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The effect of supplier manufacturing capabilities on buyer responsiveness

The role of collaboration

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Abstract

Purpose – The purpose of this paper is to examine the relationships between supplier capabilities, supply chain collaboration and buyer responsiveness.

Design/methodology/approach – The sample is drawn from UK manufacturing firms across eight industry sectors. Data are analysed using a three-step hierarchical regression model to investigate main, interaction and quadratic effects.

Findings – The results indicate that suppliers' capabilities (flexibility, responsiveness and modularity) directly impact buyer responsiveness but that the level of buyer-supplier collaboration moderates this relationship. Furthermore, the results show a curvilinear relationship directly between collaboration and buyer responsiveness, whereby there is an optimal point beyond which returns on the relationship decline.

Research limitations/implications – The method adopted is a cross-sectional design and therefore cannot imply causality. Nonetheless, the findings suggest a number of implications. The paper identifies empirical evidence for the extended resource-based view (ERBV) of the firm and therefore has implications for the unit of analysis of future studies investigating competitive advantage. Contrary to popular wisdom, the findings also suggest a curvilinear relationship between supply chain collaboration and performance.

Originality/value – The paper provides novel insights into the impact of supplier capabilities on buyer responsiveness. Furthermore, the paper provides empirical evidence for the rationale of the ERBV within the context of operations management.

Keywords Resource management, Supply chain management, Channel relationships, United Kingdom

Paper type Research paper

1. Introduction

Development of global competition coupled with consumer intolerance to slow innovation and homogenised products have raised the profile of manufacturing responsiveness. In this broad sense, responsiveness refers to the speed with which

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action is taken in response to changing customer needs in an effective and profitable manner (Holweg, 2005). Whereas academic research has traditionally focussed on the critical internal attributes and capabilities that affect an organisation's level of responsiveness (Meredith and Vineyard, 1993; Mileham *et al.*, 1999; Matson and McFarlane, 1999), recent studies have extended the scope to include aspects of the supply chain (Reichart and Holweg, 2007). This development implicitly hangs on the notion that internal capabilities are a necessary but not sufficient condition for responsiveness and that external supply networks will also have a significant effect (Fisher, 1997).

This perspective clearly resonates with recent theorising within the resource-based view (RBV) of the firm. Whereas the traditional view holds that competitive advantage is exclusively a function of internal capabilities (Barney, 1991), more recent studies hold that both internal and external capabilities are important to performance (McEvily and Zaheer, 1999; Das and Teng, 2000). This change in emphasis has led to the term "extended resource-based view" (ERBV) and is explicitly used within this paper to emphasise the need to consider the impact of suppliers' capabilities on buyer firm performance. Furthermore, since access to external resources is enabled or constrained by the interface between two organisations (Araujo *et al.*, 1999) we consider the form of inter-organisational relationship that firms have with their suppliers. We argue that the level of supply chain collaboration has an important interaction effect on the relation between external resources and buying firm performance, where collaborative forms of buyer-supplier exchange facilitate greater access to external resources.

This paper examines these arguments within the context of manufacturing buyer-supplier relationships. We suggest that three supplier manufacturing capabilities, namely responsiveness, flexibility and modularity, have a direct effect on buyer firm performance as measured by levels of customer responsiveness. Previous studies have shown that responsiveness to the customer is an important determinant of competitive advantage (Stalk and Hout, 1990) and is influenced by supplier relationships (Handfield and Bechtel, 2002). We chose to look at three firm-level capabilities that have been identified as important determinants of a responsive supply chain. For example, Fisher (1997) contends that market responsive supply chains need to select suppliers on the basis of speed and flexibility while products should use modular design to postpone differentiation for as long as possible. We also examine the extent to which the effect of supplier capabilities is contingent upon the level of buyer-supplier collaboration present in the relationship. We suggest that greater levels of collaboration enable a firm to have greater access to their suppliers' capabilities, thus moderating the effect on performance.

Grounded within the ERBV of the firm, our paper contributes to theory by exploring how firms use supplier capabilities to enhance their performance and how inter-organisational relationships between buyer and supplier determine the derived benefits. We also contribute to the management debate by showing the importance of understanding a supplier's capability as a prelude to developing close collaborations. A curvilinear (inverted-U) "trade-off" between the level of collaboration and buyer firm performance is also identified, with important implications for both the management and allocation of resources to joint collaborative ventures.

The remainder of the paper proceeds as follows. We first discuss the theoretical development of the ERBV of the firm, and develop our hypotheses related to accessing external resources and the moderating effect of the resource interface. Sample design

and measurement are then described. We then discuss each hypothesis in relation to extant theory and the management of supplier relationships. We conclude with limitations and suggestions for future research.

2. Literature review

2.1 Developing an ERBV of the firm

Given that markets for resources (strategic factor markets) are necessarily incomplete (Dierckx and Cool, 1989), the traditional RBV holds that only proprietary resources developed within the boundaries of the firm can create supernormal profits (Barney, 1991). Recent studies, however, question this restrictive assumption, insofar as there exists a growing recognition that some strategic resources may lie beyond the boundaries of the firm (Das and Teng, 2000), and that a network of inter-firm relationships may also explain competitive advantage (Araujo *et al.*, 1999). This change in emphasis has been termed the "extended resource-based view of the firm" (Mathews, 2003a).

Recognition of the extended RBV arguing that competitive advantage is derived from both internal and external assets, has led to the study of resources outside the boundaries of the firm. Recent work, particularly within the strategic management field, has emphasised the inter-firm relationship as a means to acquire external resources and capabilities (Stuart, 2000; Harrison *et al.*, 2001). The external relationship thus acts as a vehicle to acquire those resources required to fill a particular "resource gap" (Grant, 1991), defined as the difference between a firm's strategic goals and its current resource endowments (Mathews, 2003b). Examples of external resource acquisition include both intangible resources such as the transfer of knowledge (Inkpen, 2000), R&D capabilities (Ragatz *et al.*, 2002), and tangible resources such as technology (Ranft and Lord, 2002).

Less attention has been given to the role of inter-firm relationships in accessing external resources and capabilities (Grant and Baden-Fuller, 2004). A firm may choose to access an external resource to improve performance where it is considered that integration or acquisition is inefficient or unwarranted. By exploiting complementarities in capabilities, access relationships enable firms to increase customer-perceived value while retaining distinctive capabilities within the firm boundaries. If we accept this extension, competitive advantage becomes attributable to both the unique resources and capabilities of the firm, as well as those firms within its network. This strongly suggests that the unit of analysis of the RBV should be adjusted from the level of the firm to the dyadic or network levels and that firm level accounts of competitive advantage may not offer a complete picture where external resources and capabilities also help to explain performance differentials (Lavie, 2006).

2.2 Resource interfaces within the ERBV

Within this extended perspective firms should not only consider the external resources themselves, but also the interface used to access or acquire those resources. Following Araujo *et al.* (1999), we use the term "resource interface" to indicate buyer-supplier relationship classifications based on supplier capabilities and their potential to add value rather than the flow of products (Olsen and Ellram, 1997). Previous studies have shown that not all relationships are equal; that the ability to acquire or access external resources is contingent on the interface between the two parties (Araujo *et al.*, 1999). Within the context of buyer-supplier relationships, we propose that the level of

collaboration is a key determinant of external resource access or acquisition where it promotes in-depth communication and two-way interaction (Hansen, 1999). Buyer firms are better able to identify complementary capabilities which help increase performance, while supplier firms are more likely to be open and committed to the relationship.

While we suggest that collaboration has an important interaction effect on the relationship between external capabilities and internal performance, we do not contend that all relationships should progress towards greater collaboration. As a result of the transaction costs of the relationship rising with the level of collaboration (Williamson, 1991), the interface should be appropriate to the goals of the relationship. For example, where the goal of the buyer firm is simply reducing costs, collaboration can be lower than if the goal was one of knowledge transfer. The interface, or level of collaboration, should therefore reflect the resources accessed or acquired.

2.3 Conceptual model and hypotheses

We present a conceptual model (Figure 1) explicitly based on the ERBV, that examines the influence of three supplier firm capabilities; flexibility, responsiveness and modularity, on buyer firm performance as measured by buyer responsiveness. These three capabilities have been previously shown to improve customer satisfaction (Handfield and Bechtel, 2002; Rosenzweig *et al.*, 2003) and we argue that accessing and leveraging supplier firm capabilities can determine a buying firm's manufacturing performance. We focus on the impact of supplier capabilities on the buyer's performance rather than the possible relationships between capabilities as this is well developed within the competitive priorities literature (Skinner, 1969; Schroeder *et al.*, 2002).

We extend this argument to show that the type of resource interface has an important bearing on the nature of the relationship between supplier firm capabilities and buyer firm performance. Supply chain collaboration is considered to have a positive moderating effect on each of the links between suppliers' capabilities and buyer performance. Lastly, the model also posits a direct link between collaboration and buyer responsiveness, operating in a curvilinear manner.

The desired outcome of this model is improved buyer responsiveness, defined as the speed with which the buyer firm reacts to customer requests in the marketplace (Holweg, 2005). Many firms have found that being internally responsive alone is not

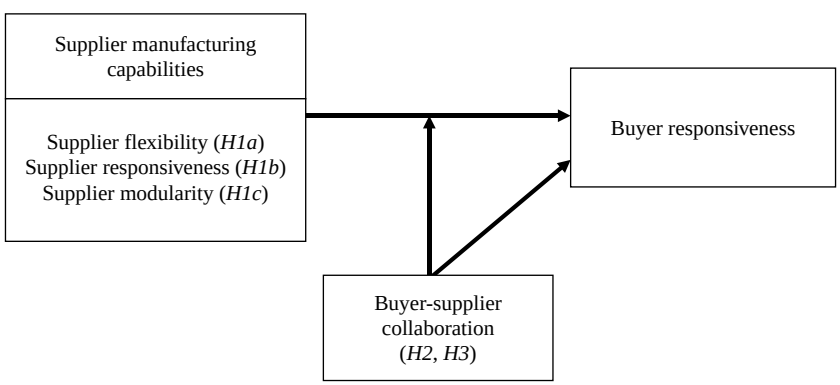

Figure 1.
The theoretical model and hypotheses

sufficient, and they must also consider the capabilities of their supply base (Reichart and Holweg, 2007). This paper is concerned exclusively with strategic buyer-supplier exchange, defined as the sourcing of products that are considered strategic in terms of complexity in the supply market and importance to the organisation (Kraljic, 1983).

2.3.1 Supplier flexibility. Supplier flexibility is defined along two dimensions:

(1) *Volume flexibility*. The ability to operate at different production levels efficiently and effectively.

(2) *Mix flexibility*. The ability to produce different combinations of products efficiently and effectively (Zhang *et al.*, 2003).

By efficient and effective, we refer to changes without concomitant increases in price or reduction in quality. We focus on the internal flexibility of the supplier, rather than flexibilities within the supply chain (Prater *et al.*, 2001) or the sourcing practices of the buyer firm (Narasimhan and Das, 2000).

Flexibility and responsiveness are considered related but distinct concepts; flexibility denotes an ability to adapt or change but not necessarily with the speed implied of responsiveness (Holweg, 2005). A major component of any flexible system is having a flexible supply network (Slack, 1991). A flexible supply network allows an organisation to respond to changes in its customer orders (volume or mix) without a concomitant increase in cost or reduction in quality. For example, Nair (2005) finds that value chain flexibility is an important moderator between postponement, centralised distribution and responsiveness. This may be explained where the buyer organisation works with a supplier to reduce lead times or minimum lot sizes, or to ensure that the supplier has an approved subcontractor to cope with significant demand fluctuations. This leads to our first hypothesis:

H1a. Supplier firm flexibility positively effects buyer firm responsiveness.

2.3.2 Supplier responsiveness. Supplier responsiveness refers to the speed with which action is taken in response to intelligence that is generated and disseminated (Kohli and Jaworski, 1990; Holweg, 2005). Responsiveness thus denotes the speed with which the supplier reacts to information from the buyer firm and more generally from the overall market. Where competitive advantage is increasingly linked to reducing cycle times, firms such as Benetton and The Limited have realised significant advantages through capabilities to respond rapidly to changes in the market (Stalk and Hout, 1990). The internal responsiveness capability of the supplier should have a direct impact on the responsiveness of the buyer firm. When considered within the framework of the ERBV, it is interesting to examine whether accessing a capability within a supplier has an impact on that same capability within the buyer firm. Thus:

H1b. Supplier firm responsiveness positively effects buyer firm responsiveness.

2.3.3 Supplier modularity. Supplier modularity refers to the extent that a supplier's product architecture can be decoupled[1]. Modular product designs incorporate knowledge about component interactions to standardise interfaces within the overall architecture, creating a system of nearly independent parts (Henderson and Clark, 1990), and enabling a high number of product variants (Sanchez and Mahoney, 1996; Hsuan, 1999). Modularisation facilitates mass customisation where firms develop the capability to substitute components and offer a wide range of product variation

(Sanchez, 1995), and build-to-order where modular product architecture offers an important source of flexibility and responsiveness which enables firms to delay final assembly until receiving a customer order (Holweg and Pil, 2001).

Supplier modularity should enable the buyer to be flexible to changes in customer specifications without increases in cost or reduction in flexibility. For example, the SMART car uses a modular architecture that reduces build-to-order lead times to between 14 and 21 days compared to a European average of 41 (Holweg and Pil, 2001). By integrating suppliers into its modular process SMART is able to be responsive to individual customer orders in an industry where make-to-stock is increasingly unsustainable. Thus:

H1c. Supplier firm modularity positively effects buyer firm responsiveness.

2.3.4 Linking collaboration, supplier capabilities and buyer manufacturing performance. Discussion of the ERBV highlighted the potential role of the resource interface to affect the buyer's access to external capabilities. Specifically, we argued that the interface acts to moderate the flow of resources between two organisations. Given that the capabilities considered in the previous section represent relatively complex, intangible assets, we argue for the positive interaction effect of buyer-supplier collaboration on each of the relations between supplier capabilities and buyer firm performance. Collaboration is defined as a process by which parties cooperate for mutual gain that does not rely on either market or hierarchical mechanisms of control (Lawrence *et al.*, 2002; Monczka *et al.*, 2005).

First, we suggest collaborative buyer-supplier relationships may help the buyer firm access levels of supplier firm flexibility that cannot be achieved under adversarial relations (Ford *et al.*, 1998). Previous studies have shown that collaboration and strategic sourcing have a positive impact on volume, mix (Suarez *et al.*, 1995) and modification flexibilities (Narasimhan and Das, 1999). Lummus *et al.* (2005) found that supplier collaboration was a primary characteristic in achieving flexibility. We suggest that engaging suppliers in collaborative relationships will result in greater levels of supplier flexibility in response to buyer's needs. Thus:

H2a. Collaboration will act to strengthen the relationship between supplier flexibility and buyer responsiveness.

Second, we suggest that collaboration with suppliers will improve responsiveness. Increased information and knowledge sharing enables partners to respond quickly to shifts in customer demands (Rosenzweig *et al.*, 2003) and reduce cycle time by removing some of the obstacles to responsiveness (Stalk and Hout, 1990). Finally, collaborative partners may simply be more willing to put themselves out for each other. Handfield and Bechtel (2002) argue that suppliers are more willing to be responsive and expedite orders, for buyers who are loyal and have exhibited trustworthiness. Thus, we posit:

H2b. Collaboration will act to strengthen the relationship between supplier and buyer responsiveness.

Lastly, we suggest that collaboration will increase the opportunities for modularity within the supplier. Hsuan's (1999, 2003) automotive studies demonstrate the impact of closer buyer-supplier collaboration on product modularisation, finding that collaboration

removes some of the interface constraints of modularisation and that technical collaboration was a significant predictor of the success of modular innovation. Similarly, Howard and Squire (2007) find that a shift to modular architectures requires a high level of integration, creating dependencies between firms through investment in proprietary assets and information systems. Thus:

H2c. Collaboration will act to strengthen the relationship between supplier modularity and buyer responsiveness.

2.3.5 Linking collaboration and buyer responsiveness. Our hypothesised model also considers the direct effect of collaboration on buyer responsiveness. Recent studies suggest that collaborative buyer-supplier relationships may not only be a means to access external resources, but also may represent strategic resources themselves (Gulati *et al.*, 2000; Gadde *et al.*, 2003). Madhok and Tallman (1998) argue that because collaborative relationships can yield higher rents, the "relationship" represents an intrinsic source of value and thus assumes the characteristics of a strategic resource. Jap (2001) goes further to demonstrate that collaboration can fulfil the specific conditions underlying strategic resources, namely heterogeneity, valuable, inimitability and imperfect mobility. This is also reflected in practice where firms have developed closer links with fewer suppliers, lured by potential benefits including cost savings, cycle time reduction, greater innovation, improved quality and knowledge sharing (Clark, 1989; Vachon and Klassen, 2008). Stalk and Hout (1990) argued that buyer-supplier collaboration will lead to greater responsiveness because firms work together to:

- provide better and more timely information;
- reduce work cycles; and
- synchronize lead times and capacities to work in a more coordinated manner.

More recently, Squire *et al.* (2006) found a linear positive relationship between collaboration and buyer responsiveness.

Conversely, recent studies indicate a "darker side" to collaboration, whereby close relationships can become unstable or dysfunctional, undermining confidence and reducing the likelihood of successful outcomes (Anderson and Jap, 2005). Within the aerospace industry, for example, prima facie collaborative relationships have become marked by infidelity as suppliers have bypassed customers and started to sell their components directly to their buyers' customers (Rossetti and Choi, 2005). Such behaviour is clearly not "collaborative" in nature but has still taken place within ostensibly collaborative relationships, indicating the well recognised "co-opetition" paradox within buyer-supplier relations (Brandenburger and Nalebuff, 1996).

We suggest that this paradox may be the result of diminishing returns to collaboration. Performance gains are made within the relationship as firms develop relationship specific assets (Dyer and Singh, 1998) and heuristics (Uzzi, 1997) that increase the efficiency and effectiveness of joint activities. For example, strong ties are likely to promote in-depth communication, facilitate the exchange of detailed information (Hansen, 1999) and increase motivations through norms of reciprocity (Reagans and McEvily, 2003). It is the development of informal control mechanisms and relationship specific heuristics underlying collaboration that increase performance.

Alternatively, the costs of collaboration, such as the costs of coordination, compromise and inflexibility (Howitch and Thiehart, 1987 cited in Das *et al.*, 2006) can

reduce these benefits and, in some circumstances, could negate any gains to a point of adverse performance. Indeed, recent empirical evidence has found an optimal set of supplier integration practices beyond which exist negative returns to investment (Das *et al.*, 2006). Taken together, these arguments imply an inverted U-shaped relationship between collaboration and performance. Too little collaboration prevents the information sharing and flexibility required for a quick response to external information. Too much collaboration reduces competition and can lead to complacency within the supply base (Rossetti and Choi, 2005). In other words, a moderate level of collaboration is likely to lead to optimal buyer responsiveness outcomes. This leads to our final hypothesis:

H3. Collaboration has a curvilinear (inverted-U) relationship with buyer responsiveness.

3. Research design

3.1 The sample

The hypothesised relationships were tested using data collected through a mail survey on one buyer-supplier relationship. Respondents were asked to select a relationship that was "critical" to the organisation using Kraljic's (1983) positioning matrix to help reduce exogenous variation. The sample base was drawn from a database held by Conquest Business Media (www.tmdatabase.com). Respondents were selected by job function (purchasing manager or equivalent), plant size (at least 50 employees) and industry sector by SIC codes (28-31, 33-36[2]). It has been suggested elsewhere that customisation is prevalent in these industries (Duray *et al.*, 2000; Duray, 2002), therefore making responsiveness an important performance factor. These criteria generated a list of 942 contacts from which 500 respondents were selected at random.

The survey instrument was pilot tested in two phases. The draft questionnaire was first sent to 15 academic colleagues and industry contacts who were asked to comment on all aspects of the design, content and scaling. The detailed feedback resulted in several minor changes to the layout of the questionnaire and the addition of potentially useful variables. The revised questionnaire was then sent to 15 firms from the database (these were not part of the 500 firms selected and were not included in the final sample) to test protocol and survey design. No changes were made at this stage.

The survey was then mailed to a named respondent. Each respondent received a letter explaining the purpose of the research, a survey and a business reply envelope. The response rate was enhanced in two ways (Forza, 2002). First, an additional two mailings were used, with a reminder postcard after two weeks and a letter and replacement survey after five weeks. Second, the respondent firms were offered the incentive of a composite summary of the results. Completed responses were received from 104 companies, for a response rate of 20.8 per cent. A profile of the respondents is provided in Table I.

A test of non-response bias compared early respondents (questionnaires received within the first two weeks), later respondents (questionnaires received within the third week or later) and non-respondents (a sub-sample of 25 non-respondents were chosen at random from the sample of 500) (Armstrong and Overton, 1977). Early and later respondents did not significantly differ in plant size ($t = 0.32$, $p = 0.75$), industry sector ($t = 0.24$, $p = 0.81$), or levels of buyer-supplier collaboration ($t = 0.43$, $p = 0.67$). Furthermore, respondents did not differ significantly from non-respondents in plant size

	n	Percentage
Number of employees (plant size)		
Over 50-100	31	29.8
Over 101-200	37	35.6
Over 201-500	23	22.1
Over 501-1,000	7	6.7
Over 1,000	6	5.8
Total	104	100.0
SIC code		
Fabricated metal products	23	22.1
Machinery and equipment other	26	25.0
Office machinery and computers	5	4.8
Electrical machinery and apparatus not elsewhere classified	6	5.8
Medical, precision and optical instruments, watches	10	9.6
Motor vehicles, trailers and semi-trailers,	13	12.5
Other transport equipment	4	3.9
Furniture	17	16.3
Total	104	100.0

Table I.
Profile of respondents

($t = 0.92, p = 0.36$) or industry sector ($t = -0.09, p = 0.93$). The non-significance of these tests indicates that non-response bias does not threaten the validity of our findings.

3.2 Operationalization of variables

Common methods variance can arise where data on the independent and dependent variables is collected from the same respondent in the same survey. Harman's one-factor test was used to examine any potential common methods problem (Podsakoff and Organ, 1986). A principal component factor analysis (with varimax rotation) was carried out on all dependent and independent variables yielding five factors explaining 68.34 per cent of the variance, with factor 1 accounting for only 18.41 per cent of the variance. These results show that no single factor emerged, nor did one general factor account for most of the variance, indicating that common methods bias may not be a serious problem in the data.

Exploratory factor analysis allows an examination of unidimensionality and discriminant validity among the items. Five distinct factors, reflecting each of the dependent and independent variables emerged, and as Table II shows, each factor had an eigenvalue above 1.0. This provides good support for the construct validity of the scales. The Appendix contains a complete list of all items used in this paper. All constructs were measured on a five-point Likert scale, anchored at "Not at all" to "A very great extent".

Buyer responsiveness. We measured the responsiveness capability of the buyer firm using a scale adapted from Harmsen *et al.* (2000). The five items ($\alpha = 0.93$) pertain to both production and service responsiveness, and focus on the extent to which the selected supplier has influenced the responsiveness capability of the focal firm.

Supplier flexibility. Supplier flexibility was measured using a scale adapted from Jack and Raturi (2002). The four items ($\alpha = 0.88$) relate to both volume and mix flexibility, and focus on the capability of the supplier.

Table II. Rotated factor matrix

Survey items	Factors				
	Buyer resp.	Supplier resp.	Supplier flex	Supplier mod.	Collab.
Focal firm ability to respond to customer demands	*0.879*				
Focal firm ability to respond to changes	*0.844*				
Focal firm ability to respond to enquiries	*0.840*				
Focal firm ability to disseminate information	*0.825*				
Focal firm ability to offer short lead times	*0.792*				
Quick response to enquiries		*0.836*			
Satisfactory response to changes		*0.829*			
Quick response to changes		*0.828*			
Quick dissemination of new products		*0.755*			
Quality change with supply mix			*0.883*		
Quality change with supply volume			*0.878*		
Price change with supply mix			*0.871*		
Price change with supply volume			*0.760*		
Components are shared across products				*0.819*	
Interchangeable features and options				*0.780*	
Options added to standard product				*0.754*	
Designed around standard base unit				*0.719*	
Frequent face-to-face planning					*0.807*
High level corporate communication					*0.610*
Direct computer links					*0.572*
Loyal to supplier					*0.544*
Eigenvalue	4.05	3.26	3.04	2.53	2.15
Percentage of variance explained	18.41	14.80	13.85	11.51	9.77
Cumulative percentage of variance explained	18.41	33.21	47.06	58.57	68.34

Supplier responsiveness. We measured supplier responsiveness using a scale adapted from Harmsen *et al.* (2000). The four items ($\alpha = 0.88$) describe both production and service responsiveness, and focus on the responsiveness capability of the supplier.

Supplier modularisation. We measured supplier modularisation using a scale adapted from Duray *et al.* (2000). The four items ($\alpha = 0.79$) captured the different levels of modularisation, and focused on the extent the capability is possessed by the supplier.

Collaboration. We measured buyer-supplier collaboration using a measure originally developed by Carr and Pearson (1999). A subset of four items ($\alpha = 0.62$) was used from the original six presented. The four items showed the loyalty in the relationship, communication between the firms and direct computer links. Although the reliability of the factor is relatively low, it does fall within acceptable limits for less established measures (Nunnally, 1978). We conducted a test of convergent validity correlating the developed factor with alternative measures related in theory (Hair *et al.*, 1998). The collaboration variable correlated positively and significantly with two related measures: the extent to which the supplier is seen as honest and truthful ($p \leq 0.05$), and the extent to which the focal firm has committed time to the training of the supplier ($p \leq 0.01$).

We also controlled for a plant's size, relationship duration, percentage of sales from customised products, and the buyer's dependence on the supplier, as follows.

Plant size. The analysis controlled for the plant's size because of its potential impact on the relationship between capabilities and performance (Rosenzweig *et al.*, 2003). Plant size was operationalized as the log of the plant's full time employees.

Relationship duration. The duration of the buyer-supplier relationship was also included to control for the formal and informal linkages that develop over time. A single item Likert-scale was used to measure the relationship length, in years.

Percentage of sales from customised products. The extent of sales derived from customised products was used to control for the degree to which the firm adjusts their production to suit customer specifications, and therefore, their extent of manufacturing responsiveness. A single-item Likert-scale was used to measure this variable.

Buyer's dependence on the supplier. Buyer dependence was tested using a two-item measure ($\alpha = 0.66$), which described the ease of supplier replacement and the number of competitive suppliers for the product sourced. This variable adjusts for the degree of supplier power, and likelihood of responding promptly to buyer's requests.

4. Analysis

Table III presents the means, standard deviations, and intercorrelations for the study's variables. These figures were based on data from 104 firms. The correlations among dependent and independent variables were consistent with expectations, and regression diagnostics also revealed a lack of serious multicollinearity among the variables.

The hypothesised relationships were tested using hierarchical moderated regression analysis. This enables analysis of the proportion of variance that is shared exclusively with each additional variable (Licht, 2003). Prior to creation of the interaction terms, both independent and moderator variables were mean-centered to reduce the potential problem of multicollinearity (Aiken and West, 1991). The variance inflation factors associated with each regression coefficient range from 1.03 to 1.38, suggesting no problem with multicollinearity. We use the completely specified models shown in Tables IV and V to discuss each of the results.

Table III. Descriptive statistics, zero-order correlations and construct reliabilities

Variable	Mean	SD	1	2	3	4	5	6	7	8	9
1. Supplier flexibility	3.35	*1.21*	*0.88*								
2. Supplier responsiveness	3.95	0.78	−0.04	*0.88*							
3. Supplier modularity	2.64	1.10	−0.13	0.11	*0.79*						
4. Collaboration	3.33	0.72	−0.04	0.31	0.20	*0.62*					
5. Buyer responsiveness	3.23	1.01	0.02	0.50	0.19	0.41	*0.91*				
6. Buyer dependence	3.02	1.01	−0.04	0.28	−0.01	0.15	0.22	*0.66*			
7. Length of relationship	3.53	0.83	−0.00	−0.07	−0.11	0.08	0.02	−0.18	–		
8. Percentage of custom sales	3.18	1.56	−0.00	−0.04	−0.16	−0.04	−0.08	−0.07	−0.08	–	
9. Plant size	258.36	321.79	−0.07	−0.02	0.03	0.08	−0.06	0.13	0.03	−0.06	–

Notes: Cronbach alphas are set in italic; for $N = 104$, r has to be 0.165 or higher to be significant ($p < 0.05$); scores for plant size (employees) are logged

	Step 1	Step 2	Step 3
Controls			
Plant size	−0.01 (0.91)	−0.07 (0.46)	−0.10 (0.26)
Relationship duration	0.04 (0.70)	0.03 (0.73)	0.04 (0.62)
Percentage of sales (custom)	−0.07 (0.52)	−0.03 (0.70)	−0.03 (0.76)
Buyer dependence	*0.18* (0.09)	0.03 (0.79)	0.02 (0.81)
Direct effects			
Supplier flexibility		0.08 (0.38)	*0.15* (0.05)
Supplier responsiveness		*0.40* (0.00)	*0.45* (0.00)
Supplier modularity		*0.14* (0.06)	*0.21* (0.01)
Collaboration		*0.27* (0.00)	*0.25* (0.00)
Moderating			
Supplier flexibility × collaboration			−0.00 (0.48)
Supplier responsiveness × collaboration			*0.17* (0.03)
Supplier modularity × collaboration			*−0.33* (0.00)
F-value	0.75 (0.59)	*10.65* (0.00)	*6.02* (0.00)
R^2	0.04	0.36	0.47
Adj. R^2	−0.01	0.29	0.40
Change in R^2		0.32	0.11
Partial *F* (change in R^2)		*9.90* (0.00)	*4.63* (0.00)

Table IV.
Influence of collaboration and supplier capabilities on manufacturing performance: OLS regression results

Notes: *p*-values for each standardised parameter estimate are shown in parentheses. Significant parameter estimates and "partial *F*" are set in italic; values shown for "change in *F*-value" are for each step; only the *F*-value is cumulative; *N*=104; single tailed *t*-tests have been used for all hypothesized variables; two-tailed *t*-tests have been used for all control variables

	Step 1	Step 2	Step 3
Controls			
Plant size	−0.01 (0.91)	−0.07 (0.42)	−0.09 (0.27)
Relationship duration	0.04 (0.70)	0.03 (0.77)	0.09 (0.30)
Percentage of sales (custom)	−0.07 (0.52)	−0.04 (0.69)	−0.01 (0.90)
Buyer dependence	*0.18* (0.09)	0.03 (0.78)	0.03 (0.79)
Direct effects			
Supplier flexibility		0.08 (0.18)	0.06 (0.25)
Supplier responsiveness		*0.40* (0.00)	*0.42* (0.00)
Supplier modularity		*0.14* (0.06)	*0.17* (0.03)
Collaboration		*0.27* (0.00)	*0.33* (0.00)
Moderating			
Collaboration × collaboration			*−0.29* (0.00)
F-value	0.75 (0.59)	*5.33* (0.00)	*6.42* (0.00)
R^2	0.04	0.36	0.43
Adj. R^2	−0.01	0.29	0.36
Change in R^2		0.32	0.07
Partial *F* (change in R^2)		*10.65* (0.00)	*10.78* (0.00)

Table V.
Influence of collaboration on manufacturing performance: OLS regression results

Notes: *p*-values for each standardised parameter estimate are shown in parentheses. Significant parameter estimates and "partial *F*" are set in italic; values shown for "change in *F*-value" are for each step; only the *F*-value is cumulative; $N = 104$; single tailed *t*-tests have been used for all hypothesized variables; two-tailed t-tests have been used for all control variables

The analyses in Table IV showed that supplier flexibility (*H1a*), supplier responsiveness (*H1b*), and supplier modularity (*H1c*) were positively and significantly related to buyer responsiveness. These results supported *H1*. The results also support the moderating effect of collaboration on buyer responsiveness, as indicated by the data from Steps 1-3 in Table IV. The addition of the interaction terms (Step 3) significantly improved the results from Step 2 ($p < 0.001$), and two of the three moderating relationships were found to be significant ($p < 0.05$). *H2* suggested that the effect of supplier manufacturing capabilities on buyer responsiveness will be moderated by collaboration. The interaction of collaboration and supplier flexibility (*H2a*) was not supported. Collaboration and supplier responsiveness (*H2b*) had a positive and significant interaction effect, significant at $p < 0.05$. Contrary to expectations, supplier modularity had a significant ($p < 0.001$), but negative, interaction with collaboration (*H2c*). These results provide mixed support for *H2*. Tables IV and V also show that the control variables of plant size, relationship duration, percentage of sales (custom) and buyer dependence were not associated with changes in a buyer's manufacturing responsiveness ($p < 0.10$, two-tailed test).

The results show that collaboration moderates the relationship between supplier and buyer responsiveness and between supplier modularity and buyer responsiveness in different ways. These interaction effects are shown in Figures 2 and 3. The relationships were plotted using values of one standard deviation above the mean to represent high levels of collaboration (labelled collaborative) and one standard deviation below the mean to represent low levels of collaboration (labelled arms-length; Cohen and Cohen, 1975). Figures 2 and 3 show a more positive relationship between supplier and buyer responsiveness in situations of high collaboration and a more positive relationship between supplier modularity and buyer responsiveness in situations of low collaboration.

As shown in Table V, *H3* predicted that collaboration would improve buyer responsiveness up to a point and then lead to a diminution (an inverted-U). The coefficient of collaboration to buyer responsiveness is positive and statistically significant (Step 2), while the coefficient of its squared term is negative and statistically significant (Step 3). The combination of a positive direct effect, and negative squared

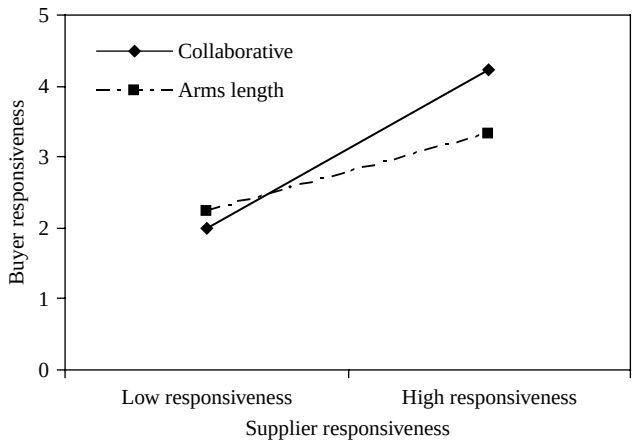

Figure 2.
The moderating effect of collaboration on the relationship between supplier and buyer responsiveness

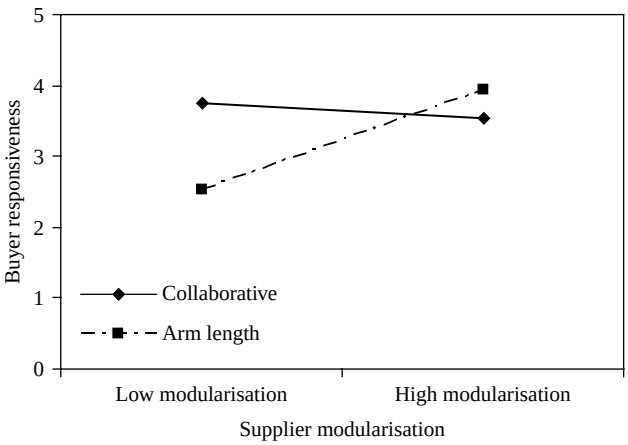

Figure 3.
The moderating effect of collaboration on the relationship between supplier modularity and buyer responsiveness

term, indicates the presence of a curvilinear relationship between collaboration and buyer responsiveness, and provides support for *H3*.

5. Discussion

Our results provide support for the majority of our theoretical arguments. We first show that supplier manufacturing capabilities significantly influence a buyer's manufacturing performance. Second, we found that collaboration strengthens the contribution of supplier responsiveness to buyer responsiveness, but weakens the relationship between supplier modularity and buyer responsiveness. Finally, collaboration was also found to have a curvilinear (inverted u-shaped) relationship with buyer responsiveness. These results have implications for the RBV, particularly the extended RBV, as well as for managers seeking to improve their manufacturing performance. The results and implications are discussed below.

5.1 Impact of supplier manufacturing capabilities on buyer performance

This paper began by constructing a rationale for an extended RBV of the firm. We pointed to the growing recognition that certain strategic resources lie beyond the boundaries of the firm. Within this framework, external relationships can be seen as "resource interfaces", employed as a means to access or acquire exogenous resources and capabilities used to fill resource gaps (Grant, 1991) or to generate collaboration specific quasi-rents (Madhok and Tallman, 1998).

Consistent with *H1*, we find that the flexibility, responsiveness and modularity capabilities of the supplier firms' positively effect buyer firm responsiveness. Given that responsiveness is increasingly important to competitive advantage, the results suggest that firms need to consider how their suppliers affect their internal performance. Suppliers with superior capabilities in terms of flexibility, responsiveness and modularity will directly enhance a buyer firm's speed to react to customer requests in the marketplace. This finding has important implications for supplier selection. Buyer firms may wish to broaden the scope of their current evaluation criteria to include not only cost, delivery and quality, but also capabilities and development factors. More broadly, the results support

the role of resources and capabilities beyond firm boundaries in explaining competitive advantage. Studies that focus exclusively on internal resources may therefore be incomplete, missing important factors that further help to explain long-term performance differentials between organisations. By extending the unit of analysis from that of the firm to that of the dyad, we show that supplier firm capabilities have an important effect on buyer firm performance at the business process level (Ray *et al.*, 2004). In particular, we point to benefits that are derived from exploiting complementarities in capabilities through external access to relationships.

5.2 Impact of collaboration and supplier firm capabilities on buyer firm performance

Since firm performance is shown to be a function of external resources and capabilities, we also consider the type of interface used to access those resources. Within the context of buyer-supplier exchange, this primarily relates to the level of collaboration between the two firms. Because costs (in terms of time, effort and money) rise with the level of collaboration, firms should be careful not to "over-specify" the interface, while also recognising that access is constrained by the degree of inter-firm collaboration.

The results indicate that collaboration does moderate the relationship between supplier's capabilities and buyer responsiveness, but that the effect is different across the various capabilities. No moderating effect was observed on the relationship between supplier firm flexibility and buyer firm responsiveness. The non-significant interaction effect is somewhat surprising, but may be explained by the internal nature of a flexibility capability. In other words, a firm's level of flexibility is constrained by internal factors, such as advanced manufacturing technologies (Suarez *et al.*, 1995; Narasimhan and Das, 1999), production planning and control systems (Cox, 1989), and labour flexibility (Cox, 1989; Zhang *et al.*, 2003), independent of the level of collaboration with the buyer organisation. No matter how closely the supplier works with the buyer firm, its level of flexibility will always be constrained by endogenous factors and thus collaboration will not have an interaction effect.

Consistent with expectations, the positive relationship between supplier and buyer firms responsiveness strengthened as the level of collaboration increased. Since collaboration is associated with increased information sharing between the two organisations (Carr and Pearson, 1999), the increased visibility of demand data will enable the supplier to be more responsive to buyer firm requirements. Therefore, contrary to the previous instance, the degree of collaboration has an important effect on accessing supplier capabilities, where the supplier's responsiveness is enhanced or constrained by the relationship.

Contrary to expectations, the positive relationship between supplier firm modularity and buyer firm responsiveness actually weakened as the level of collaboration increased. Figure 3 shows that at low levels of modularisation, or where product design is "tightly coupled" (Sanchez and Mahoney, 1996), collaborative interfaces lead to higher levels of responsiveness than arms-length interfaces. In this situation, buyer and supplier organisations can work closely together to design a product in a manner that best utilises the supplier capabilities, thus improving responsiveness. For example, the two firms may co-design a component so that it can be manufactured using FMS technology on a continuous basis, rather than having to build it off-line in batches. On the other hand, at high levels of modularisation, or where product design is "loosely coupled", the type of interface has less of an effect. Owing to the component interface being highly

standardised, the benefits of collaboration and co-design are diminished. Indeed, despite high levels of collaboration, the ability of a buyer firm to be responsive remains constrained by the product architecture and the set of features selected by the supplier (Staudenmayer *et al.*, 2005). Modularisation enables the supplier to design the component to best "fit" their internal resources, instead of receiving a design that they then have to figure out how to manufacture.

5.3 The impact of collaboration on buyer performance

Lastly, we consider the direct effects of the resource interface on firm performance. In this context, the relationship is not only a means to access external resources, but also an intrinsic source of value that generates competitive advantage (Madhok and Tallman, 1998). The findings support our original hypothesis that collaboration within buyer-supplier exchange improves buyer firm responsiveness. Moreover, we find evidence of a curvilinear relationship where collaboration first increases and then reduces the responsiveness of the buyer firm. Firms often describe this effect as a type of "complacency" within the relationship. There are a variety of reasons for this type of behaviour. First, it is well documented that once a supplier feels that the relationship has become established and the power basis is such that the buyer may be dependent on the supplier, the supplier may then at best reduce performance and at worst act opportunistically towards the buyer (Cousins, 2002). A further explanation of this curvilinear relationship is offered by Brandenburger and Nalebuff (1996). The authors develop the notion of "co-opetition", using a game theory lens to describe relationships that are competitive within a collaborative framework. The balance between competition and collaboration can be achieved through a variety of sourcing strategies (Richardson, 1994) and management approaches which are aimed at maintaining relationship "tension". A third and final explanation is associated with the resources and costs of managing these types of inter-firm collaborations. It is important for the buyer and supplier firm to have the appropriate skills and competencies in place to manage these relationships, as well as balancing out the costs and benefits of managing these relationships (Cousins *et al.*, 2006).

6. Limitations and suggestions for future research

The findings open a number of potential avenues for future studies. First, we examine the effect of supplier manufacturing capabilities on buyer firm performance, supporting the theoretical rationale for the extended form of the RBV of the firm. Future research could examine the effect of different external resources and capabilities, such as knowledge, service quality, or information systems. Similarly, future studies could be extended to examine the effect of external resources within horizontal inter-firm relationships such as strategic alliances or joint ventures. This would help to further advance the case for the extended form of the RBV.

Second, we examine the effect of supplier's capabilities on one measure of buyer firm performance. Although responsiveness to the customer is an increasingly important performance indicator (Handfield and Bechtel, 2002), future studies could examine the impact of external resources and capabilities on other performance outcomes. Following the advice of Ray *et al.* (2004), such measures should be primarily gauged at the business process level. Potential measures could thus include delivery times, customer service or

plant utilisation rates. Positive findings would again strengthen the case for the inclusion of external resources in theories of competitive advantage.

Finally, we examine the influence of collaboration as a moderating factor on the relationship between external capabilities and performance. Collaboration is an important aspect of the resource interface, particularly within buyer-supplier exchange, however, future studies may benefit from the inclusion of additional aspects of the interface. In particular, we would encourage the study of contractual mechanisms, relationship duration or the level of inter-organisational trust as potential moderating factors between external capabilities and firm performance.

7. Conclusion

The traditional conceptualisation of the RBV of the firm posits competitive advantage as a function of internal resources and capabilities that fulfil the conditions of imperfect imitability, substitutability and mobility (Barney, 1991). More recent evidence suggests that competitive advantage can be a function of both internal and external resources (Mathews, 2003a; Lavie, 2006). This paper is explicitly positioned within this latter perspective and provides empirical support for the effect of supplier's capabilities on buyer performance. Furthermore, we draw attention to the role of supply chain collaboration in accessing external capabilities. The findings show that the nature of the relationship is variable and should be appropriate to the capabilities accessed. Finally, we also provide evidence for the curvilinear impact of collaboration on buyer performance. Whereas previous studies have been keen to extol the virtues of collaboration, we find that there exists an optimal point beyond which returns on the relationship decline.

Notes

1. Note that this paper examines product modularity rather than modular organisations (Daft and Lewin, 1993).
2. SIC code: 28.00 fabricated metal products, 29.00 machinery and equipment not elsewhere classified, 30.00 office machinery and computers, 31.00 electrical machinery and apparatus not elsewhere classified, 33.00 medical, precision and optical instruments, watches, 34.00 motor vehicles, trailers and semi-trailers, 35.00 other transport equipment, 36.00 furniture.

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Appendix. Items and constructs

Supplier flexibility ($\alpha = 0.88$)

- Prices per unit do not significantly vary with increases or decreases in supply.
- Quality does not significantly vary with increases or decreases in supply.
- Prices per unit do not significantly vary with increases or decreases in supply mix.
- Quality does not significantly vary with increases or decreases in supply mix.

Supplier responsiveness ($\alpha = 0.88$)

- This supplier is quick to respond to enquiries and problems.
- This supplier is quick to respond to wants concerning changes in products and services.
- This supplier responds to changes in our demands in a satisfactory way.
- This supplier quickly disseminates information about new product developments.

Supplier modularity ($\alpha = 0.79$)

- Products have interchangeable features and options.
- Options can be added to a standard product.
- Components are shared across products.
- New product features are designed around a standard base unit.

Collaboration ($\alpha = 0.62$)

- We are loyal to this supplier.
- We have frequent face-to-face planning/communication with this supplier.
- There is high level corporate level communication on important issues with this supplier.
- There are direct computer links to this supplier.

Buyer responsiveness ($\alpha = 0.93$)

- This supplier has improved our ability to offer short lead times to our customers.
- This supplier has improved our ability to respond to enquiries and problems.
- This supplier has improved our ability to respond to wants concerning changes in products and services.
- This supplier has improved our ability to respond to customer demands in a satisfactory way.
- This supplier has improved our ability to disseminate information about new product developments.

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