# Collaboration scope and product innovation in B2B Markets: Are there too many cooks or is it the customer who spoils the broth?


## ABSTRACT

**Purpose:** Product innovations are often the result of combinations of internal and external knowledge. A significant amount of Open Innovation literature has argued that working with external partners can be beneficial, in particular when this is complemented by internal R&D yet a wholesale shift to Open Innovation has not occurred. Our work demonstrates two new limits of openness, grounded in attention-based theory, that help explain why such a shift has not occurred. We argue that specific combinations of *identities* a firm collaborates with, i.e., whether a partner is classified as a customer, supplier, competitor, or university and/or technological center predictably increase and decrease product innovation.

**Findings:** We observe positive effects of customer collaboration, partner scope (collaboration with other outside identities), and internal R&D when considered separately. Critically, we observe two important situations where these positive effects are reduced. First, we argue and observe that when customers are added to the mix of identities, diminished returns on product innovation results. Second, we argue and observe that technological customer collaboration reduces the benefits from an internal R&D department (more than collaboration with other identities). Our findings are robust in that singling out another partner identity does not reveal such patterns.

**Design/Methodology/Approach**: We demonstrate these findings using econometric techniques on a large-scale panel dataset, comprising 14,682 observations.

**Research implications**: Our findings stress the importance of considering the identity of collaborating parties in studying the impact of openness on innovation success. We

conceptually and empirically reject the–implicitly held–assumption in the literature that different partners provide similar benefits and are interchangeable.

**Practical Implications**: We propose new limits to the "open innovation" literature. As identities are easy to observe by managers and are shown to impact product innovation, we argue they are highly relevant to managerial decision-making. We also observe, through counterfactual analysis, that attention limits are critical as a theoretical setting of no attention limits would significantly lift product innovations.

**Originality/value:** We show important limitations to the Open Innovation literature by showing that customer collaboration leads to declining rates of product innovation when combined with greater collaboration scope or the internal R&D department. We add the novel insight that customer collaboration weakens the positive effect of collaboration scope and internal R&D on product innovations.

Keywords: Customer collaboration, Collaboration scope, Product innovation, R&D

## INTRODUCTION

To create product innovations, products significantly different from those produced earlier, firms in business-to-business (B2B) contexts often collaborate technologically with outside partners. Past research, typically under the aegis of the "Open Innovation" paradigm, has suggested that these outside partners usefully contribute to product innovation, whether these are customers, (e.g., Noordhoff *et al*., 2011), suppliers (Raassens *et al*., 2012), or other partners (Cui and O'Connor, 2012). Furthermore, Cassiman and Veugelers (2006) showed that these outside partners can effectively leverage collaborations with internal R&D.

However, not all these "open innovation" strategies appear equally successful, something that might underpin the observation of Love *et al*. (2014) that there is little evidence of a broad shift towards the joint use of internal and external knowledge in innovation. Past work has documented some challenges in collaboration strategies. For example, "macro" focused work argued that too much diversity or scope can be detrimental to innovation (e.g., Laursen and Salter, 2006; Mooi *et al*., 2016) but such work does not specifically focus on customers while more "micro" focused work, such as by Noordhoff *et al*. (2011) shows that collaborations between different partner identities such as customers and suppliers can be problematic due to misaligned incentives or opportunism. This line of work does not account for R&D or other collaborations. Yet, in "open innovation" strategies the internal R&D department may not "mix" well with collaboration with customers or other identities.

In this paper, we argue that difficulties to create product innovations arise due to critical variation in the identities of the external partners a firm draws on and the challenges that this generates in terms of focusing time and effort by the focal organization as reflected in the number of product innovations. We measure innovation as the number of product

innovations a firm produces[1] and focus on technological collaborations with external partners in a B2B context,[2] one of the key research priorities in B2B as identified by the Institute for the Study of Business Markets (ISBM, 2021). We distinguish four possible identities of external partners: customer, supplier, competitor, and university and/or technological center. Thus, if a firm collaborates with a supplier and a university, the firm collaborates with two external identities. We ascribe a particular role to *customer collaboration*, i.e., technological collaboration with customers, and we refer to the number of other identities a firm technologically collaborates with as *collaboration scope*. The central problem that we study is whether the number of product innovations predictably correlates with combinations of customer collaboration, collaborations with other external partner identities, and the internal R&D department.

We draw on the attention-based theory (Ocasio, 1997, p189), which defines attention as the noticing, encoding, interpreting, and focusing of time and effort by organizational decision-makers on issues and answers to hypothesize that customer collaboration reduces 1) the positive effect of collaboration scope on the number of product innovations, 2) reduces the positive effect of the internal R&D department on the number of product innovations, and 3) that the positive effect of the internal R&D department on the number of product innovations weakens more by customer collaboration than by collaboration scope. We test our hypotheses on a large-scale panel dataset, comprising 2,994 firms for the period of 1998–2006 and covering the entire Spanish manufacturing industry. Because the traditional "conditional negative binomial model for panel data, (…) is not a true fixed-effects method"

[1] We note that whereas several previous studies have focused on the (financial) success of product innovations, the number of product innovations is a particularly useful metric as it is the direct result of a firm's actions and does not confound the introduction of a new product and its success, which is influenced by many factors and may only be observed after many years. As such product innovation is a more proximal indicator of the processes we argue for.

[2] Co-creation is one of the potential forms of the observed technological collaborations with external partners. We note that given our focus on technological collaboration, we purposely restrict the focus to B2B as consumers are highly unlikely to be partners to organizations when it comes to addressing or solving technological aspects.

(Allison, 2009), we adopt the econometric procedure introduced by Blundell *et al*. (1999) to control for unobserved heterogeneity and resulting endogeneity. In doing so, this study is among the first to provide large-scale and robust empirical evidence on the innovation effects of collaborations with external partners while controlling for unobserved heterogeneity.

Our empirical results support our hypothesizing. Customer collaboration is associated with a strong increase in the number of product innovations; however, it also reduces the benefits of collaboration scope. We show a positive effect of having an internal R&D department on the number of product innovations but also find that the internal R&D department has a reduced effect on product innovations when combined with customer collaboration. Yet no such effect can be discerned for other identities. These findings provide key insights into the limits of the open innovation paradigm. Overall, the three critical elements of the open innovation paradigm; customer collaboration, partner scope, and internal R&D are individually beneficial to the number of product innovations, but combined reliance can significantly reduce their marginal benefits.

Our theory and findings provide several key contributions. Academics have produced considerable evidence establishing the reasons for collaboration (e.g., Noordhoff *et al*., 2011), but have spent far less effort theorizing and collecting evidence on the limits of openness. We develop middle range theory and show that an important reason is to be found in the identity of the partners. We demonstrate that the identities of the collaboration partners are critical. Specifically, by counting the number of involved identities, as previous papers have done (e.g., Laursen and Salter, 2006; Mooi *et al*., 2016) one assumes that these identities can be exchanged. This assumption can be problematic because, as we show, some combinations of identities promote product innovation whereas other combinations reduce the respective benefits these identities provide. In Table 1 we document how the current paper advances our understanding beyond these, and other, key papers. As we document, our

key insights are based on 1) differential effects of partner identities, 2) our focus on customer effects on innovation, 3) our empirical evidence, and 4) our ability to account for unobserved heterogeneity.

Next, we rely on attention-based theory (Ocasio, 1997) to develop a theoretical grounding for our hypotheses. We then introduce our data and methodology. We end with a discussion of our findings and implications for scholars and practitioners.

-- Insert Table 1 about here --

## THEORETICAL FRAMEWORK

### Product innovation and attention

Prior literature has ascribed significant benefit to collaborating with external partners, whether these are customers (Noordhoff *et al*., 2011), suppliers (Raassens *et al*., 2012), or any other type of partner (Cui and O'Connor, 2012). However, key work has also alluded to important limitations. For example, Laursen and Salter (2006) suggest that the marginal returns to working with outside parties increase when moving from low to medium levels of partner scope but diminish or even decrease when partner scope increases further. Limitations have also been observed for the combination of collaborations with external partners and internal R&D: key work such as Laursen and Salter (2006) and Audretsch *et al*. (1996) observed a negative interaction between internal R&D and collaboration on innovation.

We approach the potential limitations of technological collaborations with external partners in a B2B context through the lens of attention-based theory, which focuses on the noticing, encoding, interpreting, and focusing of time and effort by organizational decision-makers on "issues" and "answers" (Ocasio, 1997, p189). The cornerstone of Ocasio's theory is that attention is a scarce resource and that competing demands put significant strain on this

resource, whose pressure managers aim to relieve through selective deployment of attention to "issues" and "answers" (March, 1991; Ocasio, 1997). In our setting, managers attend to the "issue" of innovation and receive "answers" from interactions with external parties such as customers, suppliers, competitors, and universities, and from the internal R&D department. When it becomes too demanding for managers to give attention to all issues and potential answers, they will prioritize the issues and answers and allocate attention to the most important one(s).

We build on this theoretical grounding introduced by Ocasio (1997) to argue that some configurations of customer collaboration, collaboration scope, and the internal R&D department are better, and some worse, at producing product innovations because of their differential drawing on managerial attention (which underlies resource allocation) due to difficulties in noticing, encoding, interpreting, and focusing of time and effort from different sources. We argue that such difficulties particularly apply when complementing technological customer collaboration with technological collaboration with other identities, such as universities or technological centers. Moreover, we argue that technological customer collaboration can create difficulties when complemented with an internal R&D department. In the hypothesis development we provide details on how these difficulties predictably correlate with product innovation. In doing so we shed important light on prior findings (e.g. Laursen and Salter, 2006) that there may be "too few" or "too many" identities. Critically, this work implicitly assumes—by counting the number of identities—that the identity of the partners are effectively exchangeable (with the notable exception of Kang and Kang, 2010). A central thesis of our paper is that heterogeneity exists across partner identities with important consequences for managerial attention and innovation outcomes.

**Customer collaboration and collaboration scope**

The first hypothesis concerns the scenario when customer collaboration and collaboration scope interact and their predictable effect on the number of product innovations. Firms collaborate with external identities to obtain "answers" to product innovation questions. A long line of literature has demonstrated that collaboration with customers confers benefits, such as an ability to better understand customers (Di Fiore and Vetter, 2016) and ultimately increased innovation (e.g., Noordhoff *et al*., 2011). Similarly, collaborations with other identities confers significant benefits too. For example, Murtha *et al*. (2001) document how suppliers may share operations, technologies, equipment, and design to increase innovation. Un and Asakawa (2015) argue that collaboration with a university enables firms to question how processes are undertaken and to reanalyze the whole process to improve product quality.

However, these collaborations with external identities need to be monitored and coordinated, the interpretation of which requires managerial attention. While collaboration with any partner identity would raise monitoring and coordination costs (e.g., Hottenroth and Lopes-Bento, 2016), we argue that the significantly different situation of customer collaboration amplifies these costs compared to other identities. A nascent body of work (e.g., Homburg *et al*., 2011), suggests that customer interactions require significant managerial attention, for example in the form of need and problem identification and the encoding such requires, presentation and demonstration of customer solutions and the interpretation this involves, and dealing with objections and negotiation that require a great deal of interpretation too. Past work has also documented how customer relationships require specific investments and may also require significant formalization of the relationship (e.g., Noordhoff *et al*., 2011) and implies that schemas need to be used by decision-makers that require managerial attention. Moreover, Narver *et al*. (2004) argue that customers have specific use needs that customers find often difficult to express (cf. Blocker *et al*. 2011)

which generates noticing and encoding difficulties. Additionally, customers' focus on *needs and use* makes such collaborations more application-oriented (Knudsen, 2007) and thus stand out from collaborating with other identities, again requiring more significant managerial attention to be encoded and interpreted.

As the focal firm starts to work with customers, in addition to several other partner identities, the unique information from customers' needs, that are typically imperfectly expressed, need to be combined with inputs from others, which requires additional noticing, encoding, and interpreting and thus significant attention from managers. When the demand for managerial attention increases, managers must selectively focus their attention to the most important issues and provide answer(s) (Ocasio, 1997). Such a selective focus makes that some answers will just not be developed, thus resulting in a diminished number of product innovations. Formally:

*Hypothesis 1: Customer collaboration reduces the positive effect of collaboration scope on the number of product innovations.*

**Customer collaboration, collaboration scope, and the internal R&D department**

The second hypothesis concerns the scenario of when an internal R&D department is combined with technological customer collaboration and its expected effects on the number of product innovations. An R&D department benefits innovation through input, knowledge, and answers.[3] West *et al*. (2014) articulate how R&D has "two faces" where on the one hand internal R&D generates new knowledge but on the other hand also generates the absorptive capacity to effectively scan, screen, and absorb external know-how (Cohen and Levinthal,

[3] Note that our focus is on the internal *R&D department* as our arguments are about human attention and interaction. In our empirical model, we control for internal and external R&D intensity.

1989). We predict that the presence of an internal R&D department, when combined with technological customer collaboration, requires greater managerial attention.

The increased need for managerial attention is due to several reasons. First, the focus of customer collaboration (similar to hypothesis 1) is most likely on *use* situations, generating a need to coordinate with the internal R&D department. Such coordination needs will be considerable, for example because external information from the customer is often localized and hard to transfer, creating what Von Hippel (1994) calls "sticky" information that is harder to encode. The result is a transfer from one knowledge domain to another and this boundary spanning creates, as Kim *et al*. (2016) describe, difficulties. When greater requests for attention are made, managers will selectively allocate their attention to the most important issues and answer(s) where importance is determined by legitimacy, value, and relevance to the organization (Ocasio, 1997). Answers from customers likely score high on all three criteria. Customers have an incentive to provide answers that lead to the development of products that are valued in the market as they themselves would benefit and they are typically considered the most important stakeholder (Jaworski and Kohli, 1993). The greater attention for answers from customers reduces (perceived) autonomy or decision-making freedom of the internal R&D department and greater reactance is likely to occur (e.g., Brehm and Brehm, 2013). Such resistance will manifest in reduced absorptive capacity and a not-invented-here syndrome (Laursen and Salter, 2006) and thus reduced product innovation (Noble and Mokwa, 1999). Hence, we hypothesize

*Hypothesis 2: Customer collaboration reduces the positive effect of the internal R&D department on the number of product innovations.*

The third, and final, hypothesis concerns the scenario of when an internal R&D department is complemented by customer collaboration and collaboration(s) with other parties. Specifically, our hypothesis compares the relative effects on product innovation of complementing the internal R&D department with 1) customer collaboration and 2) collaboration scope.

Our key arguments draw on the relative managerial ease or difficulty of complementing the internal R&D department with collaborations with different external identities. Firms can more easily assimilate information and knowledge sufficiently similar to their own (Sampson, 2007). Technological customer collaboration differs from collaboration with other identities in that answers from customers are more application-oriented (Knudsen, 2007). Hence, while the internal schemas of noticing, encoding, and interpreting are unlikely identical to those that apply to outside knowledge (Ocasio, 1997), assimilation of customer knowledge will require managerial attention because of the unique "use" aspects. Collaboration scope requires less encoding and interpretation than customer collaboration, therefore freeing up important managerial attention (and subsequent resource allocation) for innovation. Moreover, Chan *et al*. (2010) document that customer participation creates loss of power and control in the organization, increased input uncertainty, and often generates incompatible role expectations, ones that often go beyond technical aspects as customers also have use requirements, which creates higher role stress (Singh, 1998). These elements all draw on scarce managerial attention. As a result, we expect that customer collaboration weakens the benefits of the internal R&D department more than collaborations with other external identities. In addition, it is more likely that the not-invented-here syndrome (Laursen and Salter, 2006) surfaces when dealing with customers, in part because their significant legitimacy is harder to brush off. Accordingly, we hypothesize

*Hypothesis 3: The positive effect of the internal R&D department on the number of product innovations weakens more by customer collaboration than by collaboration scope.*

## METHODOLOGY

### Data

The data used to test our hypotheses originate from the ESEE survey (*Encuesta sobre Estrategias Empresariales*) collected by the Spanish Science, Culture and Sports Ministry since 1990 to produce annual reports and statistics for the government. The ESEE surveys firms which have 10 or more employees and whose principal economic activity is listed in one of the two-digit manufacturing industries (as classified per NACE-Rev.1, see Huergo, 2006). Firms with between 10 and 200 employees are sampled while a census is performed on firms with more than 200 employees. As reported in Table 2, the sample covers the whole manufacturing sector. While product innovation and technological collaborations are reported across all sectors, we also see that some sectors, such as chemicals, office machinery and computers, motor vehicles, and other transportation equipment, report higher levels of product innovation and technological collaboration. The survey includes a set of items on innovation, R&D, customer and suppliers, employment, and accounting data and has been used extensively in academic research. For example, Cassiman and Martinez-Ros (2007) consider the link between innovation and exports while Doraszelski and Jaumandreu (2013) estimate production functions with endogenous innovation. Earlier work has adopted the ESEE to explore how R&D spending is driven by subsidies (González *et al*., 2005).

-- Insert Table 2 about here --

We have access to ESEE data for the period of 1998–2006 inclusive and report on an unbalanced sample of 2,994 firms for a total of 14,682 firm-year observations.[4] On average, we observe 1,631 firms yearly and each firm reports for about five years. The ESEE has attempted to avoid attrition in the dataset by bringing back firms that failed to respond but continue to exist. The rigor applied to the sampling approach, and the legal requirement of compliance, supports claims of representativeness of the Spanish manufacturing sector (we refer to Cassiman and Martinez-Ros (2007) for an overview). This representativeness is exceedingly hard to achieve by academics yet greatly strengthens valid inference.

We also note that since we have panel data (data for multiple firms across multiple time periods), we can focus our analysis on temporal variation in the data. In doing so, we can alleviate endogeneity concerns and make stronger claims of association, representing an additional strength of this study. Endogeneity can be a serious concern for cross-sectional studies in marketing (Rossi, 2014). The reason is that the opportunities that make firms innovate may be the same reasons that make firms collaborate. Examples of such variables include corporate culture, collaboration characteristics, customer attributes, or a firm's baseline propensity to innovate. The omission of such variables, which may come in many different forms and guises and can be hard to measure, may positively or negatively bias estimates. Provided that these unobserved variables vary between firms (cross-sectional variation) but are relatively stable over time, fixed effects estimation allows us to focus on temporal within-firm variation and estimate the parameters while avoiding an endogeneity bias due to time-invariant unobserved heterogeneity.

## Measures

[4] When specifying firm fixed effects, our sample size is reduced from 2,994 firms and 14,682 observations to 1,069 firms and 6,868 observations due to lack of variation in the dependent variable for certain companies, e.g., companies that always report zero for product innovation.

*Dependent variable*

We analyze the number of product innovations introduced by firm *i* in year *t* ($PI_{it}$), and define product innovations as "completely new products, or with such modifications that they are different from those produced earlier". We find that the average firm produces 1.6 product innovations per year with 77 percent of the firm-year observations equal to zero product innovations per year. Conditional on observing a non-zero number of product innovations, we observe an average of 7.3 and a median of 3 product innovations. As this is a count variable, outliers are likely. To limit their influence, we use a standard approach to deal with outliers (cf. Ruppert, 2006) and winsorize our dependent variable at the 99$^{th}$ percentile, i.e., we set all values larger than the 99$^{th}$ percentile (50 product innovations) to the 99$^{th}$ percentile. This affects about 150 firm-year observations with more than 50 product innovations.

*Independent variables*

For each firm *i* in year *t*, we observe whether it collaborates technologically with external identities. Specifically, we observe whether firms engage in technological collaboration with 1) customers, 2) suppliers, 3) competitors, and 4) universities and/or technological centers.[5] We use this information to create our independent variables. First, we specify $CustColl_{it}$ as a binary variable that takes the value of 1 if firm *i* collaborates technologically with customers in year *t*, and 0 otherwise. In nearly 20 percent of all observations, a firm collaborates technologically with a customer, suggesting that technological collaboration with the customer is common, but not ubiquitous. We use the

[5] Note that this measure captures the top-3 market knowledge sources and the top source of institutional knowledge as reported by Laursen and Salter (2006). Moreover, these sources have been quite constant as Urban and Von Hippel (1988) identified the four most useful sources of external knowledge 1) suppliers and customers; 2) university, government and private laboratories; 3) competitors; and 4) other nations (which does not apply to our study).

information on collaboration with other external identities to define collaboration scope ($CollScope_{it}$) as a count of whether a firm collaborated technologically with suppliers, competitors, or with universities and/or technological centers. Thus, $CollScope_{it}$ ranges from 0 to 3. We observe that the average firm engages in technological collaboration with 0.5 identities, other than the customer.

We include $R\&D_{it}$ and define this variable as the existence of an internal R&D department in a focal firm. The variable is measured using a dummy variable taking the value 1 (0) when the focal firm has (does not have) its own internal R&D department. In our sample about 22% of companies report having an internal R&D department.

*Control variables*

We include several control variables. Firstly, we control for internal R&D ($IntR\&D_{it}$) and external R&D ($ExtR\&D_{it}$) intensity. We operationalize these intensity variables as the expenditures on internal and external R&D relative to sales. Greater R&D intensity increases the likelihood of engaging in innovation activities in general (Cassiman and Veugelers, 2006) and are thus likely reflected in the number of product innovations, which we control for. We winsorize both R&D intensity variables at the top 1% due to outliers. Second, we account for a firm's leverage ($Leverage_{it}$), defined as the ratio of total long and short-term debt to total long and short-term debt plus equity. More highly leveraged firms must service relatively more debt, reducing slack resources, thereby potentially compromising their ability to innovate (O'Brien, 2003). Third, we account for a firm's size, which is typically associated with more innovations (Santos, 2017), by including the natural logarithm of the number of employees ($Size_{it}$). Fourth, we include a dummy variable that indicates whether a firm exports its goods ($Export_{it}$; 1=yes, 0=no) as there is evidence that firms operating in international

markets develop more innovations (Berchicci, 2013). Finally, we control for possible heterogeneity over time by including year fixed effects ($\gamma_t$).

**Descriptive statistics**

We present correlations and descriptive statistics in Table 3, including the mean, standard deviation, as well as the minimum and maximum. As expected, based on the prior literature, customer collaboration, collaboration scope, and the internal R&D department all are positively correlated with the number of product innovations. Just like Laursen and Salter (2006), we observe a strong correlation between $CollScope_{it}$ and $CustColl_{it}$ (0.656) indicating that firms that engage in customer collaboration typically, but not necessarily, also engage in collaboration with other identities.

-- Insert Table 3 about here --

**Model specification**

*General specification*

The number of product innovations is a count variable and therefore we specify a negative binomial model. The standard negative binomial model is characterized by:

$$E(y_{it}) = \mu_{it}, \quad (1)$$

$$Var(y_{it}) = \mu_{it}(1 + \mu_{it}/\lambda), \quad (2)$$

where

$$\ln(\mu_{it}) = \alpha + X_{it}\beta. \quad (3)$$

The negative binomial model extends the Poisson model by allowing for overdispersion in the dependent variable through $\lambda$.[6] In our application of the negative

[6] The Poisson model is a special case of the negative binomial model when $\lambda \to \infty$.

binomial model, the dependent variable, $y_{it}$, is the number of product innovations, and the independent and control variables are included in the vector $X_{it}$. Since unobserved heterogeneity is one of the main reasons why cross-sectional studies may present biased results (through omitted variable bias), we specify a firm-specific intercept.[7] The possibility to control for firm-specific heterogeneity is a substantial advantage afforded by panel data. For example, if firms with a strong innovation culture (a variable not observed by us researchers) engage in technological collaboration with customers and introduce many new product innovations, a cross-sectional study would reveal strong association between customer collaboration and the number of product innovations. However, using firm fixed effects to control for unobserved variables such as innovation culture, this association may weaken, disappear, or even reverse.

It is well known that "the conditional negative binomial model for panel data (..) is not a true fixed–effects method" (Allison, 2009). Including fixed effects is thus not trivial in a negative binomial model (e.g., Guimarães, 2008) and we, therefore, rely on the approach proposed by Blundell *et al*. (1999) for the specification of fixed effects to control for firms' propensity to innovate due to firm culture, their line of business, or other time-invariant causes. This approach requires presample information, i.e. years 1990–1997, to construct a measure of the sum of the number of product innovations introduced by firms in those earlier years. Note that for these years, item missingness precludes us from using these data as part of the main sample. We then use the (log-transformed) sum of the number of product innovations drawn from the presample information to estimate firm fixed effects. We expect that firms that were previously more innovative remain more innovative and therefore expect a positive coefficient of Blundell *et al*.'s (1999) fixed effect. We let firm-specific heterogeneity affect the mean ($\alpha_i$) as well as the variance (overdispersion parameter $\lambda_i$, which

[7] These firm fixed effects encompass industry fixed effects, which thus cannot be estimated separately.

is clustered at the firm level to account for heteroskedasticity) by using the traditional conditional negative binomial model for panel data. Finally, we control for year-specific effects through year dummies ($\gamma_t$).

We thus obtain:

$$E(PI_{it}) = \mu_{it,} \quad (4)$$

$$Var(PI_{it}) = \mu_{it}(1 + \mu_{it}/\lambda_i), \quad (5)$$

where

$$\ln(\mu_{it}) = \alpha_i + X_{it}\beta + \gamma_t. \quad (6)$$

*Detailed specifications*

We specify two alternative models by varying the specification of $X_{it}\beta$ as shown in Equation 6. First, we specify our focal model that allows us to test our hypotheses. We specify a linear and quadratic effect for $CollScope_{it}$, given by $\beta_1$ and $\beta_2$, respectively, and include the main effect of $CustColl_{it}$ ($\beta_4$).[8] Moreover, we include the interaction between $CollScope_{it}$ and $CustColl_{it}$ ($\beta_3$). This interaction term is a direct test of H1 which predicts a negative interaction term coefficient ($\beta_3$), such that collaboration with identities other than the customer becomes less rewarding when collaborating with customers. H2 posits that customer collaboration weakens the positive effect of the internal R&D department on the number of product innovations. Including an interaction between $R\&D_{it}$ and $CustColl_{it}$ allows us to directly test H2 ($\beta_7$). To test whether the positive effect of the internal R&D department on the number of product innovations weakens more by customer collaboration than by collaboration scope, we compare $\beta_6$ and $\beta_7$, i.e. the interactions between the internal R&D department and collaboration scope and customer collaboration, respectively. As per standard practice, we include the main effect of $R\&D_{it}$ ($\beta_5$) to rule out that the interaction effects

[8] Since $CustColl_{it}$ is a dummy variable, we cannot include a quadratic effect of this variable.

simply pick up a main effect. Finally, we include all the aforementioned control variables. We thus obtain:

$$X_{it}\beta = (\beta_1 + \beta_2 CollScope_{it} + \beta_3 CustColl_{it})CollScope_{it} + \beta_4 CustColl_{it} + (\beta_5 + \beta_6 CollScope_{it} + \beta_7 CustColl_{it})R\&D_{it} + \beta_8 IntR\&D_{it} + \beta_9 ExtR\&D_{it} + \beta_{10} Leverage_{it} + \beta_{11} Size_{it} + \beta_{12} Export_{it}. \quad (7)$$

Next, in Equation 8 we specify a benchmark model that does not differentiate between collaborations with customers and collaborations with other identities (collaboration scope). This benchmark specification allows us to judge the value of distinguishing between collaborations with customers and collaborations with other identities as shown in Equation 7. Moreover, this benchmark specification allows some comparison of our results with e.g., Laursen and Salter (2006) and Mooi *et al.* (2016) who establish an inverted U-shaped relationship between collaboration scope, including customer collaboration, and innovation. Our benchmark model specification includes a linear ($\beta_1$ in Equation 8) and quadratic effect ( $\beta_2$ in Equation 8) of the total number of collaboration identities ($CollScope_{it}$+$CustColl_{it}$), i.e. a variable that counts the number of identities the focal firm collaborates with while treating all identities equal. Moreover, we include the main effect of an internal R&D department ( $R\&D_{it}$; effect given by $\beta_3$ in Equation 8) and the interaction between the internal R&D department and the total number of collaborations (effect given by $\beta_4$ in Equation 8). We again include all control variables to obtain:

$$X_{it}\beta = \beta_1(CollScope_{it} + CustColl_{it}) + \beta_2(CollScope_{it} + CustColl_{it})^2 + (\beta_3 + \beta_4(CollScope_{it} + CustColl_{it}))R\&D_{it} + \beta_5 IntR\&D_{it} + \beta_6 ExtR\&D_{it} + \beta_7 Leverage_{it} + \beta_8 Size_{it} + \beta_9 Export_{it}. \quad (8)$$

## RESULTS

We estimate the two models specified above and present our estimation results in Table 4. Columns I and II display the results for the models shown in Equations 7 and 8, respectively.

-- Insert Table 4 about here --

We first focus on our focal model (column I) and observe that the linear effect of collaboration scope is positive and significant ($\beta$=0.370, $p$<0.001) while the quadratic term of collaboration scope is not significant ($\beta$=-0.014, $p$=0.680), i.e. in our focal model, we find no evidence for an inverse U-shaped curve for collaboration scope. The main effect of customer collaboration is positive and significant ($\beta$=0.793, $p$<0.001) while the interaction effect between customer collaboration and collaboration scope is significant and negative ($\beta$=-0.250, $p$<0.001). The negative interaction effect provides direct evidence in support of H1, i.e., we find evidence that customer collaboration reduces the positive effect of collaboration scope (of other outside identities) on the number of product innovations.

We illustrate these findings in Figure 1 where we plot the expected number of production innovations for different levels of collaboration scope for companies with and without customer collaboration. In line with H1, the expected number of product innovations keeps increasing with collaboration scope for firms without customer collaboration, while they are statistically flat (i.e., insignificant) for companies with customer collaboration. Hence, we find that the more identities other than the customer the firm collaborates with, the higher the number of product innovations, particularly when *not* collaborating with customers. Figure 1 illustrates that customer collaboration reduces a) the steepness of the slope and thus the marginal benefit and b) that at the highest level of collaboration scope, customer collaboration reduces the expected number of product innovations from about 1.1 to 0.9.

-- Insert Figure 1 about here –

We now turn our attention to H2 which posits that the positive effect of the internal R&D department on the number of product innovations is weakened by customer collaboration. We first establish that the internal R&D department has a positive and significant main effect on product innovation ($\beta$=0.727, $p$<0.001). The interaction between customer collaboration and the internal R&D department is negative and highly significant ($\beta$=-0.397, $p$<0.001), thus providing support for H2.

Next, H3 states that the positive effect of the internal R&D department on the number of product innovations weakens more by customer collaboration than by collaboration scope. A direct test of H3 involves comparing the coefficients for the two interactions with the internal R&D department using a z-test, while considering the covariance between the two coefficients. The interaction between collaboration scope and the internal R&D department is close to zero and not significant ($\beta$=-0.010, $p$=0.879). A formal z-test demonstrates that the coefficient for the interaction between customer collaboration and the internal R&D department is significantly larger in absolute sense (i.e. more negative) than the coefficient for the interaction between collaboration scope and the internal R&D department (z=6.58, $p$=0.010). We thus obtain strong support for H3: the positive effect of the internal R&D department is weakened significantly more by customer collaboration than by collaborations with other identities. We finally find that internal R&D intensity and export have a significant and positive effect on innovation ($\beta$=9.515, $p$<0.001 and $\beta$=0.319, $p$<0.001, respectively).

The results in column II for our benchmark specification (Equation 8) are somewhat similar to Laursen and Salter (2006) and Mooi, Wathne, and Kayande's (2016) in that the results show that collaboration scope, including customer collaboration, has a positive and significant linear effect on product innovations ($\beta$=0.533, $p$<0.001), while the quadratic effect is negative and significant ($\beta$=-0.067, $p$<0.001). Hence, when we *do not separate the*

*identities* of customers and other collaboration partners, we are able to obtain similar effects as reported by these two prior studies, thereby showing a good degree of construct validity. The main effect of the internal R&D department is positive and significant ($\beta$=0.745, $p$<0.001) while the interaction with collaboration scope, including collaborations with customers, is negative and significant ($\beta$=-0.137, $p$=0.002). Internal R&D intensity and export have the expected positive effect on innovation ($\beta$=9.596, $p$<0.001 and $\beta$=0.320, $p$<0.001, respectively).

Importantly, we can use this benchmark model to demonstrate that model fit increases when allowing for differential effects of collaborations with customers and with other identities. A comparison of the models based on Equations 7 and 8 (columns I and II, respectively) shows that the improvement in log-likelihood is significant ($\chi^2$(3 degrees of freedom) =18, $p$<0.001). Our focal model (Equation 7), where we specify differential effects of collaborations with customers and with other identities, thus better fits the data than the benchmark model (Equation 8), where we assume identical effects for collaborations with different identities.

## ROBUSTNESS CHECKS

We perform additional analyses to show robustness of our findings to alternative expectations. The critical argument we forward is that collaborations with customers are different from collaborations with other identities. However, it is possible to argue that other types of identities are *also* qualitatively different in terms of how these combine to produce product innovations. To test this alternative view, we verify whether our results hold when including each of the collaboration partners separately in our empirical model, i.e., instead of using our collaboration scope variable to capture the effects of all other identities, we include a separate dummy variable indicating each identity. Moreover, we allow for full factorial

interaction effects between each set of identities, e.g., customer and supplier, supplier, and competitor, etc., as well as between the internal R&D department and each identity. We thus obtain:

$$X_{it}\beta = (\beta_1 + \beta_2 SupplColl_{it} + \beta_3 CompColl_{it} + \beta_4 UniColl_{it})CustColl_{it} + (\beta_5 + \beta_6 CompColl_{it} + \beta_7 UniColl_{it})SupplColl_{it} + (\beta_8 + \beta_9 UniColl_{it})CompColl_{it} + \beta_{10} UniColl_{it} (\beta_{11} + \beta_{12} CustColl_{it} + \beta_{13} SupplColl_{it} + \beta_{14} CompColl_{it} + \beta_{15} UniColl_{it})R\&D_{it} + \beta_{16} IntR\&D_{it} + \beta_{17} ExtR\&D_{it} + \beta_{18} Leverage_{it} + \beta_{19} Size_{it} + \beta_{20} Export_{it}. \quad (9)$$

We present the estimation results for Equation 9 in Table 5. These results support a unique role of customer collaboration that is different from collaborations with other identities. Table 5 shows that only the interaction of the customer with either suppliers or the internal R&D department is associated with a reduction in the number of product innovations. We do not find any evidence that the interactions of the other partners amongst themselves or with the internal R&D department are associated with such a reduction in the number of product innovations.

-- Insert Table 5 about here –

Finally, we estimate the effect of product innovations on sales. We also account for potential moderating effects of customer collaboration and collaboration scope. In doing so we are able to 1) assess whether there are further benefits from product innovation and 2) address possible influences of collaborations on the sales success of innovations. We follow the literature (e.g., Castellacci and Natera, 2013) and assume that it takes some time for sales

to result from innovation and collaboration. Specifically, we estimate the following regression specification

$$\ln(Sales_{i,t+1}) = \beta_1 + (\beta_2 + \beta_3 CollScope_{it} + \beta_4 CustColl_{it}) * \ln(PI_{it})$$
$$\beta_5 CustColl_{it} + \beta_6 CollScope_{it} + \varepsilon_{i,t+1}. \quad (10)$$

We present the estimation results for Equation 10 in Table 6. Critically, we find that the number of product innovations is positively associated with sales ($\beta_2$=0.019, $p$=0.026). Our results suggest that this main effect is not significantly stronger or weaker when these innovations are developed together with customers ($\beta_4$=0.002, $p$=0.907) or other external identities ($\beta_3$=-0.009, $p$=0.166). Taking the results of (8) and (10) together, we conclude that collaborations with external identities explain the number of product innovations but we find no evidence that these collaborations affect the sales success of innovations.

-- Insert Table 6 about here --

## DISCUSSION

For a long time, scholars have noted the importance of Open Innovation (e.g., Chesbrough, 2003) and of collaborating with external partners. Based on the articulated benefits, including more innovations, one would expect a wholesale shift towards open innovation. Such a shift has, however, not materialized as Love *et al*. (2014) argue. Likely, there are, hitherto undocumented, drawbacks of Open innovation. We add to the small body of work that has documented such drawbacks (e.g., Laursen and Salter, 2006 and Mooi *et al.*, 2016) and we hypothesize, and empirically demonstrate, two new key limitations to openness that, together, might help explain why a wholesale shift to open innovation has not occurred.

First, customer collaboration reduces the positive effect of collaboration scope on the number of product innovations. While prior research explains the limitations of openness using the *number* of parties a firm collaborates with, our focus on the *identity* of these parties allows us to unravel an important limitation in that firms that technologically collaborate with customers have lower returns from technological collaboration with identities other than the customer. This limitation is significant in that, unlike any other partner type, every firm has customers. When B2B firms move from *having* customers to *collaborating* technologically with them—something which applies to 20% of the firms we observe—the benefits that collaborations with other identities bring are significantly reduced. We emphasize that this result is independent from all other characteristics of the firm, as our results include firm-specific ("fixed") effects and key control variables. We also advance the literature by showing an effect of technological collaboration, which is distinct from a party being an information source only as most past work has considered (e.g., Laursen and Salter 2006). Technological collaboration stands out as it implies a greater degree of cooperation than serving as an information source, which could not require any two-way interaction.

Second, we find that the positive effect of the internal R&D department on the number of product innovations weakens more by customer collaboration than by collaboration scope. This finding is based on the observation of a negative and significant interaction between customer collaboration and the internal R&D department (as captured by H2) and a comparison of this effect to collaboration with other identities (as captured by H3). These results are *only* obtained when we separate out the customer. Counting the number of identities the firm collaborates with would result in a drastically different conclusion that the returns to the internal R&D department decline with external collaborations. However, our decomposition of collaboration into customer and other collaboration reveals that this effect is due to collaboration with customers only and not due to collaboration with other identities.

This suggests a certain incompatibility of customer collaboration. A small body of work (Chan *et al*., 2010; Noordhoff *et al*., 2011) notes certain difficulties of collaborating with customers to which we add that customers, when combined with internal R&D, are more likely to draw on the attention of management, resulting in a somewhat reduced number of product innovations, on average. Thus, to scholars, our findings stress the importance of considering the identity of collaborating parties in studying the impact of openness on innovation success. We thus conceptually and empirically reject the implicitly held assumption in the literature that different partners provide similar benefits and are effectively interchangeable. For example, Cassiman and Veugelers (2006) find complementarities between internal R&D and external knowledge acquisition but remain agnostic about the identity of the partners that provide external knowledge. We draw on attention-based theory (Ocasio, 1997) to hypothesize that particularly customer collaborations adversely impact the returns to collaboration scope and the internal R&D department. Our results provide strong support for our hypotheses. We also note that supplementary analyses show that product innovations lift sales but that external collaboration does not strengthen (nor weaken) this linkage.

Our study has several implications for managers. First, managers need to carefully select which external identities to involve in innovation. If we use Equation 7 to calculate the expected number of product innovations for all possible combinations of customer collaboration, collaboration scope, and the internal R&D department, a clear pattern results as shown in Table 7. Firms without an internal R&D department and with no existing collaborations with external partners, benefit the most from customer collaboration. However, for firms at the *highest* level of collaboration scope, there is a marked *reduction* in the expected number of product innovations when collaborating with customers. Moreover, this reduction is particularly strong for firms with an internal R&D department.

-- Insert Table 7 about here –

Second, we attribute the negative interactions between customer collaboration and collaboration scope and the internal R&D department to managers' attention limits. What would happen if firms would allow managers to dedicate more or even unlimited attention to the management of the different identities involved in innovation? To answer this question, we perform a counterfactual analysis where we compare the estimated number of product innovations implied by our estimated model with a counterfactual case where firms would be able to suppress the negative interactions between customer collaboration and collaboration scope and the internal R&D department, i.e. conforming to a scenario where managers face trivial or no attention limits. We present the results from this counterfactual analysis in Figure 2. In the absence of negative interactions, our counterfactual shows that the number of product innovations increases more strongly with collaboration scope. This effect is of considerable magnitude. For example, in the absence of negative interactions, we estimate more than three product innovations when collaboration with all partner identities (the customer, the internal R&D department, and three for collaboration scope) occurs while this number falls to one product innovation when we do allow for negative interactions. That is, if we could address the attention limits to joint collaboration with customers, we could triple the number of product innovations in the most complex scenario where all partners are involved in the collaboration.

-- Insert Figure 2 about here --

## LIMITATIONS & FUTURE RESEARCH

We make an important contribution to the literature on openness and product innovation but acknowledge that our study, as any, has its limitations. First, we rely on a binary measure for customer collaboration and count the number of other identities a firm collaborates with. We are unable to account for the number of customers (or number of suppliers, competitors, or universities or technological centers) a firm collaborates with or the depth or intensity of each individual relationship as the longitudinal ESEE data does not report on these.[9] Although technological collaboration, which we study, is suggestive of repeated exchange and quite well-developed relationships with a limited number of partners, future research could focus on potential attention-related problems *within* collaboration identities, e.g., problems resulting from working with multiple customers, and attention problems related to the depth of the relationship.

Second, we use the number of product innovations as our key dependent variable and have explored the potential impact of collaborations with external identities on the commercial success of product innovations. Future research could be usefully directed towards studying other innovation metrics, such as the novelty of the innovation, the source of the innovation (e.g., new design or new materials), and how long they survive in the market.

Lastly, our metrics are all at the firm level, which does not allow us to consider how customer collaboration, collaboration scope, and the internal R&D department work at the individual or project level (e.g., Kobarg *et al.*, 2019). Future research could analyze individual innovation projects, specifically focusing on how managers allocate their attention to inputs from external parties and the internal R&D department.

[9] We note that our fixed effects control for all unobservable and time invariant characteristics, such as the degree to which a relationship remains "deep".

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# Tables

## Table 1: Contributions

| Paper | Partner identities considered | Theory used | Dependent variable | Partner identity effects considered separately | Customer effects observed | Empirical | Accounts for unobserved heterogeneity |
|---|---|---|---|---|---|---|---|
| Kim, Kim, and Foss (2016) | • No explicit partner identities considered | The attention-based view | A cyclic interplay between absorptive capacity and inbound innovation | N | - | N | - |
| Laursen, and Salter (2006). | • Suppliers<br>• Clients or customers<br>• Competitors<br>• Consultants<br>• Commercial<br>• Laboratories/R&D enterprises<br>• Universities or<br>• Other higher education institutes<br>• Government<br>• Research organizations private research<br>• Institutes | The open innovation paradigm | Innovative performance across three dimensions | N | N | Y | N |
| Mooi, Wathne, and Kayande (2016). | • Joint research and development<br>• Joint buying<br>• Integrated supply chain<br>• Joint marketing or distribution<br>• Other cooperative arrangements | The open innovation paradigm | Product and service innovation Process innovation Marketing innovation | N | N | Y | Tested for |
| Cui and Wu (2016). | • Customers | Knowledge-based view | New product performance | N | Y | Y | N |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Noordhoff | • Suppliers<br>• Customers | Tie-strength literature | Supplier innovation, strategic advantage, and financial performance | N | N | Y | N |
| This paper | • Supplier<br>• University/Technological center<br>• Competitor<br>• Customer | The attention-based view | The number of product innovations | Y | Y | Y | Y |

**Table 2. Data description**

| | | Percentage of cases belonging to each industry | Average number of product innovations per firm | Average customer collaboration per firm | Average collaboration scope per firm |
|---|---|---|---|---|---|
| 1 | Production, procession meat | 2.7% | 0.17 | 0.04 | 0.31 |
| 2 | Food products and tobacco | 9.2% | 0.23 | 0.07 | 0.40 |
| 3 | Beverages | 1.8% | 0.26 | 0.07 | 0.49 |
| 4 | Textiles and wearing apparel | 9.0% | 0.23 | 0.11 | 0.27 |
| 5 | Leather and leather products | 2.8% | 0.18 | 0.10 | 0.25 |
| 6 | Wood and wood products | 3.3% | 0.09 | 0.05 | 0.20 |
| 7 | Pulp, paper and paper products | 3.2% | 0.19 | 0.21 | 0.47 |
| 8 | Publishing and printing | 5.4% | 0.09 | 0.04 | 0.13 |
| 9 | Chemicals and chemical products | 6.5% | 0.37 | 0.40 | 0.92 |
| 10 | Rubber and plastic products | 5.6% | 0.27 | 0.22 | 0.40 |
| 11 | Non-metallic mineral products | 7.1% | 0.14 | 0.10 | 0.44 |
| 12 | Basic metals | 3.6% | 0.21 | 0.35 | 0.76 |
| 13 | Fabricated metal products | 11.2% | 0.14 | 0.15 | 0.30 |
| 14 | Machinery and equipment | 7.3% | 0.31 | 0.29 | 0.63 |
| 15 | Office machinery, computers | 1.4% | 0.43 | 0.40 | 0.88 |
| 16 | Electrical machinery and apparatus | 6.0% | 0.34 | 0.33 | 0.69 |
| 17 | Motor vehicles, trailers | 5.1% | 0.28 | 0.36 | 0.85 |
| 18 | Other transport equipment | 2.0% | 0.32 | 0.28 | 0.85 |
| 19 | Furniture | 5.0% | 0.24 | 0.07 | 0.21 |
| 20 | Other manufacturing | 2.0% | 0.19 | 0.04 | 0.17 |

**Table 3. Bivariate correlations and summary statistics**

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. |
|---|---|---|---|---|---|---|---|---|---|
| 1. Product innovation ($PI_{it}$) | 1.000 | | | | | | | | |
| 2. Customer collaboration ($CustColl_{it}$) | 0.169 | 1.000 | | | | | | | |
| 3. Collaboration scope ($CollScope_{it}$) | 0.164 | 0.656 | 1.000 | | | | | | |
| 4. R&D ($RD_{it}$) | 0.181 | 0.525 | 0.642 | 1.000 | | | | | |
| 5. Internal R&D to sales ($intRD_{it}$) | 0.148 | 0.359 | 0.417 | 0.434 | 1.000 | | | | |
| 6. External R&D to sales ($extRD_{it}$) | 0.069 | 0.274 | 0.351 | 0.291 | 0.416 | 1.000 | | | |
| 7. Leverage ($Leverage_{it}$) | 0.005 | -0.082 | -0.095 | -0.093 | -0.041 | -0.072 | 1.000 | | |
| 8. Size ($Size_{it}$) | 0.135 | 0.365 | 0.521 | 0.465 | 0.197 | 0.215 | -0.135 | 1.000 | |
| 9. Export dummy ($Export_{it}$) | 0.141 | 0.259 | 0.330 | 0.308 | 0.174 | 0.141 | -0.052 | 0.503 | 1.000 |
| Mean | 1.611 | 0.181 | 0.461 | 0.221 | 0.005 | 0.002 | 0.284 | 4.257 | 0.635 |
| SD | 6.235 | 0.385 | 0.769 | 0.415 | 0.012 | 0.006 | 0.276 | 1.497 | 0.481 |
| Min. | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Max. | 50 | 1 | 3 | 1 | 0.080 | 0.040 | 1.000 | 9.616 | 1 |

Notes: Correlations based on 14,682 observations for 2,994 firms.

**Table 4. Estimation results**

| Variable | Parameter estimate, (SE) and *p*-value | |
|---|---|---|
| | I | II |
| Collaboration scope | 0.370*** | |
| | (0.083) | |
| | 0.000 | |
| Collaboration scope squared | -0.014 | |
| | (0.033) | |
| | 0.680 | |
| (Collaboration scope + Customer collaboration) | | 0.533*** |
| | | (0.061) |
| | | 0.000 |
| (Collaboration scope + Customer collaboration) squared | | -0.067*** |
| | | (0.018) |
| | | 0.000 |
| Customer collaboration | 0.793*** | |
| | (0.117) | |
| | 0.000 | |
| Collaboration scope | -0.250*** | |
| x customer collaboration | (0.067) | |
| | 0.000 | |
| Internal R&D department | 0.727*** | 0.745*** |
| | (0.090) | (0.090) |
| | 0.000 | 0.000 |
| Collaboration scope x Internal R&D department | -0.010 | |
| | (0.066) | |
| | 0.879 | |
| Customer collaboration x Internal R&D department | -0.397*** | |
| | (0.109) | |
| | 0.000 | |
| (Collaboration scope + Customer collaboration) | | -0.137*** |
| x internal R&D department | | (0.045) |
| | | 0.002 |
| Internal R&D intensity | 9.515*** | 9.596*** |
| | (1.543) | (1.542) |
| | 0.000 | 0.000 |
| External R&D intensity | 9.969*** | 10.188*** |
| | (2.634) | (2.635) |
| | 0.000 | 0.000 |
| Leverage | 0.087 | 0.095 |
| | (0.102) | (0.102) |
| | 0.393 | 0.350 |
| Size | -0.028 | -0.028 |
| | (0.026) | (0.026) |
| | 0.287 | 0.278 |
| Export | 0.319*** | 0.320*** |
| | (0.086) | (0.086) |
| | 0.000 | 0.000 |
| Year fixed effects | Included | Included |
| Number of observations | 6,867 | 6,867 |
| Number of firms | 1,069 | 1,069 |
| Log likelihood | -7953 | -7960 |
| Chi-squared | 823*** | 805*** |

Notes: Dependent variable is the number of product innovations. Columns I-II pertain to the model specification assuming Equation 7-8, respectively. *** indicates $p<0.01$. All standard errors are cluster robust, using the firm as clustering variable. Year fixed effects and firm fixed effects correction not shown to conserve space.

**Table 5. Estimation results – Robustness check**

| Variable | Parameter estimate, (SE) and *p*-value |
|---|---|
| Customer collaboration | 0.825*** |
| | (0.124) |
| | 0.000 |
| Supplier collaboration | 0.506*** |
| | (0.109) |
| | 0.000 |
| University/TC collaboration | 0.394*** |
| | (0.093) |
| | 0.000 |
| Competitor collaboration | -0.532* |
| | (0.321) |
| | 0.098 |
| Customer collaboration x Supplier collaboration | -0.429*** |
| | (0.109) |
| | 0.000 |
| Customer collaboration x University/TC collaboration | -0.088 |
| | (0.103) |
| | 0.397 |
| Customer collaboration x Competitor collaboration | -0.173 |
| | (0.208) |
| | 0.406 |
| Supplier collaboration x University/TC collaboration | -0.133 |
| | (0.103) |
| | 0.195 |
| Supplier collaboration x Competitor collaboration | 0.007 |
| | (0.239) |
| | 0.976 |
| University/TC collaboration x Competitor collaboration | 0.505** |
| | (0.229) |
| | 0.027 |
| Internal R&D department | -0.406*** |
| | (0.114) |
| | 0.000 |
| Customer collaboration x Internal R&D department | -0.042 |
| | (0.112) |
| | 0.711 |
| Supplier collaboration x Internal R&D department | 0.368 |
| | (0.233) |
| | 0.115 |
| Competitor collaboration x Internal R&D department | -0.066 |
| | (0.102) |
| | 0.521 |
| University/TC collaboration x Internal R&D department | 0.825*** |
| | (0.124) |
| | 0.000 |
| Year fixed effects | Included |
| Number of observations | 6,867 |
| Number of firms | 1,069 |
| Log likelihood | -7944 |
| Chi-squared | 841*** |

Notes: Dependent variable is the number of product innovations. Results pertains to the model specification assuming Equation 9. *** indicates $p<0.01$, ** indicates $p<0.05$, and * indicates $p<0.1$. All standard errors are cluster robust, using the firm as clustering variable. Covariates (internal and external R&D intensity, leverage, size and export), year fixed effects and firm fixed effects correction not shown to conserve space.

**Table 6. Estimation results – Sales**

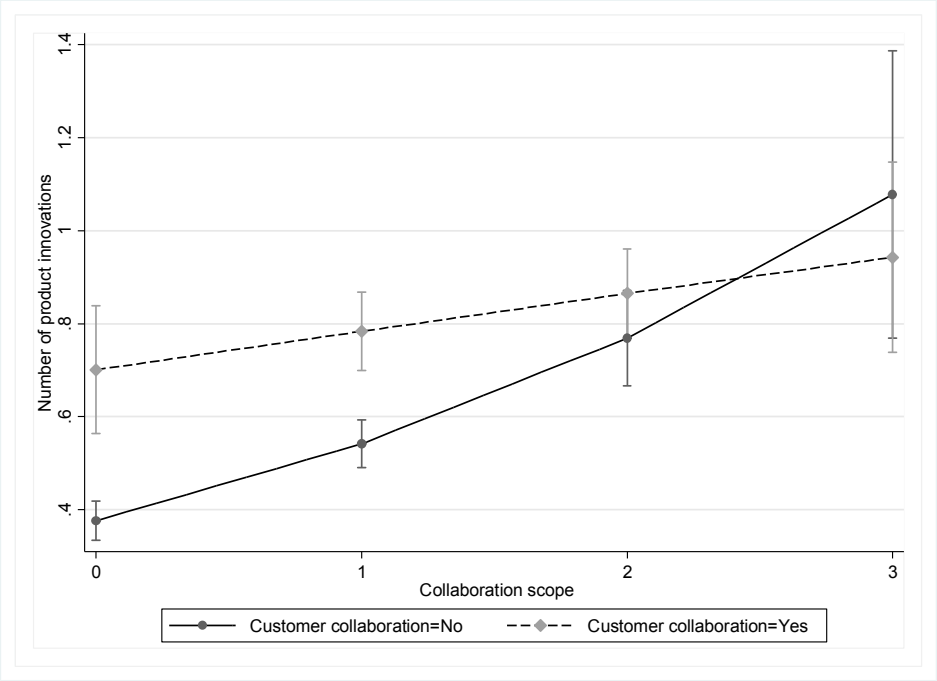
| Dependent variable: Sales (logarithm) | Parameter estimate | SE | *p*-value |
|---|---|---|---|
| Number of product innovations | 0.019 | 0.009 | 0.026 |
| Customer collaboration | 0.040 | 0.023 | 0.076 |
| Collaboration scope | 0.018 | 0.012 | 0.141 |
| Number of product innovations x Customer collaboration | 0.002 | 0.013 | 0.907 |
| Number of product innovations x Collaboration scope | -0.009 | 0.007 | 0.166 |
| Year fixed effects | Yes | | |
| Firm fixed effects | Yes | | |
| Number of observations | 12,054 | | |
| Number of firms | 2,487 | | |

**Table 7. Number of innovations with varying levels of customer collaboration, collaboration scope and internal R&D department**

| | Internal R&D department | No | | Yes | |
|---|---|---|---|---|---|
| | Customer collaboration | No | Yes | No | Yes |
| Collaboration scope | None | 0.27 | 0.60 | 0.56 | 0.84 |
| | 1 | 0.39 | 0.67 | 0.80 | 0.92 |
| | 2 | 0.54 | 0.72 | 1.09 | 0.99 |
| | 3 | 0.73 | 0.76 | 1.46 | 1.03 |

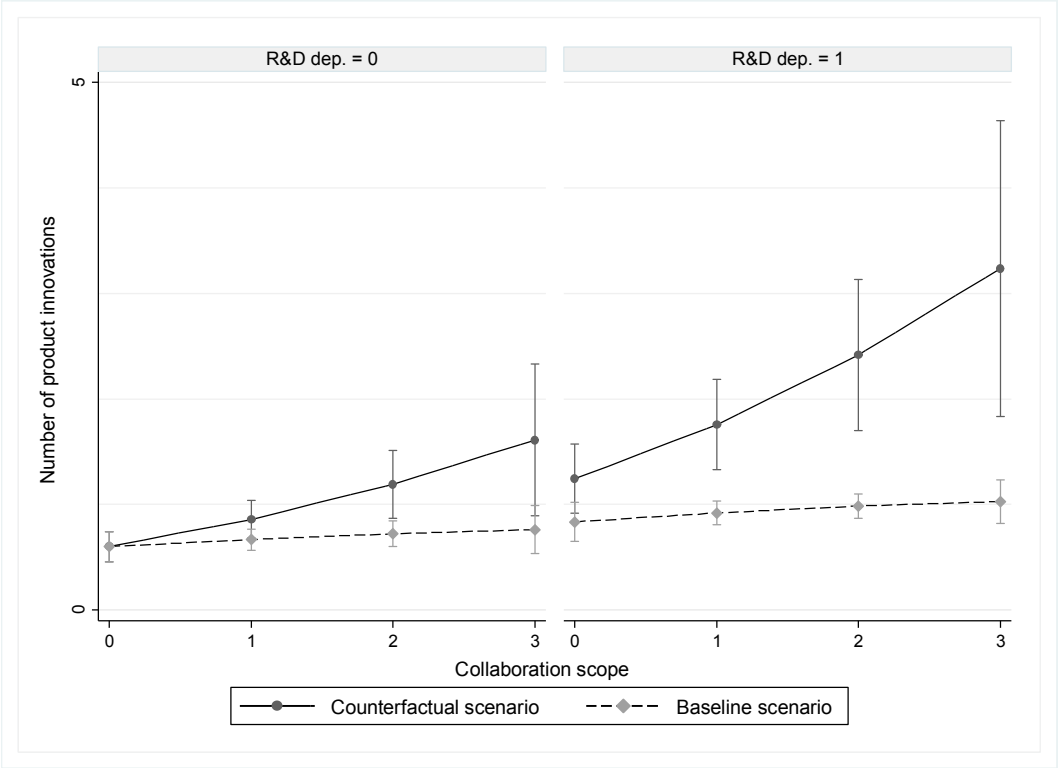
Notes: Predicted number of innovations with varying levels of customer collaboration, collaboration scope and internal R&D department. Fixed effects set to 0 and all remaining covariates evaluated as observed.

**Figure 1: Expected number of product innovations from customer collaboration and collaboration scope on product innovations**




Note: average estimated number of product innovations. Evaluated at the means of the remaining covariates.

**Figure 2: Counterfactual expected number of product innovations**




Note: average estimated number of product innovations. Evaluated when customer collaboration=yes and at the means of the remaining covariates. The "baseline scenario" corresponds to the estimates from the model reported in Table 4 (column I) while the "counterfactual scenario" corresponds to the case where the negative interactions with Collaboration Scope and the R&D department are both set to zero.

Dear Prof. Marshall,

It is our great pleasure to resubmit manuscript EJM-12-2020-0889.R1 titled “Collaboration scope and product innovation in B2B Markets: Are there too many cooks or is it the customer who spoils the broth?”. Note that the tile has changed, following guidance from the AE.

We thank you for the opportunity to revise our manuscript and greatly value the comments of the review team. In response to the comments, we have made the following changes to our manuscript:

- We have adopted the manuscript title suggested by the Associate Editor.
- We have rewritten parts of the introduction section to motivate the problem from attention-based theory. We have also included a table to clearly communicate the differences between our manuscript and past papers to articulate the intended contribution.
- We have rewritten parts of the theory section to better motivate our hypotheses from the attributes and arguments of attention-based theory.

We hope to have addressed all remaining concerns raised by the review team and thank you for your consideration of our revised manuscript.

Sincerely,

The Authors

**Reply Notes**

**Associate Editor**

Thank you for your continued support for our paper. We thank you and the two anonymous reviewers for your feedback that helped us to further improve our paper. Below, we indicate how we responded to your comments. We copy your original comments in italics.

*Thank you for your continued improvement of this paper. There are just one or two more points for consideration. First, the title is quite awkward. Please consider changing the title to: "Collaboration Scope and Product Innovation in B2B Markets: Are Their too Many Cooks or is it the Customer that Spoils the Broth?"*

Thank you for the title suggestion. We have gratefully adopted this suggestion.

*Second, per the reviewers' request you did use a theory, attention-based theory, to guide your hypothesis development. However, merely mentioning the name of the theory and giving a short description is not exactly grounding your paper in theory. R2 is not satisfied with your use of this theory and I believe that you should carefully use this theory to 1) explain the problem that you are trying to address with this piece, 2) explain how collaboration negatively moderates H1 and H2.*

We thank you (and R2) for your careful evaluation of the theory. In the revised version of our manuscript, we have rewritten parts of the introduction section to better motivate the problem from attention-based theory. Moreover, we now include a table to better communicate the contribution of our paper by showing how our manuscript is different from other papers. This table also includes the paper by Kim et al. (2016) (which R2 mentions) and other relevant work. Further, we have rewritten the theory section. As suggested by R2, we draw on the attributes and arguments of attention-based theory to motivate our hypotheses. In doing so, we now no longer use the term “conflict” and have rewritten the appropriate paragraphs to better reflect attention-based theory.

We sincerely hope to have addressed your remaining comments in this revision.

**Reviewer 1**

Thank you very much for your positive evaluation of our revision. We thank you again for your comments in the previous revision round which helped us to improve the focus of our manuscript and strengthen the empirical analysis.

**Reviewer 2**

We thank you for your careful reading of our revised manuscript and your thoughtful comments. Below, we respond to your comments by providing an answer to each of the two main comments. We copy your original comments in italics.

*[…] Therefore, here are briefly my basic conceptual problems*

*Research Gap and the positioning of the paper:*
*The research gap and thus the relevance of the research question is motivated in my view in a very abstract way and with very little literature on the central assumptions. A few examples:*

- *„ Yet, in "open innovation" strategies the internal R&D department may not "mix" well with collaboration with customers or other identities.“*
- *„We argue that difficulties to create product innovations may arise due to critical variation in the identities of the external partners a firm draws on“*
- *What is the problem? What difficulties do companies have when collaborating with external partners?? Why should conflicts of interest arise, given that companies select their partners with a specific goal in mind for cooperation within the innovation project? What "attention problem" arises here? When it comes to the balance between external sources and internal sources, this topic has already been discussed (also with regard to the attention based theory): Kim, Bongsun, Eonsoo Kim, and Nicolai J. Foss. "Balancing absorptive capacity and inbound open innovation for sustained innovative performance: An attention-based view." European Management Journal 34.1 (2016): 80-90. Furthermore, strong assumptions are made in some cases for positioning. For example:*
- *„Co-creation is one of the potential forms of the observed technological collaborations with external partners. We note that given our focus on technological collaboration, we purposely restrict the focus to B2B as consumers are highly unlikely to be partners to organizations when it comes to addressing or solving technological aspects.“*

*However, this does not take into account research from other literature strands that have already shown the opposite effects, such as lead users, crowdsourcing, netnography, idea contests..... It has already been shown here that even consumers can make a contribution to technological issues.*

*Therefore, the question of relevance and the gap remains for me. Which problem is solved from a practical or a scientific point of view?...*

Thank you for your questions about the central problem in our manuscript. The central problem that we study is whether the number of product innovations predictably correlates with combinations of customer collaboration, collaborations with other external partner identities, and internal R&D. While the existing literature has predominantly focused on the *number* of partners, we argue and find that the identity of the external partners is also predictive of the number of product innovations. The current literature has considered all of these identities separately but we argue, and demonstrate empirically, that some combinations of partner identities can reduce the number of product innovations.

We agree with you that the past literature has shown benefits from collaborating with customers, and that idea contests or the involvement of lead users etc. can promote product innovation. We also demonstrate that such benefits exist (albeit in a somewhat different setting and with a somewhat different focus). However, unlike this past work we demonstrate that customer collaboration benefits can diminish, when interacted with other partner identities or internal R&D, to the point that it reflects in fewer product innovations. We argue that this finding is a key contribution to our understanding of customer collaboration.

We now introduce this central problem more clearly in the introduction section. Moreover, we highlight the contributions of our work in the newly added Table 1. In this table, we compare our study to relevant “micro” and “macro” focused work on the intersection of Marketing, Strategy, Management, and Innovation, including the European Management Journal publication by Kim, Kim, and Foss (2016). We thank you for suggesting this publication to us. As Table 1 shows, our manuscript provides a significant contribution over this paper in part because a) we consider partner effects separately, b) we consider customer effects, c) we provide empirical evidence, and d) account for unobserved heterogeneity.

*The second problem I have with the paper is the theoretical anchoring. In the review letter as well as in the paper, the authors frequently refer to the fact that they now use attention-based theory and have thus found a theoretical perspective for deriving the hypotheses. To me, using a theory means taking the basic attributes and arguments of a theory and applying them in one's own context. In my eyes this does not happen here, the authors only refer to conflicts, limited resources, and allocation problems without taking the context into account. There is no argumentation built on the basis of the theory in the present context of analysis. Why and how do the conflicts arise?*

*For example:*
*"such as universities or technological centers as well as that technological customer collaboration may conflict with internal R&D. It is these conflicts that draw on managerial attention. As these draws of attention become more significant, resources become harder to allocate and the, in our view, the predictable outcome is diminished product innovation.“*

*However, there is a shortage of argumentation about why these conflicts arise and how an "attention" problem will then occur. According to Ocasio, attention is defined as the "noticing, encoding, interpreting, and focusing of time and effort by organizational decision-makers on issues and answers". If one now follows the argumentation of Kim et al. then, from an attention-based view, successful innovation management becomes possible when organizations focus their attention on the recognition, assimilation, and utilization of new knowledge that is hidden within and outside the organization. Capabilities to integrate knowledge within and across organizations may vary, as some organizations are better at leveraging knowledge available internally, while others are better at leveraging external knowledge*

*If one now focuses on potential attention conflicts between partners, as the authors do, then this must be derived according to the theory.*

*The following part will explain my problem: As the focal firm starts to work with customers, in addition to several other partner identities, the unique information from customers’ needs, that are typically imperfectly expressed, need to be combined with inputs from others. This requires significant attention from managers. When the demand for managerial attention increases, they must selectively focus their attention on the most important answer(s) (Ocasio, 1997). Such a selective focus makes that some answers will not be developed, thus resulting in a diminished number of product innovations.*

*The authors, on the other hand, continue to argue on a very unspecific level (this is also reflected in the wording, in H2 they often use the term „may“) or one cannot follow their argumentation (see H1, the formulation that not everything is implemented: "some answers will not be developed". But this is not a conflict, but a consequence of entrepreneurial action).*

*In the development of the hypotheses on based on the attention-based view, one would expect that the authors would apply the components of the definition "noticing, interpreting and focusing of time and effort" to their context (different sources and potential "conflicts") and would consider them accordingly in the variables in the model. This would mean that the authors would have to measure time and resource conflicts depending on the types of sources used. However, this is not done. Therefore, in my eyes, the attention-based view is an interesting and basically fitting theory, but it was neither used to derive the hypotheses nor considered in the measurement model.*

*I am therefore unfortunately not convinced by the revision of the paper. The potential contribution of the paper (dataset) is diminished in my view by the lack of research gap and theoretical anchoring. If one wants to use the theory, then it requires not only a stringent use of the theory but also a consideration of the crucial variables in the measurement model. This is not the case in the current form. Or one chooses another theory that fits the measurement model. I think one of the two approaches should be chosen by the authors in order to make a "real" contribution to the "Open Innovation" field. I wish the authors good luck with the further steps with their paper.*

Thank you for your detailed feedback on our use of attention-based theory. In response to your comments, we have rewritten parts of the theory section. Specifically:

- We now build our arguments from the definition of attention as provided by Ocasio (1997) who defines attention as the noticing, encoding, interpreting, and focusing of time and effort by organizational decision-makers on issues and answers. We connect our hypotheses to each of these elements.
- We fully agree that we should not have used the term “conflict”. When managers direct their attention to input provided by a particular partner identity, this comes at the cost of reduced attention for input from other partner identities. This is indeed not a conflict but is a consequence of managers’ actions. Hence, we have rewritten all arguments that referred to “conflict”.
- We agree that the capabilities to integrate knowledge within and across organizations may vary. However, we have controlled for this at two levels. Firstly, our models include controls in the form of internal R&D intensity, external R&D intensity, leverage, size, exporting, and our core hypothesized variables plus their interactions. Secondly, to us researchers, a number of variables remain unobserved such as managerial capacity or (innovative) firm culture. To the extent such unobserved factors are constant across our sampling window, such factors are absorbed in our fixed effects estimation and we are also able to control for their initial level using the econometric approach of Blundell et al. (1999).
- We have also removed instances of “may” or “could” in the hypotheses, where possible. We note however, that in many instances the word “may” is appropriate as the effects we consider are interaction effects where the effect is conditional on a third variable.
- Finally, we have streamlined our writing with the aim of making the arguments and hypotheses clearer.

Thank you again for your thoughtful and helpful comments. We sincerely hope that the new revision addresses your remaining concerns.