

Exhaustion or Learning? Supplier Involvement in Customer Innovation

We address whether involvement in customer firms' innovation activities affects suppliers' own product innovation activities. This issue is important not only for innovation research but also for suppliers' strategic considerations in their involvement in customers' innovation activities. Two main strands of the innovation literature are related to this question. One strand emphasises the learning benefits and other positive spill-over effects on suppliers from being involved in their customers' innovation activities (e.g. Appleyard, 2003; De Jong and Von Hippel, 2009). The other strand views suppliers' involvement in their customers' innovation activities as an exhaustive process that reduces rather than enhances their innovation ability (e.g. Boisot, 1995; Möller and Törrönen, 2003; Helper and Sako, 2010).

Previous studies on suppliers' involvement in customers' innovation activities were primarily case- or sector-specific (e.g. Jean *et al.*, 2014) or tended to treat involvement as a dichotomous decision, thus leaving no room for a discussion on the scope of involvement. By contrast, the literature on customers' innovation benefits (e.g. Clark, 1989; Eisenhardt and Tabrizi, 1995) illustrates the importance of focusing explicitly on the extent of involvement. Therefore, this study explores the importance of the scope of involvement in customers' innovation activities. This work contributes to the innovation literature in the following ways: first, it takes the suppliers' perspective on appropriating benefits from contributing to customers' innovation, which has received less attention in the literature. Second, compared with the relatively few other studies available, this study takes a broader, cross-industry approach to collaborative innovation. Third, the study explores whether the scope of involvement in customers' innovation activities matters for supplier firms' own product innovation activities.

The empirical analysis is based on a unique cross-industry dataset focusing on the supplier perspective by mapping suppliers' relations with their most important customers. This dataset is combined with innovation data from two consecutive Danish innovation surveys.

Supplier involvement in customers' innovation activities

Novozymes is a world-leading supplier of enzymes and microorganism. It is frequently involved in their customer's innovation of new products, such as Unilever's development of low-temperature washing detergents or Heineken's development of new types of beer. For Novozymes, participating in customers' innovation activities entails not only supplying specific enzymes and microorganisms but also exchanging insights and knowledge, which potentially helps Novozymes to enhance their own knowledge base and thus strengthen their own innovation ability. However, at the same time, customers, who are keen on keeping their competitive edge, provide restrictions in the re-use and may limit suppliers' insights and involvement in their development activities. This restriction potentially hampers suppliers' ability to gain insights from contributing to customers' innovation activities.

A large part of the innovation literature is concerned with the external involvement of partners in collaborative innovation activities. The phenomenon is discussed in relation to open innovation (e.g. West and Bogers, 2014), interfirm collaboration (e.g. Laursen and Salter, 2006), user-producer interaction (e.g. Lundvall, 1985; Freeman, 1991) and distributed innovation (e.g. Sawhney and Prandelli, 2000). The European Community Innovation Surveys (CIS) generally rank suppliers as the second-most important external source of innovation after customers.¹ Although supplier involvement in customers' innovation activities can take many forms, most contributions are related to suppliers participating in and even taking over sub-elements of development processes governed by their customers (Clark, 1989; Yoo *et al.*, 2015).

¹ The 2012 CIS survey found that 79.6% of innovative firms used information from their suppliers as a source of innovation and that 25.5% of these firms considered suppliers to be highly important to their innovation process. Source: Eurostat Innovation Statistics 2012.

Learning and exhaustion effects on suppliers' involvement in customers' innovation activities

Inter-firm collaboration is considered positive for innovation activities, even without necessarily considering the extent to which it applies to the two parties involved (Laursen and Salter, 2006; von Hippel, 1988). The arguments behind this view are that discovery requires knowledge, openness and interfirm reciprocity in terms of knowledge sharing (Van de Ven, 1986). Knowledge reciprocity relates to the signalling of openness and intentions of trust among business partners (Lawson and Lorenz, 1999; Meeus *et al.*, 2001). Therefore, the ability of a supplier to gain access to and to be 'in the loop' about the innovation activities of a particular field hinges on its ability to provide innovative inputs that contribute to the overall development of knowledge (Powell *et al.*, 1996). Others suggest that opening up and diffusing knowledge to customers, suppliers, and other actors may also lead to adoption effects, as these actors commit to the firms' technology (Boisot, 1995; Garud and Kamaraswamy, 1993), thereby potentially increasing suppliers' learning benefits from their involvement in customers' innovation activities.

The literature on innovation search processes demonstrates that sources outside the firm contribute positively to the scope and scale of innovation output (e.g. Laursen, 2012). Furthermore, access to value appropriation from a shared pool of innovation insights is assumed to depend on reciprocity and distributive justice, thus suggesting positive returns from increased involvement (Franke *et al.*, 2013). This conjecture can spur the assumption that suppliers gain learning benefits from being involved in their customers' innovation activities, thus leading to a positive relation between involvement and supplier firms' product innovation activities.

Others suggest that being involved in customers' innovation activities may hamper suppliers' innovation performance. Of particular concern is the scarcity of resources that are critical for innovation activities for both the supplier and the customer organisation. From a resource-based point of view, the ability of suppliers to participate in customers' innovation activities hinges on the control of critical human resources (Wright *et al.*, 2001). The opportunities for deploying these resources are limited. Even though learning possibilities may arise, the possibilities for exploiting these opportunities in other contexts are restrained by the specific innovation context of their customers' innovation activities (Möller and Törrönen, 2003). In addition, the literature on captive suppliers suggests that the power relations in the value chain expose suppliers to the opportunistic behaviour of their customers (Taskanen, 2015; Helper and Sako, 2010). This exposure may restrain suppliers' possibilities of benefitting from their involvement in their customers' innovation processes. Finally, if knowledge is assumed to be an informational asset, which is valuable to the beholder, because of its rarity, suppliers will, by diffusing their knowledge assets, lose positional advantages in bargaining with their customers, and this situation could reduce the suppliers' incentive to innovate (Arrow, 1996; Boisot, 1995). Following this theoretical vantage point, involvement in customers' innovation activities exhausts suppliers' knowledge resources, thereby leading to a negative relation between involvement and suppliers' product innovation activities.

However, the discussion of supplier benefits from being involved or not, as implied in the two opposing views, may be too simplistic to capture the potential relations between suppliers' involvement and their own innovation activity. Accordingly, we argue that from a supplier perspective, learning and exhaustion effects are not necessarily mutually exclusive but may require some form of managing the tension between the two. For example, a supplier like Novozymes, which is deeply involved in their customers' innovation activities, may incur learning benefits while at the same time be challenged in terms of how and to which extent this knowledge is deployable in other customer relationships.

Scope of supplier involvement in customers' innovation activities

Innovation managers have different approaches for mediating supplier involvement, which depends on the scope of involvement (Wynstra *et al.*, 2001; McIvor and Humphreys, 2004). Scope refers to the breadth of new development tasks in which suppliers are involved (Clark, 1989; Eisenhardt and Tabrizi, 1995). From a supplier's perspective, the degree of involvement is likely to influence whether the learning or exhaustion effects of innovation activity dominate.

Insights from the organisational learning literature suggest that positive or negative effects may be linked to balancing the scope of supplier involvement. In March and Simon's (1958) seminal contribution, the notion of limited information capacity was developed, and it suggested that organisational systems could experience information overload because of their inability to process and store information. Organisations' limited information processing capacities restrict them from continuous learning because they also need resources to assimilate learning with what is already known. The organisational learning literature claims that an organisation's ability to absorb knowledge is dependent on its previous learning and that there is an on-going and dynamic trade-off between organisational learning and knowledge assimilation mechanisms (Cohen and Levinthal, 1990; March, 1991). These effects can also be linked to new product development activities (Marsh and Stock, 2006). Organisations continuously create new knowledge by reconstructing and understanding specific use situations (Nonaka, 1994).

Customers' absorptive capacity has been associated with supplier involvement (Narafi *et al.*, 2013). It can also be linked to the scope of supplier involvement in customers' innovation activities. Instead of viewing supplier exhaustion and supplier learning as distinctive outcomes of the buyer-supplier interaction, this study suggests that these effects co-exist and that both aspects affect suppliers' ability to reap positive innovation gains from being involved in customers' innovation activities. In terms of a specific innovation project, suppliers may be partially or fully involved in customers' innovation activities. Variation in task environments enables learning opportunities that improve learning possibilities at least to some extent (Levinthal and March, 1993). Being involved in a broader range of customers' innovation activities suggests that suppliers are exposed to more variation and learning than partial (and more specialised) involvement would suggest (Geffen and Rothenberg, 2000). Likewise, learning may give way to exhaustion effects, thus negatively affecting suppliers' internal use of scarce resources if they are only partially involved in customers' innovation activities. In the latter case, suppliers experience lock-in in the form of a less contextual variation, and tasks are likely to be specialised and repetitive.

The above discussion implies that the relation between suppliers' involvement in customers' innovation activities and the suppliers' own product innovation activities may be more complex than a simple question of involvement or lack thereof. Therefore, we hypothesise that suppliers' learning outcomes differ with respect to the scope of their involvement.

- H1: The scope of involvement in customers' innovation activities affects whether learning or exhaustion effects dominate the relation between involvement and supplier firms' product innovation activities.
- H1a: If suppliers are involved only in some phases of their customers' innovation activities, exhaustion effects are likely to dominate, thus resulting in a negative association with their own innovation activity.
- H1b: If suppliers are involved in all phases of their customers' innovation activities, learning effects are likely to dominate, thus resulting in a positive association with their own innovation activity.

Other factors that are not directly related to the involvement in customers' innovation activities are also likely to influence suppliers' innovation activities. First, suppliers' general dependence on their customers can influence whether the learning or exhaustion effects dominate (Cox, 1999). The suppliers' dependence is contingent on several factors, such as the duration of the relationship with customers, the importance of customers in terms of sales, the suppliers' position in the value chain and the potential customisation of products and services. Sub-suppliers represent a special case in this regard; they customise their products to a particular customer, but doing so could lead to a higher dependence on the customer. The higher a supplier's dependence on a single customer is, the more power the customer has in the relationship, thus increasing the possibility of exploitation and exhaustion to dominate (Wynstra *et al.*, 2010).

Data and Methods

The empirical analyses are based on the combination of three datasets on firms in Denmark. The first two datasets are derived from the Danish version of the CIS in the periods of 2008–2010 and 2011–2013, respectively. Participation in the innovation survey is mandatory, and the data are derived from responses from 5,000 randomly selected firms from a population of 22,000 firms. The firms were selected on the basis of their industry affiliation and number of employees. Industries with a high R&D intensity received broader coverage than less R&D-intensive industries. The samples of the innovation surveys for different years partly overlap, making it possible to follow firms' innovation activity over time.

The third data source is a unique cross-industry dataset on suppliers' relations with their most important customers. This dataset is in the same period as the latest innovation survey data². It is based on a non-mandatory survey of the total population of approximately 4,000 firms with at least 10 employees in manufacturing industries and in a few selected business services industries. Altogether, 980 firms answered the questionnaire on suppliers' relations with their most important customers, resulting in a response rate of 23.4%. Combining the three datasets yields a matched sample of 218 firms. The subsequent analyses are based on this matched sample, weighted by number of employees and industry affiliation.

The probability of being involved in customers' innovation activities is entered as a variable in the models testing the hypotheses. The hypotheses are tested using both logistic regression analysis of the factors influencing the likelihood of supplier firms introducing product innovations and linear regression analysis [ordinary least square (OLS)]. In the first case, the dependent variable is a binary variable expressing whether the supplier has introduced a new or an improved product or service (i.e. product innovation) during the period of 2011–2013. In the second case, the dependent variable is the proportion of turnover generated from new products during the period of 2011–2013.

The degree of involvement is expressed by three explanatory dummy variables, which indicate whether the supplier firms have been involved in one, two, or three phases of their most important customers' innovation activities. The innovation activities in customer firms comprise development activities without considering whether these activities result in actual innovations.

In addition to controlling for propensity of being involved in customers' development activities, the models control for the share of turnover generated by the customers, duration of the relationship, previous innovation activity, in-house R&D, number of employees and industry affiliation. Therefore, some variables are assumed to affect the probability of selection and the suppliers' own innovation activity. A variance inflation test on the OLS version of the model reveals no potential problems with multicollinearity, as all variance inflation factors (VIFs) are below 2.

Empirical results

Table 1 shows the results of the probability model, which estimates the probability of suppliers being involved in customers' innovation activities. The generated probability scores are entered into the models testing the hypotheses of the relation between involvement in customer innovation and own innovation activities as an explanatory variable.

The probability of being involved in customers' innovation activities is positively and highly significantly associated with the proportion of turnover generated by customers, with the scope of interaction with the customers as expressed by the variety of services and products delivered and with being a sub-supplier to the customers. The location of customers also matters: suppliers are more likely to be involved in the development activities of customers located in the rest of the world (i.e. not located in the Nordic countries

² As the dependent innovation variable refers to the same period as that of the explanatory variables (with the exception of the variable expressing previous innovation activity), the analyses mainly explore the relations between supplier firms' involvement in customers' innovation activities and the suppliers' own product innovation activities; accordingly, inferences about causality must be regarded as indicative in the short term only.

or in a selected group of European countries) than in the customer–location in Denmark, whereas suppliers are *less* likely to be involved in the development activities of customers located in other Nordic countries than in Denmark. Accordingly, large distances do not hamper the possibilities of contributing to customer innovation. On the contrary, the results indicate that distant customers are likely to use Danish suppliers because they can contribute to innovation. This finding is an interesting one because it challenges the assumption that geographical proximity is important for inter-firm learning. A likely explanation is that the suppliers and customers are cognitively proximate (Boschma, 2005).

Supplier firms’ experience with own product innovation, expressed as a successful product innovation in the previous period, is neither associated with the likelihood of becoming involved in customers’ innovation activities nor with the duration of the supplier–customer relationship.

Table 1: Probability model for suppliers’ involvement in customers’ innovation activities

		Estimate		SE
Constant		-1.29	***	0.33
Supplier was product innovative in the previous period		0.10		0.08
Turnover generated by customer (log)		0.41	***	0.08
Duration of relation with customer (log)		0.01		0.08
Variety of services and products delivered to the customer (scope of interaction)		0.35	***	0.05
Sub-supplier status (dependence)		0.28	***	0.08
Location of customer (benchmark: Denmark)	1: Nordic countries	-0.60	***	0.22
	2: Selected European Union countries [#]	-0.22		0.19
	3: Rest of the world	0.85	***	0.21
Number of observations used		209		
Weights		Yes		
Log-Likelihood		-579.33		
R ² (max-rescaled)		0.58		

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level.

[#] Germany, United Kingdom, France, Italy, Spain, Portugal and Poland.

Table 2 shows the results of the OLS regression on the share of turnover from innovation and the logistic regression on firms’ likelihood of being product innovative in the period of 2011–2013. The regressions find similar results in the relation between firms’ involvement in their customers’ innovation process and their own innovation performance. The regression on turnover from innovation finds a positive and statistically significant relation between contributing to all development phases of customers’ innovation activities and firms’ turnover from innovation. This finding supports Hypothesis 1b, which indicates that learning effects dominate if suppliers are involved in all development phases. However, no significant effect is found on participation in one or two development phases. Accordingly, Hypothesis 1a on exhaustion effects is not supported.

In-house R&D and being product innovative in the previous period have a statistically positive and significant effect. The regression also demonstrates a negative relation between suppliers’ customer dependence measured by the share of turnover by customer and duration of relation by customers. As expected, dependence on customers is negatively related to supplier’s own innovation activities.

The logistic regression model on the likelihood of launching a product innovation in 2011–2013 shows a similar pattern to the OLS model. A statistically significant and positive relation is found between contributing to all three of customers’ development phases and firms’ own product innovation performance (odds ratio 3.4). Therefore, when the other innovative predictive factors are included, firms

involved in all phases have a 240% higher likelihood of innovating compared with other firms. This finding supports Hypothesis 1 in general and Hypothesis 1b in particular. The exhaustion indicated in Hypothesis 1a is not supported. These findings add to the inter-firm collaboration on innovation literature (e.g. Laursen and Salter, 2006) by suggesting that scope of involvement matters in the mutual positive benefits of collaboration. The model reveals a negative relation between firms' innovation and the two variables indicating customer dependence. This finding is an important one, as it stresses that too much stability and economic dependence on customer relations may dull suppliers' innovation effort.

Moreover, the model shows a set of other statistically positive effects. The probability of being involved in customers' innovation activities is positively related to firms' likelihood of product innovation. This finding suggests that controlling for selection effects is important and that these effects should not be neglected in studies on collaboration outcomes. The model reveals the importance of in-house R&D and an effect of innovation persistence. Therefore, although there is an effect from involvement in customers' innovation activities, this involvement is not the only important factor in firms' innovation capabilities.

Table 2: Regression results: Turnover from innovation and product-innovative firms

	Turnover from innovation (2011–2013) - continuous variable (OLS model)			Product-innovative firm (2011–2013) – binary variable (logistic regression)		
	Estimate		SE	Estimate		SE
Constant	26.93	***	9.83	-0.47		0.63
Probability of being involved in customers' innovation activities	3.82		12.10	2.15	***	0.62
Contributing to one development phase of innovation activities	4.22		4.86	0.08		0.13
Contributing to two development phases of innovation activities	-4.60		5.86	-0.18		0.16
Contributing to three development phases of innovation activities	13.43	**	5.32	0.62	***	0.14
Supplier was product innovative in the previous period	9.30	**	4.05	0.52	***	0.10
Turnover generated by customer (log)	-3.74	*	2.21	-0.50	***	0.12
Duration of relation with customer (log)	-6.82	***	1.94	-0.57	***	0.11
In-house R&D (log)	2.54	***	0.48	0.28	***	0.02
No. of employees (log)	-0.48		1.57	-0.03		0.09
Service industry (compared with manufacturing)	-11.22	**	4.56	-0.40	***	0.12
Number of observations used	214			214		
Weights	Yes			Yes		
Adj. R ²	0.26					
Log-Likelihood				-581.54		
R ² (max-rescaled)				0.86		

Note: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level.

We also conduct several regressions³ with alternative model specifications to test the stability and validity of the findings. The two models in Table 2 are analysed using the same variables for to make them comparable. However, if the contribution to customers' innovation activity is measured as a single discrete variable that compares scope of involvement with not being involved, the results will change slightly. Being involved in all phases remains significant and positively related to firms' product innovation performance compared with firms that are not involved. However, being involved in two phases has a statistically significant and negative relation to the likelihood of innovating, thus suggesting that exhaustion effects do occur, whereas being involved in one phase is statistically insignificant. A potential explanation for this

³ Results are available upon request.

finding is that a non-linear trade-off exists between exhaustion and learning; this trade-off is related to the devotion of resources relative to learning opportunities. Therefore, involvement in customer firms' two development phases commands considerable resources from supplier firms, and this exceeds the learning opportunities from the involvement. In essence, this finding may support Boisot's (1995) point about positive and negative effects being at play at the same time in the relationship. Therefore, supplier firms may be linked to customers in an unequal power relation (Helper and Sako, 2010) because the customers remain in control as long as the suppliers are not involved in all major development phases. We use the interaction effects to test for a potential mediating effect of firms' in-house R&D spending on the possibility of achieving learning and avoiding exhaustion effects of contributing to customers' innovation activities. However, no statistically significant interaction effects are found.

Discussion and implications for research and management

This study contributes to the literature on supplier involvement in customer innovation by taking the often-neglected supplier perspective. Although the innovation literature argues that involving suppliers can contribute substantially to innovation activities from the customer perspective, the present analysis shows that suppliers under certain conditions can also benefit from contributing to their customers' innovation activities.

The analysis explores the importance of scope of involvement in suppliers' learning and exhaustion effects from contributing to customers' innovation. Although the study confirms that learning effects do depend on scope of involvement, the presence of exhaustion effects for the suppliers cannot be directly confirmed. The results show that involvement in customers' innovation activities is positively related only to suppliers' own product innovation activities when the involvement covers all major phases of the development process. This finding is in accordance with the literature emphasising that innovative discovery requires openness and reciprocity and that a shared pool of innovation insights leads to benefits for all parties involved (Van de Ven, 1986; Franke *et al.*, 2013).

This study contributes to the existing stream of literature on learning benefits from innovation collaboration and provides a quantitative empirical grounding for other research results, which are usually anecdotal in nature. Furthermore, by addressing the role of scope in supplier involvement, we both extend existing studies on supplier involvement that take customers' perspective and challenge the literature that tends to treat involvement as a dichotomous decision. These findings are relevant in the research on collaborative innovation and supplier involvement. The study reveals that suppliers are affected by participation in customer firms' innovation activities to give nuance to the innovation management literature's rather one-sided focus on the benefits of collaborative innovation. Although no exhaustion effects exist, there are also no learning benefits from being involved in a few phases of customers' development activities. The results can help in the further exploration of the effect of being involved as a supplier in customer firms' innovation activities.

The overall findings indicate that several important issues must be considered to manage relationships with customer firms. If suppliers are highly dependent on customers in terms of the duration of the relation and the share of turnover, then the suppliers are more likely to become involved in the customers' innovation activities but are also less likely than other suppliers to introduce their own innovations. This reaction may be caused by limited innovation incentives and learning opportunities caused by the lock-in.

For managers in supplier firms, the findings suggest that involvement in their customers' innovation activities can benefit their own innovation ability. Suppliers become involved in their customers' innovation activities for different reasons, salient among which is catering to their main customers' needs. This reason is indicated by the finding that customer-specific turnover is positively related to suppliers' participation in customers' innovation activities. The literature on buyer-supplier relationships supports this finding (Kalwani and Narayandas, 1995). However, the current study suggests that more selectivity in the scope of involvement is advisable. To reap the learning benefits that enhance their own innovation ability, managers in supplier firms should prefer involving the firms' scarce resources in innovation projects in which opportunities exist for participation in all phases of the development process. This insight is an important

one for managers in supplier firms in terms of segmenting their customer base strategically and looking for portfolio synergies in learning and own product innovation performance. Furthermore, the findings merge with the discussions on the purchasing and operations management literature on suppliers' perception of customer attractiveness (Ellegaard, 2003). For customer firms, the study provides insights into mobilising strategically important and attractive suppliers for innovation activities (Pulles *et al.*, 2016). Customers may also reap long-term benefits from suppliers' ability to optimise their learning abilities. Therefore, for customer firms, ensuring supplier involvement in all phases of innovation activities can be considered as part of supplier development initiatives.

Limitations and future research

This study has limitations that both temper the generalisability of our findings and call for future research. First, the empirical context is a small, open and mature economy with an extensive supplier base, and it may affect the transferability of the findings to other national contexts. The role of national and institutional contexts has been previously shown to play an important role in the organisation and management of buyer–seller relationships (Helper and Sako, 1995). Second, the conclusions are based on a sample of more than 200 firms. Accordingly, studies on a larger variety of countries and firms are needed. A richer dataset can also allow for the further exploration of a potential nonlinear trade-off between exhaustion and learning effects implied in the alternative model specifications. Third, quantitative data cannot capture information on the depth and intensity of supplier involvement, which may vary independent of the scope of involvement. To investigate this further issue, a qualitative research design is called for to enable researchers to examine the processes of supplier learning and involvement in customer firms and to determine how this knowledge affects supplier's own innovation ability.

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