In Chains? Automotive Suppliers and Their Product Development Activities

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ABSTRACT

A conceptual framework is developed and tested in which supplier downstream position in the supply chain, supplier innovation strategy and customer development commitment are seen as the antecedents of supplier product development activity. Using partial least squares (PLS), we analyze the results of a survey of 161 Swedish automotive suppliers and test a series of nested models to test our hypotheses. We demonstrate that the position of the supplier in the supply chain and its strategic focus on innovation not only have a direct impact on (actual) supplier product development activity, but that there is also an interaction effect, implying that the effects of strategy are contingent on the supplier's supply chain position. Additionally, we find that customer development commitment does not have any significant direct effect on supplier product development activities, but that this relation is fully mediated by supplier innovation strategy. The meaning of the findings for developing a more extensive conceptual framework for understanding supplier product development activities, some managerial implications, and future research are discussed.

Keywords: *product development, supplier relations, supply chain*

INTRODUCTION

In the automotive industry, as in many other industries, suppliers have a growing impact on manufacturers' performance as a growing share of components and systems are being outsourced. Together with this outsourcing of production activities, suppliers have also adopted an increasing role in the development of components, assemblies and modules of the final product (i.e. the car or truck). This has led to various discussions in the literature about the actual and desired roles of various types of suppliers in terms of product development activities, also in terms of their supply chain position. But are development activities indeed organized in 'chains'?; do suppliers closer to the final assembly firm have a more substantive role in product development than those that are located more upstream? And do other factors, in particular the innovation strategy of the supplier and the behavior and commitment of customers, also have an impact on the supplier's role in product development? These questions are addressed in this paper, based on a survey among 161 automotive suppliers in Sweden.

The paper aims to make two main contributions. First, it sets out to develop a more detailed understanding of how and to what extent supply chain position drives supplier product development activity in the automotive supply chain. Secondly, the paper explicitly takes the perspective of the supplier, adding to the relatively limited number of studies that examine this perspective on supplier-customer relations (LaBahn and Krapfel 2000). In addition to these main contributions, the paper specifically looks at the European, specifically the Swedish, automotive sector whereas most research has traditionally focused on their Japanese and North American counterparts.

The paper first takes a look at existing research on the structure of and product development activities within the automotive supply chain. The following section develops our conceptual framework and research hypotheses, after which the design of the empirical study is discussed. Subsequently, the findings from our survey are presented, and the paper ends with discussion and conclusions.

THE AUTOMOTIVE SUPPLY CHAIN

Supply Chain Structure

The general trend towards more outsourcing in the automotive industry has increased the importance for vehicle manufacturers of effectively controlling and managing their suppliers (Lamming 1993; Mercer 1995). This includes not only the direct, 'first tier' suppliers but also lower tier suppliers further upstream, as first tier suppliers also outsource a growing part of their activities (Von Corswant and Fredriksson 2002).

The term 'supplier tiers' was first used to describe the various levels in pyramid-shaped supply chains found in the Japanese automotive and electronics industry (Nishiguchi 1987; Hines 1994). First-tier suppliers provide the auto manufacturer with sub-assembled units (e.g. complete seats or instrument panels) based on components from lower-tier suppliers. First, second and third-and-below tier suppliers tend to differ significantly in terms of size and the type and content of their customer relations (Fujimoto 2001, pp. 10-11).

The tier structure is supposed to simplify not only material flows but also information flows between customers and suppliers as *"first-tier suppliers coordinate the activities of the second tier and so on down the hierarchy, allowing customers to focus scarce communication resources on the top tier"* (Kamath and Liker 1994). Figure 1 depicts a typical, 'tiered' supply chain, where the supplier in the chain found closest to the original equipment manufacturer (OEM) is called 'tier 1 supplier' and so forth. US and European auto manufacturers have begun to restructure their supply base, along the (Japanese) tier model, shifting from a large number of direct supplier relationships with to a few close relationships (Womack, Jones and Roos 1990; Nishiguchi 1994; Bidault, Despres and Butler 1998; Von

Corswant and Fredriksson 2002). However, the Japanese structure is still different in that Japanese auto manufacturers own large shares of equity in their largest suppliers (Dyer 1996a, p. 56; Lamming 1993, p. 186).

[INSERT FIGURE 1 ABOUT HERE]

It should be pointed out, however, that in reality, the automotive supply chain - and thus the tier structure - looks much more complicated (Nishiguchi 1987; Brown, Lamming, Bessant and Jones 2000, pp. 137-8). In general, many authors have more or less explicitly criticized the concepts of supply chains and supply chain management. More specifically, various groups of authors both from operations management (Lamming, Johnsen, Zheng and Harland 2000; Brown et al. 2000) and from purchasing and supply management (Gadde and Håkansson 2001; Axelsson and Wynstra 2002) have argued that in reality, supply chains do not exist. In fact, "It may be more accurate to use the terms supply network or supply web to describe the structure of most supply chains" (Chopra and Meindl 2001, p. 5). Mabert and Venkataramanan (1998, p. 538) also define supply chain as "the *network* of facilities and activities that performs the functions of product development, procurement (…..), the movement of materials (…), the manufacturing of products, the distribution (…) and after-market support for sustainment.' (emphasis added).

Specifically in relation to the automotive industry, Lamming (1993, pp. 186-190) also makes some critical comments on this view of strictly organized tiers of suppliers. First of all, suppliers may in fact deliver components to various customers at different levels in the supply chain. In other words, they could operate as, for example, first and second tier suppliers simultaneously. Secondly, pointing to the original meaning of tiers in the Japanese 'Keiretsu' system, Lamming emphasizes the necessary element of organizational 'alignment' between customer and suppliers to be able to speak of tier structures. Related to this, it should be noted that not all Japanese first-tier suppliers are regarded as 'partners': *"In fact, [Japanese auto* *manufacturers] typically regard only a handful as partners and assign more limited roles to the rest. […] Only an elite corps of about a dozen first-tier suppliers enjoy full-blown partnership with their customers"* (Kamath and Liker 1994). Finally, Lamming (1993, p. 187) argues that some suppliers may indeed supply their products indirectly to the OEM, but at the same have direct technical contacts with these final assembly firms to discuss the design and development of their component (cf. Wynstra 1998).

In conclusion, Fujimoto (2001, p. 10), however, states: "Although the real transaction network is far from a simple hierarchy, such a classification is possible according to the *main stream* of transactions. (emphasis added)."

Product Development

Traditionally, most product development has been performed internally at the auto manufacturers. Based on detailed technical specifications (drawings etc.) suppliers were then contracted to produce the products. However, as the pace of technological development has increased and customer demands have changed, product development costs – and risks - have increased. Therefore, auto manufacturers have increasingly outsourced design, development and engineering activities – primarily at the level of components and sub-systems.

More intensive collaboration with suppliers in product development has been the natural consequence of the increased outsourcing of production activities as suppliers increasingly acquire valuable production expertise and product development capabilities (Dröge, Jayaram and Vickery 2000; Wasti and Liker 1997, 1999; Kamath and Liker 1994; Clark and Fujimoto 1991; Clark 1989). Through supplier involvement, better product quality, shorter development lead-time and reduced product and development cost can be achieved, and potentially also better long-term alignment of technology strategies (Wynstra, Weggeman and Van Weele 2003; Wynstra, Van Weele and Axelsson 1999).

In Japan, supplier involvement in product development has traditionally been much more widespread than in the US and Europe (Liker, Ettle and Campbell 1995; Nishiguchi 1994; Clark and Fujimoto 1991; Helper 1991; Clark 1989), although the differences seem to be time-dependent and to be converging recently (Sobrero and Roberts 2002; Dyer 2000; Liker, Kamath, Wasti and Nagamachi 1995). In a recent survey among (primarily European) car manufacturers and first tier suppliers, Von Corswant and Fredriksson (2002) found that a significant decrease has occurred in car manufacturers' share of total product development resources between 1988 and 1998 (from 70 to 60 %), and that this trend is expected to continue (50 % expected for 2003). In the same period, the share of first tier suppliers has grown from 18 to 31 %, with an expected share of 38 % in 2003.

Product Development in the Supply Chain

As for production activities, previous research has argued that product development activities tend to be distributed along the automotive supply chain following the tier structure. For example, Fujimoto (2001, pp. 10-11) indicates that first tier suppliers are much more likely to have their own development and engineering capabilities and responsibilities than second tier suppliers, whereas third tier suppliers fully rely on the engineering activities of their buyers (customers). Similarly, Von Corswant and Fredriksson (2002) report that the share of second (and lower) tier suppliers in total product development resources in the automotive supply chain has significantly increased over the past 15 years, but is still small compared to that of first tier suppliers. This observation is in line with the increasingly widespread notion that not all suppliers should and/or can be involved in the same way (Sobrero and Roberts 2002, 2001; Sobrero and Toulan 2000; Wynstra and Ten Pierick 2000; Bidault et al. 1998). Supplier involvement is not without cost, time and effort and should thus be applied selectively and efficiently.

In most of the literature, a supplier's level of desired responsibility or activity in product development is closely connected to the product being produced. Kamath and Liker (1994), for example, distinguish between 'Partner' suppliers, that have up to concept-definition responsibilities for entire subsystems; 'Mature' suppliers that develop the critical specifications of complex assemblies; 'Child' suppliers that develop the detailed specs of simple assemblies together with the manufacturer; and finally, 'Contractual' suppliers that have no development responsibility to speak for the simple parts they deliver. This would also suggest that first tier suppliers are more active in product development than second tier suppliers, who are more active than third tier suppliers etc.

In conclusion then, existing research clearly argues that, given their different roles and activities in the supply chain, first, second and third-and-below tier suppliers tend to differ significantly regarding the extent of their product development activities. This has been the main starting point in our empirical study of the Swedish automotive supply chain; to what extent is this true, and what other factors affect the level of product development activities for the different tiers of suppliers?

CONCEPTUAL FRAMEWORK

Our conceptual framework seeks to explain supplier product development activity in terms of three antecedents: supplier downstream position in the supply chain, supplier innovation strategy and customer development commitment.

Supplier Product Development Activity

In the light of the increasing interest in supplier involvement in product development, various attempts have been made to measure the nature and extent of this involvement (Takeishi, 2001; LaBahn and Krapfel, 2000; Twigg, 1998; Hartley, Zirger and Kamath, 1997; Hartley, Meredith, McCutcheon and Kamath, 1997; Birou and Fawcett, 1994; Kamath and Liker, 1994; Clark, 1989) Based on this literature, we propose to distinguish four dimensions of a supplier's level of activity in product development processes: the *influence* the supplier has on the specifications of its products, the quantitative *share* in total product development regarding the supplier's set of products, the *phase* of the product development process the supplier is active in, and finally the *complexity* of the product development activities (Table 1). The influence a supplier has on specifications has been used as one of the key aspects of the extent of supplier responsibility in product development (Twigg, 1998; Clark, 1989). The quantitative *share* in total product development regarding the supplier's set of products has been used as another, more quantitative indicator (Von Corswant and Fredriksson, 2002). The phase of the product development process the supplier is active in reflects the influence a supplier has on specifications and the type of development activities (f.e. conceptual design vs. detailed engineering) it may execute (Wynstra and Ten Pierik 2000; Twigg, 1998; Birou and Fawcett, 1994). Finally, the type of product development activities undertaken by a supplier in relation to the type of product (f.e. components vs. system) is a measure of the complexity of the development tasks of the supplier (Twigg, 1998; Kamath and Liker, 1994).

Supplier Downstream Position

Based on the discussions above, we hypothesize that the further downstream towards the OEM a supplier operates, the more active it is in product development. First of all, therefore, we will look at which tier in the supply chain the supplier is operating. However, as we have seen earlier, important differences may exist between first tier suppliers in terms of the product they deliver. Specifically, one important group of first-tier suppliers delivers complete modules to the OEM whereas another important group delivers very simple components, such as fasteners. These suppliers can be expected to have a completely different profile regarding product development, since a supplier's involvement in product development has much to do with the kind of product it delivers to its customer. Therefore, we will rank the different types of suppliers in the following order of operating increasingly down-stream: raw material suppliers; third-tier suppliers; second tier suppliers; direct suppliers; module suppliers (c.f. Lamming 1993).

However, we also want to include the possibility of second tier and third tier suppliers selling part of their products directly to OEM's. In other words, in our operationalization of the concept of 'downstream position' we will explicitly include and measure any direct sales going to the OEM, even for second and lower tier suppliers. Thus, we hypothesize:

H_1: The further downstream in the supply chain a supplier is located, the higher the supplier development activity.

Supplier Innovation Strategy

Besides the respective supply chain position of a supplier, we also expect the supplier's competitive strategy to have an impact on its involvement – or level of activity – in product development. Many suppliers nowadays have an explicit strategy to become more involved in product development, and this not only holds for first tier suppliers (Anderson, Oliver and Anderson 2001). Even suppliers at more upstream tiers, with less complex products, may try to differentiate themselves from their competitors, by means of building product development competencies. These development competencies generally have a positive impact on supplier involvement in product development (Wasti and Liker 1999; Hartley, Zirger and Kamath 1997). The great extent of self-developed technological capabilities is, for example, forwarded as an explanation of the traditionally high involvement of suppliers in product development in Japan (Nishiguchi 1994; Hines 1994). Thus, we hypothesize:

H_2: The more a supplier follows a strategy focused on innovation, the more active it is in product development.

Customer Development Commitment

In the literature on purchasing and supply management, a broad distinction is made between transaction-oriented and relation-oriented purchasing (Axelsson and Wynstra 2002, pp. 213-236). Transaction-oriented purchasing is geared towards creating competition between suppliers, which are kept at arm's-length, in order to get the most advantageous offerings, whereas the relation-oriented approach is more focused on creating advantageous exchanges with suppliers through intensive, close collaboration with a limited number of partners (Gadde and Håkansson 2001; Dyer 2000; Araujo, Dubois and Gadde 1999).

Regarding the automotive industry, various studies have characterized the traditional practices adopted by the Japanese OEMs as more relational based, and especially the US practices as more transactional-oriented. However, as among others Dyer (1996b; 2000) points out, important differences among US OEMs exist as well: in the 1990s, especially Chrysler has adopted a much more relational approach and has benefited significantly from this both in terms of static (product costs etc) and dynamic (product development speed etc.) efficiency.

An important element in this 'collaborative' approach is joint product development; customers that have a relational-oriented approach towards their suppliers are much more focused on product development collaboration than transactional-oriented buyers (f.e. Araujo et al. 1999). One could even argue that a collaborative approach is necessary for joint product development to take place, since ".. the use of collaborative arrangements allowing for mutual access to internal processes will facilitate both the development and the transfer of tacit knowledge. " (Sobrero and Roberts 2002, p. 161; see also Gulati, 1998) Equally, for those suppliers that are facing such 'collaborative' customers it makes much more sense to engage in joint product development activities since it is much more likely that such activities will be rewarded economically in the future; collaboration extends ‘the shadow of the future’ (Heide and Miner 1992).

Within their broad supply strategy, customers have various means to induce suppliers to carry out product development activities. Wynstra et al. (2003) refer to this as ‘mobilization’; forcing, encouraging or motivating suppliers to engage in particular technology or product development activities that are beneficial to the customer. LaBahn and Krapfel (2000) demonstrate that credible commitment by customers has a positive effect on suppliers’ intention for early supplier involvement. Such commitment, or ‘promise’, primarily involves favored access to additional business and financial compensation for development efforts. Apart from such rewards that are contingent on behavior, customer development commitment may also be reflected in its general emphasis on supplier development competencies. As discussed earlier, development competencies generally have a positive impact on supplier involvement in product development, but LaBahn and Krapfel (2000) demonstrate that this is only the case when the customer is considered likely to adhere to supply agreements. Thus, we hypothesize:

H_3: Customer commitment towards supplier’s product development activities increases supplier development activity.

Alternative Models

Our three main hypotheses reflect a direct effects model (Figure 2, Panel A), in which all the antecedents are directly related to the supplier development activity. In addition, we have specified three alternative, nested models (cf. Schwab, 1999), as illustrated in Figure 2. In the fully mediating model (Figure 2, Panel B), the relationship customer development commitment and supplier development activity is mediated by supplier innovation strategy. In other words, we expect customer development commitment to have no direct impact on supplier development activity – only as far as it has an impact on supplier innovation strategy (which, according to our original hypotheses, has a positive impact on supplier development activity). In the partially mediating model (Figure 2, Panel C), the direct relation between customer development commitment and supplier development activity is again added to the model to control for any remaining direct effects. Finally, in the moderated effects model (Figure 2, Panel C) we have added the moderating effect of customer development commitment on the relationship between supplier innovation strategy and supplier development activity, in order to find any remaining interaction effects between customer development commitment and supplier innovation strategy. More importantly, we have added the moderating effect of supplier downstream position on the relation between supplier innovation strategy and supplier development activity, to test for any interaction effects between supplier downstream position and supplier innovation strategy. The hypotheses (and their direction) for the alternative models are depicted in Figure 2 as H_4 to H_6.

[INSERT FIGURE 2 ABOUT HERE]

METHOD

The research underlying this paper consists of a survey among companies with manufacturing activities in the Swedish automotive industry, executed in 1999.

Measurement Instruments

Supplier development activity was operationalized using four items (SDA1-4) adapted from a combination of previous research (Von Corswant and Fredriksson, 2002; Wynstra and Ten Pierik 2000; Twigg, 1998; Birou and Fawcett, 1994; Kamath and Liker, 1994; Clark, 1989). Supplier innovation strategy was operationalized using three items developed for this study. Supplier downstream position was operationalized using two items in line with our earlier discussion; one measuring the actual supplier position in the supply chain and the other measuring the supplier's share of sales going directly to the OEM (final assembly firm), following Lamming (1993). Finally, customer development commitment was operationalized using two items adapted from LaBahn and Krapfel (2000) and Wasti and Liker (1999).

A pre-test was conducted, first with a number of academics in the field of industrial networks, purchasing management and product development, and then with representatives of ten supplier firms. This resulted in some minor adjustments to the questionnaire. The eleven resulting items (translated from the Swedish original), mostly measured on a 5-point Likert-type scale, are listed in Table 1.

Sampling and Data Collection

Firms were selected with the help of the four largest Swedish passenger car and truck manufacturers' supplier registers, the Swedish Vehicle Component Association, Statistics Sweden and other public registers. The manufacturers' data was very useful since it was based on actual purchase volumes, and therefore ensured that all important suppliers (in terms of purchase value) were included in the sample.

In February 1999, the questionnaire was sent to 601 companies. In fact, to the best of our knowledge, this includes all registered automotive suppliers in Sweden. Fax and letter reminders were sent out at several occasions, and once by telephone. By December 1999, a total of 242 companies had answered the survey resulting in a response rate of 40.3%. Of these, 81 were component factories owned by car or truck manufacturers or suppliers of products for the aftermarket, and were therefore not included in the analyses presented in this paper, resulting in a satisfactory net response of 161 companies (suppliers of production material to car and truck manufacturers) (27 %). Among the companies that declined to respond to the questionnaire a group of 20 companies were selected to analyze any non-response bias. Moreover, a large number of companies in the total sample were known to the researchers from previous studies. No evidence was found indicating structural differences between companies that did respond and those who did not. The sample of responding companies was also compared with the total population regarding the representation of companies in each part of the value chain, which yielded no significant differences. The sample used for the research in this paper is therefore regarded as an accurate representation of automotive suppliers in Sweden.

The questionnaire, in Swedish, was sent to either the general manager or the plant manager. In some cases, it was then delegated to the marketing manager or the information manager. We expect no significant differences between the different types of respondents; we see our respondents as *informants* on the situation at their respective firms – the questions are not on an individual level. Of the 161 respondents, 23 firms could be classified as 3rd tier suppliers, 69 as 2nd tier, 58 as direct suppliers and 11 as system suppliers (see Figure 1). There were no raw material suppliers in our sample.

Data Analysis

We used the Partial Least Squares (PLS) approach to estimate both the measurement and structural parameters in our structural equation model (Barclay, Higgins and Thompson 1995; Chin 1998; Fornell and Bookstein 1982; Lohmöller 1989; Wold 1985). As opposed to the covariance-based or factor based approach to structural equation modeling implemented for example in LISREL, PLS is component-based. As a consequence, PLS does not require multivariate normal data, places minimum requirements on measurement levels and is more suitable for small samples (Chin 1998; Wold 1985). PLS uses an iterative estimation algorithm, which consists of a series of simple or multiple ordinary least squares regression analyses (Chin 1998). Therefore, the path coefficients in the structural models can be interpreted as standardized regression coefficients and the loadings of the measures on their respective constructs as factor loadings. Finally, PLS is considered more appropriate for models containing complex relationships (i.e. a large number of indicators, constructs and relationships).

FINDINGS

We used the Partial Least Squares (PLS) approach as implemented in PLS-Graph Version 3.0 (Chin 2001) to estimate both the measurement and structural parameters in our structural equation model. In our study we specified reflective indicators for all the constructs. We used a series of nested models to test our hypotheses (Schwab 1999; See Figure 2). As can be observed from Figure 2, the first model is a direct effects model with direct effects of the exogenous constructs, supplier downstream position (SDP), supplier innovation strategy (SIS) and customer development commitment (CDC) on the endogenous construct, supplier development activity (SDA). Next, we developed two mediating models, in which customer development commitment (CDC) serves as a partial and a full mediating construct. Finally, we introduce two moderating effects (SIS*SDP and SIS*CDC).

Construct Validation

Before we start with the testing the substantive hypotheses in our study, we will first evaluate the validity of the measurement model of the direct effects model. We examined the reliability, convergent validity and discriminant validity for the measurement instruments used in our study. Reliability was assessed using composite scale reliability (Chin 1998; Fornell and Larcker 1981; Werts, Linn and Jöreskog 1974) and average variance extracted (Chin 1998; Fornell and Larcker 1981). We calculated composite scale reliability and average variance extracted for the constructs employed in our study (See Table 2). Composite scale reliability ranged between 0.79 and 0.91 exceeding the cut-off value of 0.7 suggested by Nunnally and Bernstein (1994). Average variance extracted ranged between 0.64 and 0.85. All constructs exceeded the 0.5 cut-off value proposed by Fornell and Larcker (1981).

Convergent validity can be evaluated by inspecting the factor loadings of the measures on their respective constructs. Discriminant validity can be assessed by examining the cross-factor loadings of the measures (Barclay et al. 1995; Chin 1998; Howell and Avolio 1993).

The measures should not load higher on another construct than it is intended to measure. Additionally, a construct should share more variance with measures than it shares with other constructs in the model (Barclay et al. 1995; Chin 1998; Howell and Avolio 1993). Consequently, the square root of the average variance extracted should exceed the intercorrelations of the construct with the other constructs in the model. After inspection of the factor loadings and the factor cross-loadings one item (SIS2) was omitted from the analysis as it exhibited a standardized loading less than 0.5 in magnitude. Inspection of Table 2 reveals that the average variance extracted exceeded the intercorrelations of the construct with the other constructs in the model.

Hypotheses Testing

To test the effects and the statistical significance of the parameters in the structural model we used a bootstrapping procedure with 250 and 500 resamples (Chin 1998, 2001; Efron and Tibshirani 1993). The resulting t statistics for both the 250 and 500 resample revealed a consistent pattern.[4] Using a significance level of 0.05 we found a significant, positive effect of supplier downstream position (β=0.33) and supplier innovation strategy (β=0.40) on supplier development activity (R^2=0.29) in the direct effects model (See Figure 3, Panel A). For the mediating model (See Figure 3, Panel B and Panel C) we additionally obtained a significant, positive effect of customer development commitment (β=0.41) on supplier innovation strategy (R^2=0.16). Finally, we introduced two product terms (SIS*SDP and SIS*CDC) to test for the moderating effects of supplier downstream position and customer development commitment. PLS allows us to employ a product indicator approach, while simultaneously accounting for measurement error (Chin, Marcolin and Newsted, 1996). For the moderator analysis, the indicators were standardized and subsequently the indicators of the product

[4] Using the individual sign changes option in PLS-Graph Version 3.0 (Chin, 2001).

terms were obtained by creating all possible products from the two sets of indicators (Chin, Marcolin and Newsted, 1996). Our results (See Figure 3, Panel D) suggest a positive and significant moderating effect for supplier downstream position (β=0.17).

DISCUSSION

Our results demonstrate that supplier product development activity is affected by the supplier's position in the supply chain and any explicit strategic focus on innovation. Moreover, there are significant interaction effects between this position and innovation strategy, implying that the effects of strategy on actual development activity are contingent on the supplier's supply chain position; the more it is located downstream, i.e. closer to the OEM, the more likely the strategy is to result in actual product development activities.

The commitment of customers to support such development activities, on the other hand, has no direct positive impact on supplier product development, but the effect appears to be fully mediated by the supplier's strategy. In other words, a supplier strategy focusing on innovation is positively affected by the commitment of customers – but this commitment in itself has no significant direct impact on supplier product development activity.

This combination of direct, moderating and mediating effects, as modeled in our final, moderating effects model (Figure 3, panel D), explains more of the observed variances in supplier development activity than a model just positing direct effects (Figure 3, panel A). Some important observations can be made on the basis of these results.

First, while the position of the supplier in the supply chain does have a direct impact on the extent of its product development activity, it does not fully constrain it. Any supplier, no matter in which position in the supply chain, that demonstrates an explicit strategy focused on innovation is more likely to become involved in product development activities for its customers, although the likelihood increases for innovative suppliers located downstream. So, suppliers are not completely ‘in chains’. This is not in strong contradiction with the (more recent) literature on supplier involvement in product development, but provides some better insight into the actual factors at play. Secondly, the purchasing strategy and behavior of customers, especially in relation to rewarding product development activities of their suppliers, have no direct impact on these activities but need to be ‘consolidated’ in the strategy of the supplier first. This provides an interesting connection between two strands of literature that, on the one hand, emphasize the role of customer commitment, and on the other hand, focus on the role of supplier strategy and capabilities.

CONCLUSION

In this paper, we have developed and tested a conceptual framework which supplier downstream position in the supply chain, supplier innovation strategy and customer development commitment are seen as the antecedents of supplier product development activity. Testing a series of nested models, we find significant support for the hypothesis that the position of the supplier in the supply chain and its strategic focus on innovation not only have a direct impact on (actual) supplier product development activity, but that there is also an interaction effect, implying that the effects of strategy are contingent on the supplier’s supply chain position. Additionally, we find that customer development commitment does not have any significant direct effect on supplier product development activities, but that this relation is fully mediated by supplier innovation strategy.

Obviously, the factors included in our analysis here, can only explain just a share of the variation in supplier’s product development activity. For example, apart from strategy, differences in internal resource endowments (skills and capabilities, laboratories etc.) could provide additional explanations. Also, relations with other customers than in the automotive industry could have an impact on product development activities. Still, we think our paper makes some interesting contributions to the debate on product development activities in the (automotive) supply chain. First of all, suppliers and their product development activities are not fully ‘in chains’, but neither are they are completely ‘free’. Both a supplier’s proximity to the final assembly firm and innovative strategy have a positive impact on its actual product development activity, but there is also a combined effect in that the more downstream a supplier is located, the stronger the impact of strategy on product development activity (or, the more innovation-oriented the strategy, the stronger the impact of downstream position on activity). In terms of managerial implications, this implies that suppliers should indeed consider (among others) their supply chain position in determining their desired level of product development activities. Suppliers located more upstream would have greater difficulty to establish a strong presence in product development, although it would not be impossible. Our second contribution relates to the identification of the mediating role of – again – supplier innovation strategy in linking customer commitment to product development activity. This has some important implications regarding the approach customers should take in promoting suppliers’ product development activities; unless such commitment and incentives are anchored in an explicit strategy of the supplier, there will not be a significant increase in product development activity.

We see interesting future research in three main directions. First of all, it would be interesting to investigate the antecedents of innovation strategy. For example, what (internal) resource endowments or organizational characteristics would support such a strategy? Secondly, what are the underlying characteristics of customers that show high commitment towards supplier product development? Does company size, market segment etc. matter? Finally, similar studies could investigate the role of strategy, supply chain position and customer commitment in other industries than automotive to investigate the generalizability of our findings.

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FIGURE 1: Tiered supplier structure (Clark and Fujimoto 1991, p. 139).

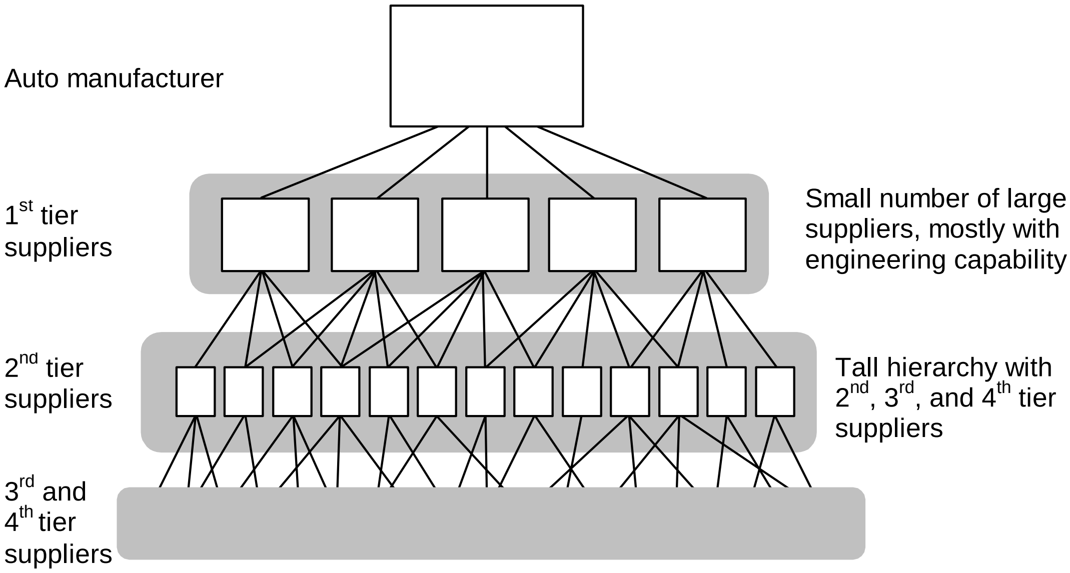
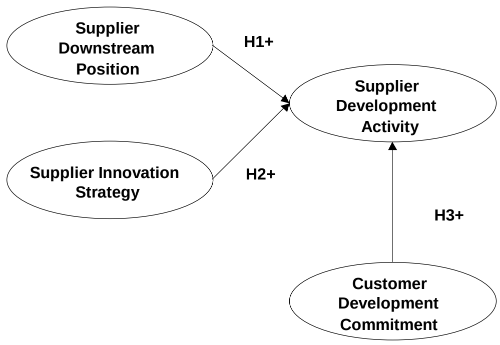
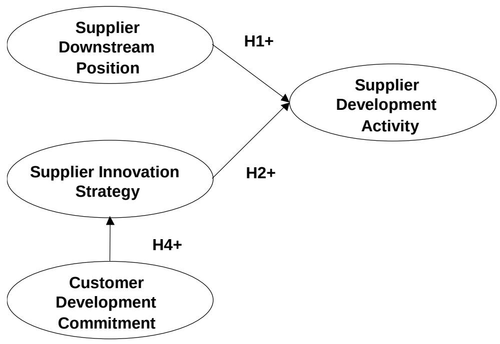


FIGURE 2: Conceptual models[a]

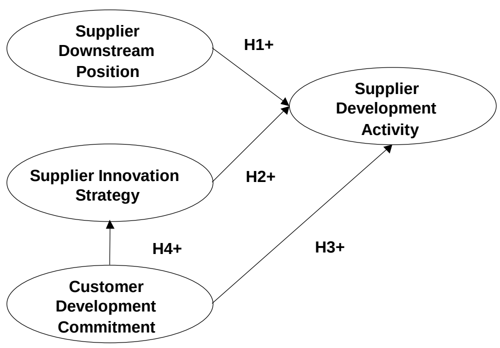
Panel A: Direct Effects Model



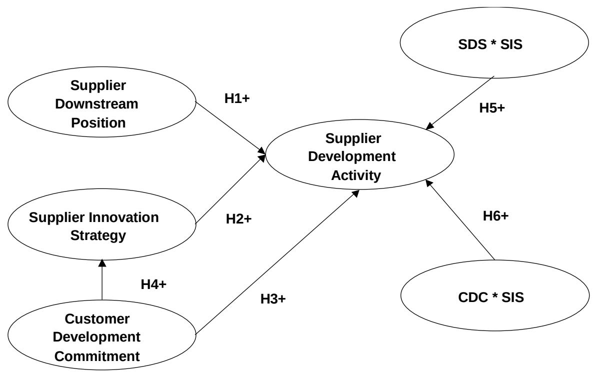
Panel B: Full Mediation Model



Panel C: Partial Mediation Model



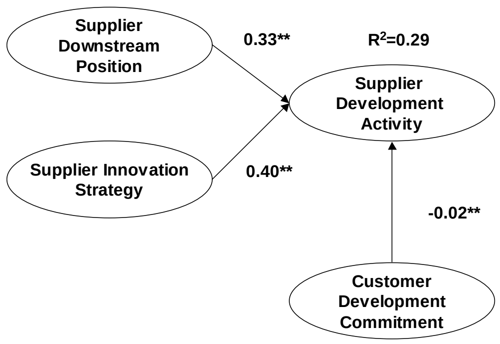
Panel D: Moderating Effects Model



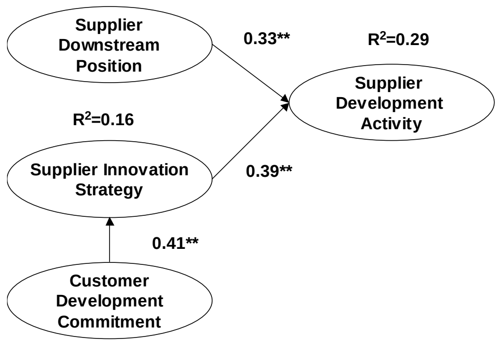
a SDS=Supplier Downstream Position; SIS=Supplier Innovation Strategy; CDC=Customer Development Commitment.

FIGURE 3: Testing Hypotheses [a]

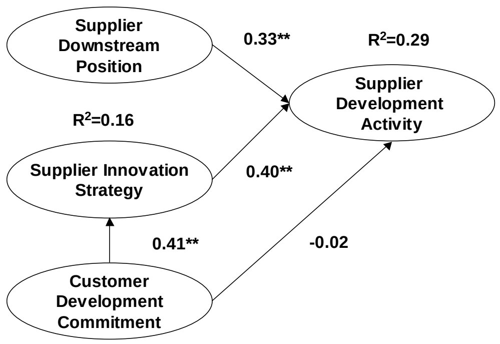
Panel A: Direct Effects Model



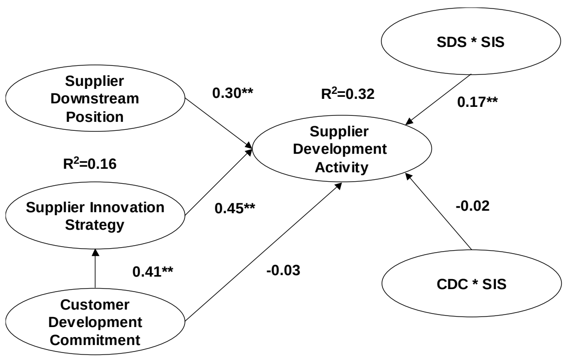
Panel B: Full Mediation Model



Panel C: Partial Mediation Model



Panel D: Moderating Effects Model



a SDS=Supplier Downstream Position; SIS=Supplier Innovation Strategy; CDC=Customer Development Commitment.
* p<0.05
** p<0.01

TABLE 1: Measurement Instruments

Supplier Downstream Position (SDP)	
SDP1	Which position best describes your firm's position in the supply chain? [1]
SDP2	Share of sales directly to automotive final assembly firm (%)
Supplier Innovation Strategy (SIS)	
SIS1	Focus on product performance [2]
SIS2	Focus on broad product offering [2,*]
SIS3	Focus on customization of products [2]
Customer Development Commitment (CDC)	
CDC1	Our customers value product development competencies in their suppliers[3]
CDC2	Our customers pay (in the unit-price or directly) for the product development costs our firm incurs [3]
Supplier Development Activity (SDA)	
SDA1	Extent to which supplier manufactures products on customer specification [4]
SDA2	Share in total development time of the products the supplier manufactures/delivers (%)
SDA3	Product development phases in which the supplier actively participates [5]
SDA4	Complexity of product development activities [6]

[1]: 1: Raw material supplier, 2: Simple component supplier, 3: Component supplier, 4: Direct supplier, 5: System Supplier (see Figure 1);
[2]: Item measured on 5-point scale: 1 "no focus" to 5 "strong focus";
[3]: Item measured on 5-point scale: 1 "fully disagree" to 5" fully agree";
[4]: Item measured on 5-point scale: 1 "developed totally on customer specifications" to 5 "developed totally on own initiative";
[5]: 1:"Basic research", 2: "Advanced development", 3: "Concept phase", 4: "Engineering phase", 5: "Product modifications";
[6]: 1: "Small changes in existing product", 2: "Redesigns of existing components/sub-assemblies", 3: "Development of completely new components/sub-assemblies"; 4: "Redesigns of existing systems", 5: "Development of completely new systems";
*: Item was dropped after construct validation.

TABLE 2: Means, Standard Deviations, Composite Reliability and Intercorrelations [a]

		Items [b]				Constructs [c]			
		M	**SD**	**Loading**	**CR**	**1.**	**2.**	**3.**	**4.**
1. SDP	**SDP1**	3.35	0.81	0.94	*0.91*	***0.92***			
	SDP2	26.28	30.27	0.89					
2. SIS	**SIS1**	3.65	1.11	0.87	*0.83*	0.13	***0.84***		
	SIS3	4.14	0.97	0.81					
3. CDC	**CDC1**	4.22	0.83	0.84	*0.79*	0.26	0.41	***0.80***	
	CDC2	3.08	1.13	0.77					
4. SDA	**SDA1**	2.19	1.43	0.84	*0.89*	0.38	0.44	0.23	***0.81***
	SDA2	1.75	1.19	0.77					
	SDA3	35.60	38.02	0.80					
	SDA4	2.36	1.39	0.84					

a SDS=Supplier Downstream Position; SIS=Supplier Innovation Strategy; CDC=Customer Development Commitment; SDA=Supplier Development Activity.

b M=Mean; SD=Standard Deviation; Loading=Standardized Loading; CR=Composite Reliability.

c Square Root of Average Variance Extracted on Diagonal.

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