm to understand the factors that contribute to success, referred to as causal ambiguity (Lippman and Rumelt, 1982; Reed and DeFillippi, 1990). Causal ambiguity is defined as a "[...] lack of understanding of the logical linkages between actions and outcomes, inputs and outputs, and causes and effects that are related to technological or process know-how" (Simonin, 1999, p. 597). Previous research has typically focused on the extent of causal ambiguity within firms, rather than between firms (Simonin, 1999; Szulanski *et al.*, 2004). This study focuses

on the buyer's perceptions of the ambiguity of supplier's knowledge, as distinct from causal ambiguity residing within the NPD itself. Knowledge transfer between firms is more difficult because causal ambiguity often makes it harder for firms to identify the knowledge they wish to transfer from suppliers (Grant, 1996a; Spender, 1996). Furthermore, when a supplier's competitive advantage is based on knowledge that is itself causally ambiguous, then it is often difficult for buyer firms to receive inter-firm knowledge transfers (Reed and DeFillippi, 1990).

2.3 Absorptive capacity

Firms often find it difficult to absorb new knowledge, particularly when it originates from outside the firm. Absorptive capacity, defined as the ability to value, assimilate, and apply new knowledge, thus plays a central role in determining the extent of knowledge transfer from beyond the boundaries of the firm (Cohen and Levinthal, 1990). Empirical evidence highlights that firms possessing high levels of absorptive capacity are more likely to experience lower transfer costs and a faster speed of knowledge transfer (Cummings and Teng, 2003). Despite the theoretical importance attributed to absorptive capacity, comparatively little research focuses on its role within buyer-supplier relationships, and in particular when suppliers become involved in a firm's NPD project (Ettlie and Pavlou, 2006). Moreover, we apply the dyadic-level construct of relative absorptive capacity (Lane and Lubatkin, 1998), recognising that firm's often do not have equal capacity to learn from all other organisations.

3. Theoretical framework

Figure 1 outlines our theoretical framework focusing on the relationships between learning motivations (buyer learning intent, supplier protectiveness), characteristics of knowledge (causal ambiguity), absorptive capacity, and the degree of inter-firm knowledge transfer. We develop hypotheses exploring the interrelationships between these factors. Learning intent is hypothesised to increase both the amount of inter-firm knowledge transfer, but also increase the degree of supplier protectiveness experienced. In turn, supplier protectiveness increases the inter-firm knowledge ambiguity. Buyer firms respond by investing in relative absorptive capacity to overcome this ambiguity and to facilitate inter-firm knowledge transfer. Each hypothesis is explored below.

Figure 1.
Theoretical framework

Learning about the knowledge embedded within the supply base is one of the main objectives of involving suppliers in product development (Clark and Fujimoto, 1991). Whilst knowledge is recognised as an important component of success in NPD, it is the buyer firm's intention to learn which determines whether that knowledge is then transferred (Pérez-Nordtvedt *et al.*, 2008; Tsang, 2002). In particular, the acquisition of knowledge from beyond the boundaries of the firm is an intensive process that requires commitment of resources, time and effort (Pucik, 1988). Consequently, senior management will only deploy the resources necessary to acquire knowledge from suppliers if there is a clear learning intent within the firm (Hamel, 1991). A greater learning intent focuses the firm's strategies, practices and heightens the importance of learning new knowledge as a strategic objective (MacInnis *et al.*, 1991). Importantly, a strong intention to learn external knowledge represents the first step towards removing organisational barriers that can hinder the transfer of knowledge across organisational boundaries. Without the intention to learn, a firm is less likely to commit resources to knowledge acquisition, and is therefore less likely to transfer supplier knowledge across inter-organisational boundaries. Consequently, we expect that greater learning intent will increase the degree of inter-firm knowledge transfer. Thus:

- H1.* Buyer firm learning intent is positively related to the degree of inter-firm knowledge transfer.

A supplier's technological knowledge is a source of their competitive advantage, and thus the protection of this proprietary knowledge is an important strategic concern (Inkpen, 2002; Ko *et al.*, 2005; Pisano *et al.*, 1988). Lambskin (1996), for example, argues that the asymmetric distribution of knowledge between firms can be explained, in part, by some organisations being more capable than others at protecting and defending their knowledge from appropriation (Norman, 2002). We argue that a buyer firm's learning intention acts as a behavioural incentive for suppliers to become more protective of their knowledge, and resort intentionally to policies that restrict the transfer of knowledge. Therefore:

- H2.* Buyer firm learning intent is positively related to the level of supplier protectiveness exhibited by the supplier.

When a supplier becomes more protective of their knowledge, the buyer can adapt by developing strategies and practices that increase the transferability of sticky technological know-how (Szulanski, 1996; von Hippel, 1994). Of these practices, ranging from developing relational capital to renegotiating contracts, one of the most influential is likely to be improving the firm's absorptive capacity within the buyer-supplier relationship (Argote *et al.*, 2003). A buyer firm can adapt their practices, routines and orientation to increase their capacity to counteract supplier protectiveness and achieve knowledge transfer. Thus, supplier protectiveness acts a trigger for buyer firms to devote more effort to developing their absorptive capacity in valuing, assimilating, and applying the supplier's technological knowledge. This leads us to the following hypothesis:

- H3.* Higher levels of supplier protectiveness are positively associated with increased levels of buyer-firm relative absorptive capacity.

Supplier protectiveness is an important determinant of the degree of inter-firm knowledge ambiguity (Norman, 2002; Simonin, 1999). Specifically, we argue that when a supplier acts protectively then the knowledge they provide is likely to be more opaque and difficult for the buyer firm to understand and incorporate into their NPD activities (Norman, 2002). From the supplier's perspective, protecting their knowledge helps to generate causal ambiguity within the relationship, which prevents their knowledge from being imitated and maintains their competitive advantage (Coff *et al.*, 2006; Reed and DeFillippi, 1990). Greater supplier protectiveness increases the degree of knowledge ambiguity experienced by the buyer firm with regards to the supplier's technological knowledge. Thus:

- H4. Supplier protectiveness is positively related to the degree of supplier knowledge ambiguity experienced by the buyer firm.

Causal ambiguity is one of the most subtle and effective means of ensuring knowledge is difficult to transfer and imitate (Baughn *et al.*, 1997; Inkpen and Beamish, 1997). Higher levels of knowledge ambiguity have been shown to result in decreased inter-firm knowledge transfer (Reed and DeFillippi, 1990; Wilcox-King and Zeithaml, 2001). For example, supplier knowledge which is technologically complex is likely to be causally ambiguous to the buyer firm, making it more difficult to transfer (Simonin, 1999). Prior research has typically examined inter-firm knowledge transfers within strategic alliances (Simonin, 1999; Szulanski *et al.*, 2004), with little attention paid to the role of causal ambiguity and knowledge transfer in the context of inter-firm NPD. Thus, we suggest that as a buyer firm finds it increasing difficult to make sense of the cause-and-effect relationships among the supplier's knowledge contribution to the project, the likelihood of receiving and integrating knowledge transfers from a supplier's decreases. Consequently:

- H5. The degree of knowledge ambiguity is negatively related to the degree of inter-firm knowledge transfer.

One of the central determinants of a firm's ability to facilitate knowledge transfer is its level of absorptive capacity, with many studies demonstrating that absorptive capacity is positively related to the degree of knowledge transfer (Easterby-Smith *et al.*, 2008; Van Wijk *et al.*, 2008). First, we propose that absorptive capacity helps decision makers to make sense of the potentially ambiguous knowledge they receive from the supplier. The buyer is thus better able to understand the underlying cause-and-effect relationships of the supplier's technological knowledge, lowering the level of knowledge ambiguity experienced. Second, we propose absorptive capacity directly improves the degree of inter-firm knowledge transfer. Absorptive capacity helps identify where the desired knowledge resides within the supplier, develops the common knowledge base required to assimilate supplier's knowledge and apply this external knowledge within the NPD project (Cummings and Teng, 2003). Thus, we propose:

- H6. Absorptive capacity is negatively related to the degree of supplier knowledge ambiguity.
- H7. Absorptive capacity is positively related to the degree of inter-firm knowledge transfer.

4. Research methodology

4.1 Sample characteristics

A sample of 1,700 medium-to-large manufacturing firms was developed from databases held by Department of Trade & Industry (UK) and other publicly available sources. Respondents were selected on the basis of industry SIC code, job function (purchasing manager or equivalent), and plant size (at least 100 employees). R&D intensive manufacturing industries within the UK were the focus of this study, including automotive, aerospace, pharmaceutical, electrical, chemicals, and general manufacturing. These industries were selected due to the likelihood of firms involving suppliers within their NPD activities. To ensure that firms met our selection criteria, telephone calls were made to the purchasing managers of each of the manufacturing firms prior to distribution of the survey. 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 percent (153/1,496).

Of the responding firms, manufacturing industries represented were automotive (8.5 percent), aerospace (14.4 percent), pharmaceutical (10.4 percent), electrical (35.3 percent), chemicals (11.8 percent), and general manufacturing (11.1 percent). The final 11 percent of firms had no response to industry classification. The response by position held within the firm was operations manager (19.6 percent), R&D manager (17.0 percent), purchasing manager (38.5 percent), and procurement director (15.6 percent). 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 I presents further sample characteristics.

4.2 Survey administration

The unit of analysis was a single product development project in which a supplier was involved, and had been 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 buyer firm's end product. As an additional validation check, we also asked respondents their level of knowledge of the supplier relationship and NPD project. A mean response of 5.8 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 help develop and refine the focus of the survey. The completed instrument was then pilot-tested with a further ten 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 posted 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 had opportunity to respond via return post, or internet, and were also 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 in an attempt to elicit response.

Table I.
Sample characteristics

	Frequency	Percentage
<i>(1) Industry</i>		
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
<i>(2) Business units' annual sales</i>		
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
<i>(3) Titles</i>		
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

A number of tests were conducted to detect the presence of response bias. First, we tested 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 χ^2 tests to determine whether particular types of firms were over or under represented within the sample compared to the population (Greene, 2002). No significant differences were found with respect to industry, or firm size. While our analysis does not rule out the possibility of response bias, it does suggest that the sample is broadly representative.

4.3 Operationalisation of variables

All constructs were previously validated and 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 the Appendix.

Inter-firm knowledge transfer. We adapted Simonin's (1999) three-item scale, assessing the extent to which the buyer firm had captured their supplier's technological know-how, reduced their technological reliance on the supplier, and assimilated the supplier's technology.

Learning intent. We modified the scale originally developed by Hamel (1991). Respondents were asked to assess the extent to which the purpose of the supplier's involvement was to learn about technology they owned, and to acquire the supplier's technological knowledge.

Supplier protectiveness. We adapted Norman's (2002) two-item scale to assess the buyer firm's perception of how protective the supplier was of its technological know-how, and the degree to which the supplier uses intentional policies to restrict knowledge transfer.

Absorptive capacity. We measure absorptive capacity using a four-item measure by Ettlie and Pavlou (2006). This measure focuses on the integration of firm-specific and supplier-specific knowledge pools, the exploitation of the supplier's knowledge, the routines used to obtain the supplier's technological knowledge, and the firm's ability to identify, value and import knowledge from the particular supplier.

Supplier knowledge ambiguity. Knowledge ambiguity was a three-item scale adapted from Simonin (1999) and Wilcox-King and Zeithaml (2001). Respondents were asked the extent to which they understood the association between supplier's technological know-how and its role in the overall product architecture. Items assessed the understanding of supplier inputs and outputs, cause and effect and ease of transferability of knowledge to the buyer firm.

5. Data analysis

5.1 Confirmatory factor analysis

A two-step process of analysis (Anderson and Gerbing, 1988), with AMOS 7.0 (Arbuckle, 2006), was employed to test our hypotheses. Confirmatory factor analysis (CFA) was used to test for construct validity and unidimensionality using latent and manifest variables. Table II presents the details of the loadings and error terms of the manifest variables onto each latent variable. Within each construct, one of the loadings was fixed to the value of one. Particular attention was given to low factor loadings, high residual values, and the modification indices. Overall, no anomalies were identified from this analysis, and negative variance and high item correlations were not found.

Factors and items	Standardized loading	Error term	<i>t</i> -value
<i>Learning intent</i>			
LI1	0.84	—	—
LI2	0.73	0.12	7.04
<i>Supplier protectiveness</i>			
SP1	0.88	—	—
SP2	0.79	0.14	6.63
<i>Supplier knowledge ambiguity</i>			
KA1	0.62	—	—
KA2	0.54	0.21	5.41
KA3	0.90	0.24	5.73
<i>Absorptive capacity</i>			
AC1	0.62	—	—
AC2	0.67	0.19	6.74
AC3	0.87	0.18	7.88
AC4	0.81	0.19	7.67
<i>Inter-firm knowledge transfer</i>			
KT1	0.68	—	—
KT2	0.63	0.17	3.81
KT3	0.61	0.19	5.33

Table II.
Assessment of reliability
and construct validity

Model fit was examined using four measures: the χ^2 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 ($\chi^2(67) = 115.63, p = 0.00$; CFI = 0.93; TLI = 0.90; and RMSEA = 0.069). A number of procedures were then followed to check for convergent validity (Bagozzi and Yi, 1988) and discriminant validity (Anderson and Gerbing, 1988; Fornell and Larcker, 1981). 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 ($t > 2.0$). For all but one of the variables, the average variance extracted (AVE), which measures the variance captured by the indicators relative to measurement error, was greater than the 0.50 benchmark (Hair *et al.*, 1998). Inter-firm knowledge transfer was 0.46; in the context of good overall fit of the model this was considered acceptable. 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 0.68 to 0.83, 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 ($p < 0.05$) (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). These results suggest the five constructs and their 14 items are reliable and valid in this study. The inter-item correlations, Cronbach's α , composite reliabilities (CR), and AVE values are shown in Table III. We now proceed to test the structural model.

5.2 Structural model

The structural model was tested using maximum likelihood estimation. The structural model indicates an acceptable fit to the data ($\chi^2(70) = 117.68, p = 0.00$; CFI = 0.93; TLI = 0.91; and RMSEA = 0.067), therefore the overall fit of the structural model is satisfactory (Bagozzi and Yi, 1988). Figure 2 shows the results from the structural model, indicating that all seven research hypotheses were supported. All parameter estimates in the structural model were found to be statistically significant, and in the expected directions.

The results show that learning intent is significantly positively associated with the degree of inter-firm knowledge transfer ($\beta = 0.69, p < 0.001$), providing support for *H1*.

Variable ^{a,b}	1	2	3	4	5
1. Inter-firm knowledge transfer	0.66				
2. Supplier protectiveness	0.27	0.70			
3. Learning intent	0.40	0.36	0.63		
4. Supplier knowledge ambiguity	0.24	-0.11	0.00	0.68	
5. Absorptive capacity	0.29	0.14	0.16	0.38	0.82
Mean	3.85	3.77	4.13	4.56	4.73
Standard deviation	1.11	1.55	1.67	1.03	0.97
Average variance extracted	0.46	0.70	0.63	0.50	0.56
Compositie reliability	0.68	0.82	0.77	0.74	0.83

Table III.
Correlation matrix and
descriptive statistics

Notes: ^aFor $n = 153$, r has to be 0.161 or higher to be significant ($p < 0.05$); ^bCronbach's α shown on the diagonal; two-item scales are bivariate correlation

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, all one-tailed tests
Manifest items and error terms omitted for clarity

Figure 2.
Structural model

Equally, *H2* is supported with results indicating that learning intent is positively associated with the degree of supplier protectiveness ($\beta = 0.53$, $p < 0.001$). In turn, supplier protectiveness is positively associated with both the buyer's relative absorptive capacity ($\beta = 0.18$, $p < 0.05$) and the level of knowledge ambiguity experienced by the buyer ($\beta = 0.19$, $p < 0.01$), consistent with *H3* and *H4*, respectively. Knowledge ambiguity leads to a significant reduction in inter-firm knowledge transfer ($\beta = -0.22$, $p < 0.05$), providing support for *H5*. Finally, we show that absorptive capacity not only reduces the level of knowledge ambiguity (*H6*) ($\beta = -0.40$, $p < 0.001$), but it also increases the degree of inter-firm knowledge transfer (*H7*) ($\beta = 0.26$, $p < 0.01$).

6. Discussion

This study has examined the dynamics of inter-firm knowledge sharing within collaborative NPD projects. In particular, the effect of learning intention, supplier protectiveness, absorptive capacity, and knowledge ambiguity on the level of inter-firm knowledge transfer were examined. Our hypotheses were supported, and contribute to our understanding of how these factors interact, individually and in combination, in determining the degree of inter-firm knowledge transfer. Using the results from the structural model, we now discuss each of the seven hypotheses in turn.

The results support *H1*, that a buyer's learning intent increases inter-firm knowledge transfer. From the buyer firm's perspective, the intention to internalise the supplier's valuable technological knowledge is sufficient to achieve a transfer of knowledge across inter-organisational boundaries. Such a clearly defined learning intention heightens the overall strategic importance of learning within the firm, and acts as a behavioural incentive to remove organisational barriers that hinder knowledge transferability (Foray, 2004). Conversely, without the desire or intention to learn new knowledge, the involvement of suppliers will not lead to any substantial inter-firm knowledge transfer, and will potentially limit the ability of the R&D team to develop innovative new products (Pérez-Nordtvedt *et al.*, 2008; Tsang, 2002).

H2 proposed that when the buyer firm aims to acquire, as opposed to access, the supplier's knowledge about a particular technology, the supplier would respond

by becoming protective of their know-how and resort to intentional policies designed to restrict the sharing of knowledge. Consistent with a transaction cost economics perspective, suppliers implement defensive procedures in order to safeguard their knowledge from appropriation, and reduces the potential of opportunistic behaviour by the buyer (Williamson, 1975). From the supplier's perspective, following such a strategy can act as an important barrier that prevents the buyer from imitating the supplier's knowledge, thereby reducing the supplier's bargaining power within the dyadic relationship, and restricting its competitive position within the marketplace. In particular, if the supplier's technological know-how is an important source of its competitive advantage, then this may reduce the supplier's willingness to share proprietary knowledge of its core competencies with external organisations (Inkpen, 2002; Pisano, 1990).

H3 proposed that supplier protectiveness encourages buyer firms to invest in absorptive capacity that can overcome the intentional restrictions that suppliers place on the transfer of their knowledge (Zahra and George, 2002). Whilst absorptive capacity is regarded as an important determinant of inter-firm knowledge transfer (Ettlie and Pavlou, 2006), it is less clear whether it has the ability to overcome barriers raised by supplier protectiveness. Our results suggest that when suppliers are involved in product development, buyer firms do increase their level of absorptive capacity, increasing their ability to value, assimilate and apply new knowledge and helping counteract supplier's protectiveness (Gulati, 1995).

In *H4* we investigated whether supplier protectiveness increases the level of knowledge ambiguity experienced by the buyer firm regarding the supplier's knowledge (Lippman and Rumelt, 1982; Reed and DeFillippi, 1990). Our findings illustrate that increased supplier protectiveness does make it more difficult for the buyer firm to understand the cause and effect connections between the supplier's knowledge and its role in the new product. Our results extend prior literature, showing that supplier protectiveness serves to increase inter-firm knowledge ambiguity not only within strategic alliances (Simonin, 1999), but also NPD.

H5 argued that ambiguity regarding supplier's knowledge reduces the level of inter-firm knowledge transfer within a NPD project. Consistent with previous research, our results provide support for this hypothesis and illustrate the difficulties in transferring technical knowledge across inter-organisational boundaries. Further, the indirect relationship from supplier protectiveness to inter-firm knowledge transfer indicates that the supplier can exert some influence over the effectiveness of their involvement in the project. The finding also provides support for the KBV regarding the role of causal ambiguity in helping preserve a competitive advantage, in this case for the supplier (Grant, 1996b).

H6 and *H7* examined the role of relative absorptive capacity in reducing causal ambiguity of supplier's knowledge and promoting inter-firm knowledge transfer, respectively. We find support for *H6* whereby relative absorptive capacity provides insight for the buyer firm into the supplier's technical knowledge, and an accompanying reduction in the level of knowledge ambiguity experienced. Since the effort devoted to developing relative absorptive capacity is at managerial discretion, and not without cost, we show that positive benefits will accrue from the initiative. Absorptive capacity helps decision makers within the product development team build a clearer understanding of how the supplier's technology fits within the overall product architecture, and helps in solving technical problems, reducing design errors and glitches (Hoopes and Postrel, 1999; Postrel, 2002). Similarly, a lack of absorptive capacity also increases the risk that the firm

will absorb “incomplete” knowledge that contains missing contents, lost data, unaccounted for information, technological omissions, and technical mistakes. Such incomplete knowledge transfers are likely to increase the degree of inter-firm knowledge ambiguity within the project and lead to the development of suboptimal new products.

Finally, we found support for *H7*, in that relative absorptive capacity is associated with increased knowledge transfers from supplier to buyer within the NPD. These results build upon a large number of empirical studies that have found absorptive capacity to be positively related to inter-firm knowledge transfer, lower transfer costs, and a faster speed of knowledge transfer (Cohen and Levinthal, 1990; Van Wijk *et al.*, 2008). Our study shows that similar results occur within an inter-firm NPD context. Put simply, without the ability to value, assimilate, and apply new knowledge from key suppliers, it is unlikely that the transfer of “sticky” technological knowledge will occur between suppliers and the internal product development team (Szulanski, 1996; von Hippel, 1994).

Managerial implications

A number of managerial implications are apparent from our study. First, we suggest that repeated actions in seeking to acquire (rather than access) supplier’s technological knowledge may be detrimental to dyadic collaboration across multiple projects over time. We show that suppliers will respond by becoming increasingly protective of their firm-specific know-how and take action to restrict spillover of their technical knowledge. Thus, managers should consider the strategic reaction of the focal supplier, and whether the learning approach adopted within the project is consistent with the broader relationship strategy, particularly where the supplier is to be awarded the contract for production of the component after product launch. Although an acquisitive learning intent is effective in the short-run, it would be interesting to consider whether accessing, rather than acquiring, supplier technical knowledge through long-term collaborative relationships may be a more effective long-run approach.

Second, we illustrate that the actions of a supplier in actively protecting their knowledge within an NPD project can, indirectly via causal ambiguity, limit the degree of knowledge transfer ultimately achieved by the buyer firm. Suppliers may also decide to transfer parts of their technological know-how, whilst at the same time restricting access to commercially sensitive knowledge that relates to its core competencies (Inkpen and Beamish, 1997). Such actions help the supplier sustain its bargaining position within the dyadic relationship, enabling it to control how its technological know-how can be applied within the product development project (Coff *et al.*, 2006). However, it does increase risk for the buyer firm of introducing errors and glitches into the design interface between the supplier’s component and overall product architecture. For example, a manager we interviewed from a large aerospace multinational spoke of an NPD project where due to previous quality failures they had a deliberate intent to acquire the technological know-how held by one of its strategic suppliers. In response the strategic supplier responded by becoming more protective and providing ambiguous knowledge transfers, which led to design glitches and delays. The buyer firm employed practices, such as building a supplier association, employee secondment, and supplier team membership, which allowed them greater insight into the supplier’s knowledge base.

Third, our results show that buyer firms seeking to acquire supplier’s knowledge can reduce knowledge ambiguity and facilitate supplier-to-buyer knowledge transfer when they invest in relative absorptive capacity (Lane and Lubatkin, 1998). Recognising that

absorptive capacity is path-dependent, we suggest that managers need to not only build internal technological capability, but also develop relationship-specific human investments (to facilitate rich, high quality, privileged information sharing), and implement formal project structures to reinforce this effort (e.g. co-location, supplier membership on NPD teams, joint education and training). These investments help to reduce the cognitive and structural barriers to knowledge sharing (Nahapiet and Ghoshal, 1998), and act as an effective strategy to offset supplier protectiveness efforts (Cummings and Teng, 2003).

Limitations and future directions

Our study is not without limitations. First, the focus on R&D intensive industries means the results may not be generalisable to other industry sectors; though our study does enable us to examine those firms most likely to adopt supplier involvement practices. Second, a cross-sectional survey restricts our ability to make assumptions of causality. Longitudinal methods would enable greater examination of the process of knowledge transfer within NPD projects, particularly the interaction between buyer's learning intent and the supplier's willingness to share across multiple projects. Third, we focused on knowledge transfer from the buyer's perspective. It would be interesting to examine the supplier's perspective, including the tension between sharing information and protecting knowledge considered critical to their competitive advantage (LaBahn and Krapfel, 2000). Finally, we focused on knowledge transfer outcomes only. Other outcomes including new product or project performance were beyond the scope of the study, but would be worthwhile.

Additional future directions for research include examining whether our findings also apply to the transfer of knowledge from the buyer firm to the supplier, especially in relation to supplier development activities (Krause *et al.*, 2007). Second, as we have focused exclusively on the transfer of knowledge from the supplier to the buyer firm, future research is required to explore whether sharing the buyer firm's knowledge with the supplier and developing collaborative long-term relationships helps to overcome supplier resistance towards sharing its own technological know-how. Finally, this study has focused on knowledge transfers, much could be learnt by exploring whether other governance practices, such as equity agreements or formal incentives, can help to counteract supplier protectiveness, and improve the effectiveness of supplier involvement in NPD.

7. Conclusions

Our study investigated the impact of buyer learning intent, supplier protectiveness, absorptive capacity, and knowledge ambiguity on the degree of inter-firm knowledge transfer within collaborative NPD projects. We show that a strong learning intent does increase inter-firm knowledge transfer, but in the process also increases protectiveness by the supplier of their knowledge. Buyer firms can overcome this protectiveness by investing in absorptive capacity to alleviate the increased causal ambiguity of the supplier's knowledge. Overall, our results provide support that involving suppliers in NPD projects is an effective mechanism for buyer firm's to acquire new knowledge and capabilities. Our study provides a more detailed view regarding the dynamics of knowledge transfer within inter-firm NPD projects, showing how transfer is influenced by the buyer firm's learning intention, supplier's response, characteristics of the relationship and knowledge to be transferred. We encourage further research into managing the involvement of suppliers in NPD efforts.

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Appendix. Survey items

Inter-firm knowledge transfer

- KT1 – we have learned a great deal about the technological know-how.
- KT2 – we have greatly reduced our initial technological reliance.
- KT3 – we have assimilated the technological know-how held by the supplier.

Learning intent

- LI1 – when deciding to involve the supplier, we had a strong interest to learn about a particular technology owned by this supplier.
- LI2 – involving this supplier is viewed as a means to acquire knowledge about a particular technology, rather than to simply use the supplier's know-how.

Supplier protectiveness

- SP1 – this supplier was very protective of its technological know-how.
- SP2 – this supplier introduced intentional policies designed to restrict the sharing of relevant information.

Supplier knowledge ambiguity

- KA1 – the association between inputs and outputs related to the technological know-how held by the supplier was clear.
- KA2 – the association between causes and effects related to the technological know-how held by the supplier was clear.
- KA3 – the supplier's technological know-how was easily transferable back to our firm.

Absorptive capacity AC1 – *integrate our existing knowledge with new knowledge acquired from this supplier.*

- AC2 – exploit the new integrated knowledge into concrete applications.
- AC3 – internal routines to analyse the knowledge obtained from this supplier.
- AC4 – we were able to identify, value, and import external knowledge from this supplier.

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