CUSTOMER COLLABORATION IN NEW PRODUCT DEVELOPMENT: THE MODERATING IMPACT OF INTERNAL R&D EFFORTS.

Erwin Kruitbosch

ABSTRACT

In this study, we examine the moderating impact of internal R&D efforts on the relationship between customer collaboration and both, new-to-the-firm innovation performance and new-to-the-market innovation performance. Conducting OLS regression analyses, supplemented with the Johnson-Neyman technique, on a sample of 305 firms, we observe that firms can benefit from customer collaboration in terms of new-to-the-firm innovation performance. In addition, we observe that firms can benefit from customer collaboration in terms of new-to-the-market innovation performance only when at least 22% of the employees are employed in order to support internal R&D activities. These findings have important theoretical and managerial implications in the field of open innovation.

1. INTRODUCTION

Companies are operating in an uncertain and dynamic environment, which is characterized by changing customer preferences and rapidly changing technologies (MacCormack et al., 2001). Therefore, companies are shifting from a closed to a more open innovation model (Chesbroug, 2003), whereby customers collaboration becomes more and more important. But, we observe that collaboration with customers in practice results in contradictory outcomes. Boeing, for instance, reported on the success of customer collaboration during the development for its new Boeing 777 airplane (Condit, 1994). On the other hand, companies like Compaq and Motorola have achieved surprising successes by ignoring their customers from time to time (Martin, 1995). Moreover, Campbell & Cooper (1999) sampled 52 partnership projects, of which a proportion of 31% failed.

Since customer collaboration in practice delivered mixed findings, many scholars have started to examine this collaboration (for an overview, see Bogers et al., 2010). However, until now empirical research did not provide consisting results. Whereas some scholars found a positive impact of the collaboration with customers on innovation performance (Gruner & Homburg, 2000; Salomo 2003), others scholars reported a negative impact (Martin, 1995) or did not found a relationship at all (Campbell & Cooper, 1999).

The purpose of this study is to explain the contradicting results, by 1) testing the moderating impact of internal R&D efforts and 2) acknowledging the multi-dimensional nature of innovation performance. We will test the moderating impact of a firms' internal R&D efforts on the relationship between customer collaboration and, both, new-to-the-market and new-to-the-firm innovation performance. To test this relationship, we rely on a sample of 305 Belgian manufacturing firms. For these firms, data is collected about their collaboration with customers and their innovation performance via the Fourth Community and innovation survey. We used ordinary last squares (OLS) regression analyses, supplemented with the Johnson-Neyman technique (Hayes & Matthes, 2009), to testing our hypotheses. Because we had to deal with two dependent variables, which are probably correlated, we conducted a multivariate GLM analysis as additional test.

We hypothesized a positive relationship between customer collaboration and new-to-the-firm innovation performance and no relationship between customer collaboration and new-to-the-market innovation performance. Moreover, we hypothesized that a firms' internal R&D

efforts positively moderates the relationship between customer collaboration and new-to-the-firm innovation performance. In other words, we expected a stronger relationship between customer collaboration and new-to-the-firm innovation performance for firms with a higher level of internal R&D efforts. We did not expect a significant interaction effect with regard to new-to-the-market innovation performance. Our findings provide evidence for the positive relationship between customer collaboration and new-to-the-firm innovation performance and for the absence of a relationship between customer collaboration and new-to-the-market innovation performance. Surprisingly, our findings do not provide evidence for the positive interaction effect between customer collaboration and internal R&D efforts, with regard to new-to-the-firm innovation performance. On the other hand, we did find an unexpected positive interaction effect between customer collaboration and internal R&D efforts, with regard to new-to-the-market innovation performance. With these results, we contribute to the explanation of the contradicting findings of previous studies.

This paper is structured as follows. First, we will develop a theoretical framework and formulate our hypotheses. Next, we will discuss our methodology. Afterwards, the results of our analyses will be presented. Finally, we will point out the main theoretical and managerial implications of our study, we will discuss the limitations and we will suggest interesting directions for future research.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

The purpose of this paper is to explain the contradicting results of the past studies in the field of customer collaboration during new product development. In order to do so, we developed a framework that is presented in figure 1. This framework provides hypotheses on the moderating impact of internal R&D efforts on the relationship between, both, new-to-the-market innovation performance and new-to-the-firm innovation performance.

----- Insert Figure 1 about here -----

Impact of customer collaboration on innovation performance: Advantages and disadvantages.

Several scholars conducted research about the topic of customer collaboration in new product development in different ways (for an overview, see Enkel et al., 2005). Some scholars discussed the integration of customers in a virtual setting (Nambisan, 2002). Others discussed

the different roles of customers in the product development process (Lengnick-Hall, 1996), or the different methods for customer involvement in new product development (Kaulio, 1998).

Relying on different theoretical perspectives, scholars found different advantages or disadvantages for customer collaboration in new product development. A frequently named advantage in the marketing literature is that customer collaboration can be used to understand customers' needs, especially in a rapidly changing world (Kohli & Jaworski, 1990; Enkel et al., 2005). Collaboration with customer can be used as a major source of information. One of the first researchers that explicitly paid attention to the central role of customers as source of information is Von Hippel. In the early 70s, he sampled 111 successful innovations and showed that customers were involved in approximately 80% of these innovations (Von Hippel, 1976). Hereby, he demonstrated that customers can be a major source of information. Later on, other scholars found additional evidence that customer collaboration could be an important tool to acquire information about customer preferences (Salomo, 2003; Enkel et al., 2005) and that customers can suggest innovative ideas (Enkel et al., 2005). "Once users acquire some familiarity with the new product they often desire added capabilities in future versions of the product" (Athaide et al., 1996). Other studies in relationship marketing provided more theoretical and empirical evidence that customer collaboration may raise the innovation performance success rate (Gruner & Homburg, 2000).

Another potential advantage is that collaboration with customers during product development may provide access to new resources and capabilities that the manufacturer lacks in-house (Ruekert & Walker, 1987; Athaide et al., 1996; Campbell & Cooper 1999). By collaboration with customers, firms might have access to improved information, capabilities and resources that would otherwise be unavailable Campbell & Cooper (1999).

Because customers can provide useful feedback in early stages, another potential advantage is that collaboration with customers leads to fewer errors in the early development stages and to a better product quality (Enkel et al., 2005). For new products, "some 'bugs' can be detected only when the product is being used in the buyers environment" (Athaide et al., 1996, p. 415). This results not only in a better product quality, but also in a reduction of the product development cycle time. In addition, there are more scholars who claim that customer collaboration contributes to the reduction of the product development cycle time (Sherman et al., 2000), which is really important in a rapidly changing environment.

Finally, customer collaboration can be used as a method to reduce market risks (Enkel et al., 2005). Through the collaboration with customers, companies aim to decrease the costs of R&D and share the technical and financial risks (Grassmann & Enkel, 2004). A lot of companies have, in fact, already stated to take advantage of customer collaboration and so reducing the risk of failure (Enkel et al., 2005).

Next to these advantages, there are also disadvantages of collaboration with customers. A first drawback of collaboration with customers is that customers can confuse a company. Just because customers say they want something, does not mean that they will buy it. (Martin 1995). In addition, the integrated customers will represent only a small group of all potential customers. It is possible that the integrated customer is the only one interested in the newly created product (Enkel et al., 2005), so customers can give unrepresentative feedback (Campbell & Cooper, 1999). Moreover, most customers do not have a sufficient domain of expertise (Campbell & cooper, 1999). This can lead to inefficient development.

Another disadvantage is that manufactures might become slavishly devoted to their customers (Martin, 1995). Most integrated customers mainly expect a personal benefit (Enkel et al., 2005). This might results in disagreements about exclusive rights to the innovation. In addition, Campbell & Cooper (1999) also warns for the battle of property rights.

Thirdly, "cooperative manufacturing may end up as nothing more than a subcontractor for key customers" (Campbell & Cooper 1999, p. 509). By comparing the new development undertaken in partnership versus those developed in-house, Campbell & Cooper (1999) did not find any significant differences.

The final potential disadvantage has to deal with the not-invented-here syndrome, in which firms resist accepting innovative ideas from the environment (Cohen & Levinthal, 1990). Some R&D departments are openly against the collaboration with customers during new product development (Enkel et al., 2005) and will reject all external ideas.

Collaboration with customers in different innovation contexts

Since previous studies about customer collaboration during new product development presented contradicting results, we want to explain these contradictions by acknowledging the multi-dimensional nature of innovation performance. Several scholars distinguished the nature of innovation performance in several ways. Christensen & Overdorf (2000), for

instance, made difference between sustaining and disruptive innovations and Dewar & Dutton (1986) dichotomized between radical and incremental innovations. In line with previous research on the innovation performance implications of the open innovation model (Faems, 2010), we made a distinction between new-to-the-market and new-to-the-firm innovation performance.

Since there is a difference in innovation context, not all new product development processes should be managed similarly. What may be beneficial for innovations that are new-to-the-firm, may not be appropriate for innovations that are new-to-the-market (O'Conner, 1998). The value that customers can provide during the new-to-the-market product development process is limited (O'Conner 1998; Lundkvist & Yakhlef 2004). The integrated customers are, in the first place, chosen on their experiences (Von Hippel 1986). Since customers do not have the experience with products that are new to the market, their limited domain of expertise can lead to inefficient development (Campbell & Cooper, 1999). So, personal experience is not usable to find products that are new to the market (Enkel et al., 2005).

On the other hand, the role of customer has mainly been recognised in connection with innovations that are new to the firm (Lundkvist & Yakhlef 2004). Faems et al. (2005) labelled the collaboration with customers as an "exploitative oriented collaboration", which is associated positively with higher levels of new-to-the-firm performance. When customers are familiar with products or technologies, their personal experience can help to improve products (Enkel et al., 2005). When customers acquired some familiarity with products or technologies, they often desire added capabilities (Athaide et al., 1996). These desires and requirements could be the input for innovations that are new to the firm. Moreover, customers that are familiar with products and technologies, can provide useful feedback in early stages.

In line with several scholars (Athaide et al., 1996; Salomo, 2003; Enkel et al., 2005; Faems et al., 2005), we expect that the collaboration with customers during new-to-the-firm product development is important to understand customers' needs. Moreover, the collaboration with customers could be an entrance to new resources and capabilities to the manufacturer. Therefore, we formulated the following hypothesis:

H1: Customer collaboration during new product development does have a positive influence on the new-to-the-firm innovation performance.

In line with others (O'Conner, 1998; Lundkvist & Yakhlef, 2004; Enkel et al., 2005), we expect that the value of collaboration with customers during new-to-the-market product development is limited. Personal experience of customers is not usable for the development of products that are new to the market. Therefore, we formulated the following hypothesis:

H2: Customer collaboration during new product development does not have a significant influence on the new-to-the-market innovation performance.

Moderation impact of internal R&D efforts

Although much has been written about the expected consequences of customer collaboration during new product development, there is little focus on potential factors that moderates the relationship between customer collaboration and innovation performance. Ritter & Walter (2003) stated that collaboration with customers is "a complex process that is influenced by a whole bundle of different aspects" (Ritter & Walter 2003, p. 494). Therefore, the effect of customer collaboration on innovation performance can differ under different kinds of contingency factors. In previous studies, internal R&D efforts is frequently named as antecedent of external collaboration (Kleinknecht & Reijnen 1992; Colombo & Garrone 1996; Fritsch & Lukas 2001), but the focus on the possible moderating impact of internal R&D efforts on the relationship between external collaboration and innovation performance is very scare.

Cohen & levinthal (1990) highlighted that "the ability to exploit external knowledge is a critical component of innovative capabilities" (Cohen & levinthal 1990, p. 128). They argue that firms can only benefit from external knowledge if they are able to 'absorb' that information. Cohen & Levinthal (1990) demonstrated that the level of a firm's internal R&D efforts is an important predictor of the absorptive capacity of the firm.

Based on these insights, several scholars have started examining the interaction between external and internal R&D efforts. Cassiman & Veugelers (2006), for example, provided evidence for a significant interaction effect between internal and external R&D efforts. They stated that "acquiring external know-how is found to significantly increase innovative performance only when the firm at the same time is engaged in internal R&D activities" (Cassiman & Veugelers 2006, p. 25). They claimed that "own R&D activities are highly

correlated with external technology acquisition" (Cassiman & Veugelers 2006, pp. 25-26), because a certain level of internal R&D efforts is necessary to screen available projects. Moreover, in 2003 they even found evidence for the moderating impact of performing own R&D on the relation between cooperation with universities and innovation performance (Veugelers & Cassiman 2003).

Other scholars argue that internal R&D investment is the creation of firm-specific knowledge that makes a firm more capable to screen, evaluate and utilize externally generated knowledge (Rotaermel & Alexandre, 2009). It enables a firm to synthesize and apply current and acquired knowledge. "An adequate level of absorptive capacity tends to not only be more sensitive to opportunities that present themselves in their technological environments, but also more proactive in exploiting those opportunities" (Rotaermel & Alexandre 2009, p. 764).

In line with Cohen & Levinthal (1990), we expect that the 'absorptive capacity' of the firm is an important factor for the utilization of external knowledge. Since we know that internal R&D efforts positively affect a firms' absorptive capacity (Veugelers & Cassiman, 2003; Rotaermel & Alexandre, 2009; Faems, 2010), we formulated the following hypothesis:

H3a: A firms' internal R&D efforts positively moderates the relationship between customer collaboration and new-to-the-firm innovation performance in such a way that the positive effect of customer collaboration is stronger when the firm possesses higher levels of internal R&D efforts.

Since we expect that the value of collaboration with customers during the new-to-the-market product development process is limited (Lundkvist & Yakhlef, 2004; Enkel et al., 2005), we do not expect that the 'absorptive capacity' of a firm can be used as a tool for the utilization of knowledge with regard to new-to-the-market innovation performance. Customers do have a limited domain of expertise about products that are new to the market, so the utilization of knowledge is not possible in such cases. Therefore, we formulated the following hypothesis:

H3b: A firms' internal R&D efforts does not moderates the relationship between customer collaboration and new-to-the-market innovation performance.

3. RESEARCH METHODOLOGY

Sample

To test our hypothesis, we needed information on collaboration with customers, innovation performance and internal R&D efforts of firms. All of this data is collected out of the fourth Flemish Community of Innovation survey (CIS IV). This innovation survey provided quantitative data about the innovation behaviour of private organizations. A sample of 2075 Belgian manufacturing firms was selected to participate in the CIS IV. A 20-page questionnaire was sent out to them, with questions about their innovation behaviour and innovation performance. In total, 888 firms responded to the questionnaire, resulting in a 42,8% response rate. For this study, we needed only firms that had introduced at least one new product or process innovation between 2004 and 2006 or that had initiated innovation activities between 2004 and 2006. For that reason, the analysis is restricted to a sample of 526 manufacturing firms. Because we had to deal with missing values on some of the variables of our model, the size of our sample was further restricted. In total, the sample of this study consists of 305 firms.

Measures

This study includes two dependent variables (new-to-the-firm innovation performance and new-to-the-market innovation performance), one independent variable (customer collaboration in new product development) and one moderating variable (internal R&D efforts). Moreover, we included several control variables to control for possible confounding effects.

Innovation performance

In line with previous research on the consequences of innovation performance by external collaboration (Enkel et al., 2005; Belderbos et al., 2004; Faems 2010), we made a distinction between two kinds of innovation performance. We measured both, new-to-the-market and new-to-the-firm innovation performance. In the CIS IV survey, respondents had to indicate the proportion of turnover in 2006, attributed to new or strongly improved products that the company introduced between 2004 and 2006 and that were new to the market. This proportion is used as new-to-the-market innovation performance. New-to-the firm innovation performance is measured as the proportion of turnover in 2006, attributed to new or strongly improved products that the company introduced between 2004 and 2006 and that were new to

the firm. In order to gain a normal distribution, the analyses do not make use of the percentages itself, but instead the natural logarithm of 1 + the percentages.

Customer collaboration in new product development

Customer collaboration in new product development is the independent variable in our study. In the CIS IV survey, respondents had to indicate whether or not they collaborated with customers in R&D or other innovation-related projects between 2004 and 2006. Based on this information, a dummy variable is created. This variable received the value of 1 when respondents indicated that there was collaboration with customers and the value of 0 when such collaboration was lacking.

Internal R&D efforts

Internal R&D efforts is the moderating variable in our research. In the CIS IV survey, respondents had to indicate both the total number of employees and the number of employees that were employed in order to support internal R&D activities. We considered the relative number of R&D employees (i.e. the ratio of employees that were employed in order to support internal R&D activities by the total number of employees) as the measurement of the firms' internal R&D efforts. The variable internal R&D efforts is the average of the relative number of R&D employees in 2004 and in 2006.

Control variables

We included 5 control variables in our study to control for possible confounding effects. The control variables are: firm size, industry, subsidiary, appropriation effort and collaboration with others.

The relationship between size and performance has been a debate for a long time (Elliott, 1972; Acs & Audretsch, 1986; Vaona & Pianta, 2006). Since we know that there might be a relationship between firm size and performance, we included the variable 'firm size' to control for this possible effect. This variable is measured by the average of the total number of employees in 2004 and 2006. In order to obtain a normal distribution, the analyses do not make use of the values itself, but instead the natural logarithm of this values.

Because of the potential performance variance of different industries (Powell, 1996), we included several industry dummy variables as our second control variable. We made a distinction between 10 different industries. Table 1 provides an overview of the frequencies of the different industries.

----- Insert Table 1 about here ----

The fact whether or not a firm is part of a holding might affect the firms innovation performance. Deeds & Hill (1996), for instance, found evidence for a positive significant relationship between subsidiaries and innovation performance. To control for this effect, we included the dummy variable 'subsidiary' as our third control variable. This variable received the value of 1 when the firm is a subsidiary of another firm and the value of 0 when this is not the case.

Firms with superior and unique technological competencies tend to perform at a higher level than firms without superior and unique competencies (McEvily et al., 2004). Protection is the process by which firms sustain the uniqueness and value of their technological competencies (McEvily et al., 2004, P. 714). Since we know that the protection of innovations sustain the uniqueness, and so might affect the performance of the firm, we wanted to control for innovation protection. Therefore, this study included the variable 'appropriation effort', indicating whether the organization filed for at least one patent between 2004 and 2006.

Since companies can not only engage in collaboration with customers, but also in collaboration with other external partners like competitors, suppliers or universities, we included collaboration with other extern partners as our last control variable. In fact, there is evidence that alternative types of collaboration could affect innovation performance (Veugelers & Cassiman, 2003; Belderbos et al., 2004; Faems, 2010). Therefore, we controlled for the presence of collaboration with other external partners. In the CIS IV, respondents had to indicate whether they collaborate with suppliers, customers, competitors, consultants, universities and the government between 2004 and 2006. Based on this information, we included the dummy variable 'collaboration with others' as the total number of presented collaboration types between 2004 and 2006 next to customer collaboration.

4. RESULTS

Descriptive statistics

Table 2 gives an overview of the most important descriptive statistics. The means for our dependent variables new-to-the-market and new-to-the-firm innovation performance are 0.08 and 0.06. Taking into account that this study makes use of logarithmic transformations for these variables, the average turnover rate, attributed to new or strongly improved products that the company introduced between 2004 and 2006 and that were new to the market, is 8.11%. The average turnover rate, attributed to new or strongly improved products that the company introduced between 2004 and 2006 and that were new to the firm, is 9.20%. Because the variable 'R&D efforts' is centered, table 2 shows a mean of 0. The implication is that, on average, 7.24% of the total number of employees is employed in order to support internal R&D activities. The mean for the variable 'customer collaboration' is 38.4%, which means that 117 out of the 305 firms did engage in customer collaboration between 2004 and 2006.

----- Insert Table 2 about here ----

To test our hypotheses, we used ordinary least squares (OLS) analysis. This statistical technique is appropriate for testing the main effect, as well as the interaction effect. Table 3 summarizes the main findings of the OLS analysis.

----- Insert Table 3 about here ----

Customer collaboration in new product development

H1 hypothesized that customer collaboration during new product development does have a positive influence on the new-to-the-firm innovation performance. Table 3, model 1 shows that customer collaboration does indeed have a positive significant impact on new-to-the-firm innovation performance ($p<0.01$). This is in line with other scholars (Salomo, 2003; Gruner & Homburg 2000), who also found a positive significant effect. H2 hypothesized that customer collaboration during new product development does not have any influence on the new-to-the-market innovation performance. This hypothesis is supported by our data as we did not find any significant effect for the relationship between customer collaboration and new-to-the-market innovation performance.

Moderating impact of R&D intensity

Relying on the absorptive capacity theory (Cohen & Levinthal 1990), H3a hypothesized that a firms' internal R&D efforts moderates the relationship between customer collaboration and new-to-the-firm innovation performance. Table 3, model 2 shows no significant interaction effect. On the other hand, H3b hypothesized that a firms' internal R&D efforts does not moderate the relationship between customer collaboration and new-to-the-market innovation performance. Surprisingly, our data suggests a positive interaction effect with regard to new-to-the-market innovation performance ($p<0.01$).

For probing this interaction effect, we used the Johnson-Neyman technique (Hayes & Matthes, 2009). This technique allows us to "indentify regions in the range of the moderator variable where the effect of the focal predictor on the outcome is statistically significant and not significant" (Hayes & Matthes 2009, pp. 924-925). Moreover, this technique allows us to interpret the interaction with a visual depiction of the interaction. Table 4 gives on overview of the significance interaction regions with regard to new-to-the-market innovation performance. Table 4 shows that the effect of the focal predictor on the outcome is statistically significant for an internal R&D level of .22 or higher. This means that there is a positive interaction between customer collaboration and internal R&D efforts on new-to-the-market innovation performance, only when at least 22% of the employees are employed in order to support internal R&D activities.

----- Insert Table 4 about here ----

Figure 2 is a visual depiction of the interaction between customer collaboration and internal R&D efforts for the new-to-the-market innovation performance. This figure shows that, when a firm is engaged in customer collaboration, a higher level of R&D intensity provides a higher level of new-to-the-market innovation performance.

----- Insert figure 2 about here ----

Because we had to deal with two possible correlating dependent variables, we did an additional test to control for this correlation. A General Linear Model (GLM) multivariate analysis provides regression analysis and analysis of variance for multiple correlating

dependent variables. The results of our GLM analysis (see table 5) correspond with the results of our OLS analysis. Therefore, this finding can support our conclusion.

----- Insert Table 5 about here ----

5. DISCUSSION AND CONCLUSION

In this section, we will point out the main findings of our study. Moreover, we will present both, the theoretical as well as the managerial implications of our findings. We will finish with the main limitations of our study and directions for interesting future research.

Main findings

In this study, we tried to find empirical evidence for the relationship between customer collaboration and innovation performance and the moderating impact of a firms' internal R&D efforts. Based on previous studies (Salomo, 2003; Gruner & Homburg, 2000; O'Conner, 1998; lundkvist & Yakhlef, 2004), we developed hypothesis in which we stated that customer collaboration does have a positive influence on new-to-the-firm innovation performance (H1), but does not have any influence on new-to-the-market innovation performance (H2). The first hypothesis has been confirmed. Collaboration with customers is positively associated with a higher level of turnover attributed to new or strongly improved products that were new to the firm. It seems that customers can help to improve products with which they are familiar, by supporting the identification of their needs and the translation of this information into improved products. Moreover, customers collaboration could be an entrance to new resources and capabilities. Since we found no direct relationship between customer collaboration and new-to-the-market innovation performance, our second hypothesis is also supported.

Based on the absorptive capacity theory (Cohen & Levinthal 1990), we expected a positive moderating influence of a firms' internal R&D efforts on the relationship between customer collaboration and new-to-the-firm innovation performance (H3a). Surprisingly, we did not find evidence for this positive interaction effect. On the other hand, we did not expect a moderating influence of a firms' internal R&D efforts on the relationship between customer collaboration and new-to-the-market innovation performance (H3b). Unexpectedly, we did

find a positive interaction effect here. By using the Johnson-Neyman technique for probing this interaction effect, we found that the interaction effect between customer collaboration and a firms' internal R&D efforts on new-to-the-market innovation performance is only significant when the level of a firms' internal R&D efforts is at least 0.22. Therefore, collaboration with customers is positively associated with a higher level of turnover attributed to new or strongly improved products that were new to the market, only when at least 22% of the employees are employed in order to support internal R&D activities.

A possible explanation for this unexpected interaction effect could be that the interaction effect between internal R&D efforts and customer collaboration can differ during the different phases of the design process. Kaulio (1998) identified five different phases of the design process. We expect that collaboration with customers could results into a higher level of new-to-the-market innovation performance, only when a firm uses this collaboration as, for instance, input during the specification phase of the development process. A firm should have sufficient internal R&D efforts to continue the next phases of the development process without customers. Moreover, a firm can use customers collaboration during the prototyping phase. In that way, a firm should have sufficient internal R&D efforts to proceed the development process without customers, until the prototyping phases. Since this study did not make any distinction between customer collaboration during the different stages of the new product development process, we could not find evidence for this statement.

Another possible explanation could be that the interaction effect between internal R&D efforts and customer collaboration can differ under different types of customer collaboration. Kaulio (1998) defined three categories of customer collaboration. These categories are 'design for customers', 'design with customers' and 'design by customers'. The first type of customer collaboration (design for customers) results into a higher level of internal R&D efforts, because "the firm designs and is the leading actor" (Kaulio 1998, p. 147). In such cases, customer collaboration could results into a higher level of new-to-the-market innovation performance, because customers are not used on account of their technological capabilities. "Customers are more or less objects from which it is possible to elicitate general requirements" (Kaulio 1998, p. 147), which might be useful during the development of products that are new to the market. Since this type of customer collaboration goes hand in hand with a higher level of internal R&D efforts, a positive interaction effect is conceivable.

Since this study did not make any distinction between different types of customer collaboration, we could not find evidence for this statement.

Theoretical implication

Since several years, companies are shifting from a closed to a more open innovation model as a way to develop new products or processes (Chesbroug, 2003). Therefore, there is an increased number of papers about the impact of collaboration with external partners on innovation performance (for an overview, see de Man & Duysters, 2005) and similarly on the explicit collaboration with customers during new product development (for an overview, see Bogers et al., 2010). But, previous studies delivered mixed findings. In this study we have developed and tested a conceptual model in order to clarify these mixed findings. This study contributes to the customer collaboration literature in two ways.

Acknowledging the multi-dimensional nature of innovation performance

Since innovation performance does have a multi-dimensional nature, not all new product development processes should be managed similarly. Many studies in the field of open innovation make use of this theory by separate the variable innovation performance into two different variables: new-to-the-market innovation performance and new-to-the-firm innovation performance. However, this distinction is very scarce with respect to studies in the field of the explicit collaboration with customers during new product development. Our study suggest different impacts of collaboration with customers for different kinds of innovations. In particular, we observed a positive relationship between collaboration with customers and new-to-the-firm innovation performance but we did not find any direct relationship at all for collaboration with customers and new-to-the-market innovation performance. In this way, our study supports to the explanation of the contradictory findings of previous studies by distinguishing different kinds of innovations.

Acknowledging the connection between internal and external innovation activities.

Although much has been written in the field of collaboration with customer during new product development, most researchers ignored the possible interaction effect between internal and external innovation activities. In his open innovation model, Chesbrough (2003) already refers to the expected connection between internal and external R&D efforts. In previous studies, a firms' internal R&D efforts is frequently named as antecedent of external collaboration (Kleinknecht & Reijnen 1992; Colombo & Garrone 1996; Fritsch & Lukas

2001), but the focus on the possible moderating impact of internal R&D effort on the relationship between external collaboration and innovation performance is very scare. However, our study suggest the existence of a partial interaction effect between internal and external R&D efforts. In particular, we observed an indirect relationship between collaboration with customers and new-to-the-market innovation performance via internal R&D efforts. In this way, our study supports to the explanation of the contradictory findings of previous studies by making use of a moderating variable.

Managerial implications

Based on the findings of our study, we developed some managerial recommendations. First of all, our findings suggest that managers have to rely on collaboration with customers for the purpose of developing products that are new to the firm. At the same time, our findings suggest that collaboration with customers for the purpose of developing products that are new to the market is only appropriate when a firms meets sufficient internal R&D efforts. The implication is that firms should engage in customer collaboration for the development of products that are new to the market, only when at least 22% off the employees are employed in order to support internal R&D activities.

Limitations and future research

Despite of the great care taken at every stage of this study, there are several limitations that need to be taken into account by interpreting the findings. First, by choosing to focus on the CIS IV database, there is a danger to generalize our findings to other industries or other countries. Our results can only be applied to the setting of Belgian manufacturing firms. We need future research in other settings to generalize our findings to a broader perspective.

Our second limitation has to deal with the operationalization of our dependent variables. We measured 'innovation performance' as the proportion of turnover in 2006, attributed to new or strongly improved products that the company introduced between 2004 and 2006. Although we think that this time-frame is adequate to measure the innovation performance, we are aware of the fact that this time-frame might be too short. New introduced products in 2006 might affect the turnover only after 2006. We therefore suggest future research to increase this time-frame. Moreover, we only measured the proportion of turnover, attributed to new or strongly improved products, as innovation performance. Future research could use other measuring instruments like the relative number of new or strongly improved products, the

product development cycle time of the innovation or the rate between successful and unsuccessful innovation projects to measure innovation performance

Thirdly, we could not control for past product innovation performance, while pas product innovation performance might affect the current innovation performance. Moreover, we could not control for experience with customer collaboration. As a result, we could not assess how previous customer collaboration and past product innovation performance might influence a firms' innovation performance. Future research could control for these effects

Another limitation is that we did not distinguish different intensity levels of customer collaboration. Gruner & Homburg (2000) find support for the proposition that the intensity of customer interaction in the new product development process has a positive impact on new product success. Besides, we did not distinguish different types of customers, while the characteristics of the involved customers could have significant effects on innovation performances (Gruner & Homburg 2000). Moreover, we did not distinguish different forms of customer collaboration. According to Kaulio (1998), different forms of customer collaboration will have different results. Since we measured neither the intensity of collaboration with customer and the different types of customers, nor the different forms of customer collaboration, future research could elaborate on this.

In addition, we made no distinction between the development of different types of products. It is plausible that, for the development of mass-produced goods, customer collaboration is less attractive than for the development of customized goods. Future research could control for this distinction.

Finally, we made no distinction between the different stages of the new product development process. Previous research found evidence that customer collaboration during different stages of the new product development process has different impacts on the innovation performance of the firm (Kaulio, 1998; Enkel et al, 2005). We therefore encourage scholars to examine the moderating impact of internal R&D efforts during the different stages of the new product development process.

Despite these limitations, we believe that our research has provided interesting insights in the field of customer collaboration during the new product development process. We hope that our study can help manager to improve their innovation performance by engaging in collaboration with customers. Moreover, we hope that our suggestions for future research will trigger scholars in future examining the interaction between a firms internal R&D efforts and the collaboration with customers.

REFERENCES

Acs, Z., & Audretsch, D. (1987). Innovation in large and small firms. *Economics Letters , 23*, 109-112.

Athaide, G. A., Meyers, P., & Wilemon, D. (1996). Seller-Buyer interactions during the commercialization of technological process innovations. *Journal of product innovation management , 13*, 402-421.

Belderbos, R., Carree, M., & Lokshin, B. (2004). Cooperative R&D and firm performance. *Research Policy , 33*, 1477–1492.

Bogers, M., Afuah, A., & Bastian, B. (2010). Users as Innovators: A Review, Critique, and Future Research Directions. *Journal of Management , 36* (4), 857-875.

Campbell, A., & Cooper, R. (1999). Do customer partnerships improve new product success rates? *28* (1), 507-519.

Cassiman, B., & Veugelers, R. (2004). In search of complementarity in the innovation strategy: internal R&D and external knowledge acquisition. 1-38.

Chesbrough, H. (2003). *Open innovation.* Cambridge: Harvard University Press.

Christensen, C., & Overdorf, M. (2000). Meeting the challenge of disruptive change. *Harvard Business Review* (April), 67-75.

Cohen, W., & Levinthal, A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly , 35* (1), 128-152.

Colombo, M., & Garrone, P. (1996). Technological cooperative agreements and firm's R & D intensity. A note of causality relations. *Research Policy , 25*, 923-932.

Condit, P. M. (1994). Focusing on the customer: How Boeing does it. *Research Technology Management , 34* (1), 33-34.

De man, A., & Duysters, G. (2003). *Collaboration and innovation: a review of the effects of mergers,.*

Deeds, D., & Hill, C. (1996). Strategic alliances and the rate of new product development: an emperical study of entrepreneurial biotechnology firms. *Journal of Business Venturing , 11*, 41-55.

Dewar, R., & Dutton, J. (1987). The adoption of radical and incremental innovations: an empirical analysis. *Management science , 32*, 1422-1433.

Elliott, J. (1972). Control, size, growth, and financial performance in the firm. *The Journal of Financial and Quantitative Analysis , 7* (1), 1309-1320.

Enkel, E., Kaush, C., & Gassmann, O. (2005). Managing the risk of customer integration. *European management journal , 23* (2), 203-213.

Enkel, E., Perez-Freije, J., & Gassmann, O. (2005). Minimizing market risks through customer integration in new product development: learning from bad practice. *The authors journal compilation , 14* (4), 425-437.

Faems, D. (2010). Competitor collaboration and innovation performance: exploring the moderating impact of internal R&D efforts. 1-29.

Faems, D., Van Looy, B., & Debackere, K. (2005). Interorganizational Collaboration and Innovation: toward a portfolio approach. *Journal of product innovation management , 22*, 238–250.

Fritsch, M., & Lukas, R. (2001). Who cooperates on R&D? *Research Policy , 30*, 297–312.

Grassmann, O., & Enkel, E. (2004). Towards a theory of open innovation: Three core process archetypes. *Institute of Technology Management* , 1-18.

Gruner, E., & Homburg, C. (2000). Does customer interaction enhance new success. *Journal of business research , 49*, 1-14.

Hayes, A., & Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior research methods , 41* (3), 924-936.

Kaulio, M. (1998). Customer, consumer and user involvement in product development: A framework and a review of selected methods. *Total quality management & business excellence , 9* (1), 141-149.

Kaulio, M. (1998). Customer, consumer and user involvement in product development: A framework and a review of selected methods. *Total Quality Management & Business Excellence , 9* (1), 141-149.

Kleinknecht, A., & Reijnen, J. (1992). Why do firms cooperate on R&D? An empirical study. *Research Policy , 21*, 347-360.

Kohli, A., & Jaworski, B. (1990). Market orientation: The construct, reserach proposition, and managerial implications. *Journal of marketing , 54*, 1-18.

Lengnick-Hall, C. (1996). Customer contributions to quality: A different view of the cutomer-oriented firm. *The academy of management review , 21* (3), 791-824.

Lundkvist, A., & Yakhlef, A. (2004). Customer involvement in new service development: a conversational approach. *Managing Service Quality , 14*, 249-257.

MacCormack, A., Verganti, R., & Iansiti, M. (2001). Developing products on "internet time": The anatomy of a flexible development process. *Management science , 47* (1), 133-150.

Martin, J. (1995). Ignore your customers. *Fortune* (May 1), 87-90.

McEvily, S., Eisenhardt, K., & Prescott, J. (2004). Guest editors' introduction to the special issue: The global acquisition, leverage, and protection of technological competencies. *Strategic Management Journal , 25* (8/9), 713-722.

Nambisan, S. (2002). Designing virtual customer environments for new product development: Toward a theory. *The academy of management review , 27* (3), 392-413.

O'Conner, G. (1998). Market learning and radical innovation: A cross case comparison of eight radical innovation projects. *Journal of product innovation management , 15*, 151-166.

Powell, T. (1996). How Much Does Industry Matter? An Alternative Empirical Test. *Strategic Management Journal, , 17* (4), 323-334.

Reukert, R. W., & Walker, O. C. (1987). Marketing interaction with other functional units: A conceptual framework and emperical evidence. *Journal of marketing , 51*, 1-19.

Ritter, T., & Walter, A. (2003). Relationship specific antecedents of customer involvement in new product development. *International journal of technology management , 26* (5), 482-498.

Rothaermel, F., & Alexandre, M. (2009). Ambidexterity in technology sourcing: The moderating role of absorptive capacity. *Organization Science , 20* (4), 759-780.

Salomo, S., Steinhoff, F., & Trommsdorff, V. (2003). Customer orientation in innovation projects and new product development success - the moderating effect of product innovativeness. *International journal of technology management , 26* (5/6), 442-463.

Sherman, J., Souder, W., & Jenssen, S. (2000). Differential effects of the primary forms of cross functional integration on product development cycle time. *Journal of product innovation management , 17*, 257-267.

Vaona, A., & Pianta, M. (2006). Firm size and innovation in European manufacturing. *Kiel Working Paper* (1284).

Veugelers, R., & Cassiman, B. (2003). R&D Cooperation between Firms and Universities: Some empirical evidence from Belgian manufacturing*. *nternational Journal of Industrial Organization* , 1-29.

von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management science , 32* (7), 791-805.

Von Hippel, R. (1976). The dominant role of users in the scientific instrument innovation process. *Reseach policy , 5*, 212-239.

Figure 1: Theoretical framework

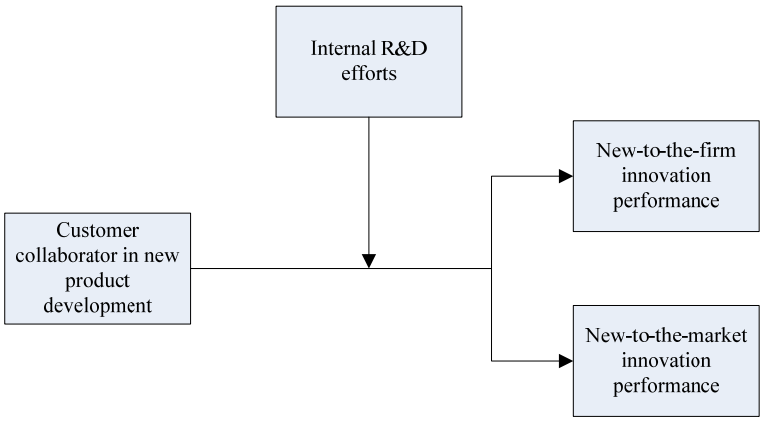

Table 1: Industry frequencies

Industry	Frequency	Percentage
Chemicals and pharmaceuticals industry	*72*	*23.6%*
Electrical equipment industry	*35*	*11.5%*
Machines industry	*33*	*10.8%*
Metals and manufacturing industry	*40*	*13.1%*
Textile fur leather industry	*23*	*7.5%*
Transport industry	*20*	*6.6%*
Wood and paper industry	*11*	*3.6%*
Furniture industry	*9*	*3.0%*
Food, beverages and tobacco industry	*45*	*14.8%*
Other industries	*17*	*5.6%*

Table 2: Descriptive statistics and correlations
(* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level)

Variable	Mean	SD	New-to-the-firm innovation performance	New-to-the-market innovation performance	R&D intensity	Size
New-to-the-firm innovation performance	0.07	0.11	1.00			
New-to-the-market innovation performance	0.06	0.10	0.09	1.00		
R&D intensity	0.00	0.11	0.08	0.25**	1.00	
Size	4.86	1.51	0.09	0.09	-0.13*	1.00

Table 3: Overview results OLS analyses
(* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level)

	Model 1		**Model 2**	
	New-to-the-firm innovation performance	*New-to-the-market innovation performance*	*New-to-the-firm innovation performance*	*New-to-the-market innovation performance*
(Constant)	0.02	0.03	0.02	0.02
Customer collaboration	0.05**	-0.01	0.02**	-0.01
Internal R&D efforts	0.06	0.16**	0.09	0.03
Size	0.00	0.00	0.01	0.00
Appropriation effort	0.00	0.03*	0.00	0.02
Subsidiary	-0.02	0.01	-0.02	0.01
Collaboration with others	-0.00	0.00	-0.00	0.00
Chemicals and pharmaceuticals industry	0.04	-0.02	0.04	-0.01
Electrical equipment industry	0.06	0.05	0.06	0.05
Machines industry	0.04	0.04	0.04	0.04
Metals and manufacturing industry	0.01	-0.02	0.01	-0.01
Textile, fur and lather industry	0.05	-0.01	0.05	0.00
Transport industry	0.07	0.02	0.07	0.03
Wood and paper industry	0.00	0.00	-0.00	0.01
Food, beverages and tobacco industry	0.02	0.02	0.02	0.02
Furniture industry	0.05	0.01	0.05	0.01
Interaction (Customer collaboration * Internal R&D efforts)			-0.05	0.30**
Number of observations	303	304	303	304
R-squared	0.09	0.15	0.09	0.18

Table 4: Regions of significance

R&D intensity	b	se	t	p	LLCI(b)	ULCI(b)
0.00	-0.03	0.02	-1.82	0.07	-0.05	0.00
0.05	-0.01	0.01	-0.94	0.34	-0.04	0.01
0.10	0.00	0.01	0.12	0.90	-0.03	0.03
0.15	0.02	0.02	1.08	0.28	-0.01	0.05
0.20	0.03	0.02	1.74	0.08	-0.00	0.07
0.22	0.04	0.02	1.97	0.05	0.00	0.08
0.25	0.05	0.02	2.16	0.03	0.00	0.09
0.30	0.06	0.03	2.42	0.02	0.01	0.11
0.35	0.08	0.03	2.59	0.01	0.02	0.13
0.40	0.09	0.03	2.70	0.01	0.02	0.16
0.45	0.11	0.04	2.78	0.01	0.03	0.18
0.50	0.12	0.04	2.84	0.00	0.04	0.21
0.55	0.14	0.05	2.88	0.00	0.04	0.23
0.60	0.15	0.05	2.91	0.00	0.05	0.25
0.65	0.17	0.06	2.94	0.00	0.05	0.28
0.70	0.18	0.06	2.96	0.00	0.06	0.30
0.75	0.20	0.07	2.98	0.00	0.07	0.33
0.80	0.21	0.07	2.99	0.00	0.07	0.35
0.85	0.23	0.08	3.00	0.00	0.08	0.37
0.90	0.24	0.08	3.01	0.00	0.08	0.40
0.95	0.26	0.08	3.02	0.00	0.09	0.42
1.00	0.27	0.09	3.03	0.00	0.10	0.45

Figure 2: Visualization of the interaction

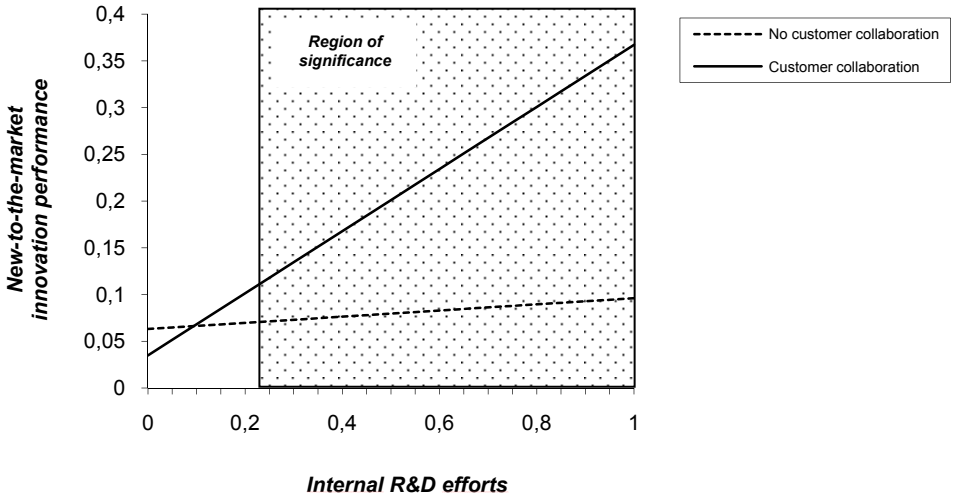

Table 5: Overview results GLM multivariate analyses
(* Correlation is significant at the 0.05 level; ** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.001 level)**

	Model 1		Model 2	
	New-to-the-firm innovation performance	*New-to-the-market innovation performance*	*New-to-the-firm innovation performance*	*New-to-the-market innovation performance*
Intercept	0.02	0.03	0.05*	0.01
Customer collaboration	0.11**	0.00	0.10**	0.01
Internal R&D efforts	0.01	0.09***	0.01	0.12***
Size	0.01	0.01	0.01	0.00
Appropriation effort	0.00	0.02	0.00	0.02
Subsidiary	0.01	0.01	0.01	0.01
Collaboration with others	0.01	0.01	0.03	0.06
Chemicals and pharmaceuticals industry	0.02	0.00	0.02	0.00
Electrical equipment industry	0.03	0.02	0.03	0.02
Machines industry	0.02	0.02	0.02	0.02
Metals and manufacturing industry	0.00	0.00	0.00	0.00
Textile, fur and lather industry	0.03	0.00	0.03	0.00
Transport industry	0.04	0.00	0.04	0.01
Wood and paper industry	0.00	0.00	0.00	0.00
Food, beverages and tobacco industry	0.01	0.01	0.01	0.01
Furniture industry	0.01	0.00	0.02	0.00
Interaction (Customer collaboration * Internal R&D efforts)			0.00	0.08**
Number of observations	303	303	303	303
R-squared	0.09	0.17	0.08	0.15