Cooperation for innovation and its impact on technological and non-technological innovations: empirical evidence for European SMEs in traditional manufacturing industries

INTRODUCTION

Since the mid-1990s, not only multinational companies but also small and medium-sized enterprises have engaged more extensively in cooperation (De Faria, Lima, and Santos, 2010). Nowadays, firms can be found cooperating with a diverse network of parties, which enables them to access external knowledge and resources and, in that way, complement their internal innovation activities. This study investigates how cooperation for innovation with various partners affects innovation output in traditional-sector manufacturing SMEs.[1] Its contribution is two-fold and empirical: first, it addresses issues within this broad topic on which the evidence is still far from conclusive – hence, not compelling from a policy perspective; and, secondly, this topic is investigated for the first time in the context of a sector that is largely neglected by the research literature but nonetheless still of major importance throughout the EU.

Empirical work on the performance effects of R&D cooperation and, more broadly, cooperation for innovation, have mostly focused on technological product and process innovations (Pippel, 2014; Sánchez–Gonzáles, 2014). However, since the European Community Innovation Survey (CIS) was introduced in the early 1990s, the concept of innovation has been extended to take into account non-technological aspects of innovation. This trend resultedin the broad definition of innovation proposed in the *Oslo Manual* (OECD, 2005), incorporating non-technological organizational and marketing innovations. Likewise, in the stream of innovation research focused on cooperation, most recent studies have

[1] Cooperation and networking are found to be used interchangeably in the literature. For instance, Pittaway *et al*. (2004) adopted the definition by Perez and Sanchez (2002: 261), whereby networks are defined as "a firm's set of relationships with other organizations".

examined how cooperation is associated with non-technological organizational and marketing innovations (see for example: Pippel, 2014; Sánchez–Gonzáles, 2014). Similarly, Pittaway *et al*. (2004) argue for more research on the influence of cooperation for innovation on technological process and non-technological organizational innovations. In line with these developing concerns in the extant literature, this study investigates whether the impact of cooperation is heterogeneous and conditional on actual types of innovation. In this respect, a particular contribution of this study is a methodological approach designed to account for the potential interconnection and complementarity of technological and non-technological innovations, which previously, to our knowledge, has not been a subject of empirical investigation. This study is one of only a few to investigate the impact of cooperation on non-technological innovations (particularly in the context of SMEs) and is the first of its kind in this stream of research to take into account that technological and non-technological innovations may be associated.

A further novelty of this study is that we explore, besides the performance effects of individual cooperative partners, how the number of different cooperative partners affects not only technological and non-technological innovations but also the subsequent commercialization of technological innovations. Katila and Ahuja (2002) were among the first to examine the effects of the scope and depth of search strategy (i.e. the use of external knowledge sources) on firms' innovation performance. Following this line of investigation, Laursen and Salter (2006) introduced the concept of the breadth and depth of external search strategies and found a curvilinear relationship with innovation performance.[2] Some authors use these concepts to investigate how the breadth and depth of other factors besides the use of external knowledge sources affect innovation performance, such as: cooperation for

[2] Prior to their 2006 study, Laursen and Salter (2004) develop a measure of openness to external knowledge sources by counting the number of sources (up to 15) that UK firms utilize in their innovation process.

innovation (see Grimpe and Kaiser, 2010; Chen, Chen, and Vanhaverbeke, 2011; Ebersberger *et al.*, 2012); innovation objectives (see Leiponen and Helfat, 2010); and types of innovation (see Gronum, Verreynne, and Kastelle, 2012). We follow the former line of investigation and explore how breadth of cooperation influences SME innovation performance.[3]

As well as contributing to the broad topic of cooperation for innovation, this study has a unique focus on SMEs in traditional manufacturing industries. This addresses substantial gaps in the research literature. Previously in the literature, even those studies that include SMEs in their samples do not report results specific to SMEs or different types of industries. Moreover, traditional manufacturing industry is largely neglected in the innovation literature. Yet, SMEs in traditional sectors are currently of first-order importance in EU employment and corresponding policy concerns.[4] The European Commission's 'key priorities for industrial policy' (European Commission, 2014a, p.2), continue to "mainstream" SMEs (see also European Commission, 2013) and innovation has now been joined by reindustrialization and a corresponding emphasis on manufacturing industry embracing not only high-tech sectors but also traditional industries. Responding to these priorities, this study utilizes a new survey sample of SMEs from six traditional manufacturing industries in seven EU regions to investigate performance effects of cooperation not only on technological innovations but also on non-technological innovations.[5]

The cooperation relationships investigated include: between firms within an enterprise group; with suppliers, customers, and competitors; with other private sector firms

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[3] The same construct is used by Chen *et al*. (2011), but they refer to it as the scope of openness. Grimpe and Kaiser (2010), Ebersberger *et al*. (2012) and Love, Roper and Vahter (2014), on the other hand, use the same construct and terminology as in our study, that of cooperation breadth. We cannot investigate the effect of the depth of cooperation due to a lack of information on the intensity of cooperative ties.

[4] In these regions these six industries (both detailed below) account for upwards of 40 percent of all manufacturing jobs. More generally, in around half of EU regions the share of these traditional industries in manufacturing employment increased over the period 1995 to 2009. For the definition of and extensive documentation on the continued importance of traditional manufacturing industry in most EU regions, see Wintjes *et al*. (2014).

[5] The dataset was obtained from the GPrix project commissioned by the European Commission, FP7-SME-2009-1; Grant Number: 245459 (http://www.gprix.eu/): Which support measures can help regions based on traditional industries to prosper in the knowledge economy?

(consultants, commercial labs and private R&D institutes); with Higher Education Institutions (HEIs); and with public-sector agencies. Innovation output is measured in two ways: by the introduction of both technological (product and process) and non-technological (organizational and marketing) innovations; and by innovative sales as a proportion of total sales, which measures the commercial success of product and process innovations (see for example: Aschhoff and Schmidt, 2008; Love *et al*., 2014). Our modeling strategy takes into account the potentially complementary nature of all four types of innovation. In addition, we investigate the impact of breadth of cooperation on performance.

This study is organized as follows: the next section discusses theory and evidence on cooperation for innovation and its impact on firms' innovation performance, particularly in the context of SMEs. The third section on methodology reviews the database used in the study and specifies the model. The fourth section presents and discusses the empirical results. Finally, we present conclusions as well as implications for policy makers and managers.

THEORETICAL FRAMEWORK

Theproposed benefits of cooperation on firms' innovation activities are extensive: risk pooling and cost sharing; shortening of the innovation process; fast commercialization of products; obtaining access to complementary and/or similar resources; and access to external knowledge (Hagedoorn, 1993; Belderbos, Carree, and Lokshin, 2004b; Pittaway *et al*., 2004)**.** Theoretical insights into the motivation for establishing and maintaining cooperative relationships are provided by transaction cost economics (Williamson, 1985) and the resource-based view of the firm (Barney, 1991).

Transaction cost economics suggests that the motivation is associated with gaining access to similar resources, whereby internal and external knowledge are treated as substitutes (Santamaria, Nieto, and Barge–Gil, 2009; Vega–Juardo, Gracia–Guitierrez, and

Fernandez–De–Lucio, 2009). That is, the firm is seen as a substitute for the market, whereby the choice between external procurement and internal production (i.e. the “make or buy” decision) is influenced by minimizing transaction costs. By exploiting similar resources, firms can achieve economies of scale, experience and risk diversification (Hagedoorn, 1993; Arranz and de Arroyabe, 2008). With respect to the actual type of cooperative partners that are conducive to the combining of similar resources, Miotti and Sachwald (2003) report that cooperation between competitors is prominent in this case.

In contrast, the resource-based view of the firm proposes that the motivation behind cooperating for innovation is to gain access to complementary resources (Miotti and Sachwald, 2003; Arranz and de Arroyabe, 2008; De Faria *et al*., 2010). In relation to cooperative partners, the literature suggests that vertical cooperation (with customers and suppliers) is aimed at utilizing complementary resources. As a result of this, vertical cooperation is also termed symbiotic or differentiated cooperation (Arranz and de Arroyabe, 2008). Besides vertical cooperation, Miotti and Sachwald (2003) found that cooperation with universities is targeted at pooling complementary resources.

Consistent with the resource-based emphasis on firms’ capabilities, the concept of absorptive capacity likewise advances the complementarity of internal and external innovation sources (Cohen and Levinthal, 1990). Considered to be necessary for exploring and exploiting external knowledge, firms' internal innovation capacity (i.e. absorptive capacity) is usually proxied by the presence within firms of R&D departments and qualified R&D personnel (Miotti and Sachwald, 2003; De Faria *et al*., 2010; Love *et al*., 2014). However, because SME innovation is not captured by formal R&D measures (Santarelli and Sterlacchini, 1990; Ortega–Argilés, Vivarelli, and Voigt, 2009; Raymond and St–Pierre, 2010) - indeed, SMEs more often conduct informal R&D activities (Kleinknecht, Monfort, and Brouwer, 2002) - and because this applies in particular to SMEs in traditional manufacturing industry (GPrix, 2011), in this study we construct a more direct indicator of firms' absorptive capacity (see below, "model specification").

Cooperation for innovation is prominent in the open innovation literature – a concept introduced by Chesbrough (2003). Thus, literature on open innovation recognizes two distinct forms of open innovation practices: 1) inbound practices associated with the acquisition of external knowledge; and 2) outbound practices pertinent to the commercialization phase of the innovation process, such as venturing and selling of Intellectual Property (IP) rights. Based on this dyadic categorization, cooperation for innovation is regarded as an inbound open innovation practice. Similar to the resource-based view of the firm, the open innovation literature proposes that external and internal innovation sources are complementary, with both synergistically contributing to firms' innovation performance (De Faria *et al*., 2010). Next, we review the particular benefits of cooperation with a variety of cooperative partners.

Research interest in cooperation with suppliers can be traced back to the 1980s with Japanese car and electronics manufacturers' successes and was closely associated with the relationships between these firms and their suppliers (Sako, 1994; Liker *et al*., 1996; Bidault, Despres, and Butler, 1998). Amongst rationales for such cooperation, firms may manage to reduce their risks and mistakes in the design of technological products and processes (Fujimoto, Iansiti, and Clark, 1996; Nishiguchi and Ikeda, 1996; Robertson and Swan, 1996). Pippel (2014) suggests that the main incentives for firms to cooperate on technological innovations apply also to non-technological organizational and marketing innovations. While cooperation with customers can be of primary relevance for marketing innovations, cooperation with suppliers could be more focused on organizational innovations.

As well as collaboration with suppliers, similarly positive outcomes may arise from close cooperation between firms and their customers (Fitjar and Rodriguez–Pose, 2013). Accessing customer knowledge may be beneficial for firms' innovativeness. This cooperative tie is particularly valuable in the context of new technologies and products (Urban and Von Hippel, 1988; Neale and Corkindale, 1998; Lilien *et al*., 2002;Tether, 2002; Bogers, Afuah, and Bastian, 2010) and may be of help in improving existing designs (Shaw, 1994) and in inventing new products or applications. Conversely, the dependence on customer knowledge alone may force producer firms to search for new solutions along more established pathways instead of pursuing new or even radical innovations (Laursen, 2011). However, empirical findings confirm that vertical cooperation with customers and suppliers plays a distinct role in the innovation process, particularly amongst SMEs (De Propris, 2002; Zeng, Xie, and Tam, 2010). This joint development of a product between firms and customers is said to improve market share and product credibility (Tidd and Trewhella, 1997; Tether, 2002) and potentially reduce risks associated with the introduction of a new product to the marketplace (Gemünden, Heydebreck, and Herden, 1992; Ragatz, Handfield, and Scannell, 1997; Tether, 2002). Concerning non-technological innovations, cooperation with customers is particularly relevant for marketing innovations (Pippel, 2014; Sánchez–Gonzáles, 2014). Customers' needs and preferences may also significantly contribute to the introduction of organizational innovations, particularly those focusing on firms' external relations.

Horizontal cooperation with competitors is most frequently found in high technology sectors (Mariti and Smiley, 1983) and often sought as a cost and/or risk reduction strategy. By its very nature it is regarded as a potentially precarious alliance due to the possibility of anticompetitive behavior by the cooperating (sic) firms (Tether, 2002). However, such cooperative alliances may have common problems for which they seek solutions and thus avoid potential areas of market rivalry (Tether, 2002). Regarding non-technological innovations, cooperation with competitors may allow firms to realize and adopt successful organizational structures from their rivals (Pippel, 2014). In addition, firms can develop and implement joint pricing and promotion strategies, or, if cooperating in designing new products, firms can engage in a common marketing strategy for a jointly developed new product (Pippel, 2014; Sánchez–Gonzáles, 2014). However, all potential pitfalls of cooperating with competitors on technological innovations, such as opportunistic behavior and restrictive knowledge sharing, can arise in cooperating on non-technological innovations (Pippel, 2014; Sánchez–Gonzáles, 2014).

Firms that cooperate with private sector institutions, experts and consultants may not only seek to manage costs but also to pursue the possibility of shared experiences on innovation, helping the firm to pinpoint and specify its exact needs in innovation, contributing ideas for new needs and solutions (Bessant and Rush, 1995) and offering opportunities to bring outside perspectives into the company (Bruce and Morris, 1998). Furthermore, the role of consultants in undertaking organizational and marketing innovations is derived from their potentially broad knowledge base. Namely, consultants can provide an extensive and expert knowledge in many areas relevant for introducing non-technological innovations (Pippel, 2014; Sánchez–Gonzáles, 2014).

Seeking external cooperation with HEIs and other public-sector knowledge providers normally entails little to no commercial or market risk (Cassiman and Veuglers, 2002). It is aimed at knowledge development (Miotti and Sachwald,2003) via access to academic expertise (Link and Scott, 2005; Azagra–Caro *et al*., 2006) to inform both technological and non-technological innovation (e.g. new marketing information; Cohen, Nelson, and Walsh, 2002) as well as at reducing costs (e.g. by securing funds for research; Fontana, Geuna, and Matt, 2006) and/or risks. Concerning non-technological innovations, cooperating with HEIs and public research institutes can foster the introduction of innovations that are radical, rather than incremental in nature (Pippel, 2014), given that their main focus is on conducting basic research and providing a heterogeneous knowledge base (Miotti and Sachwald, 2003). Moreover, universities can suggest improvements in firms' organizational structure and management and provide training and knowledge transfer to firms' employees (Sánchez–Gonzáles, 2014).

The main advantage of cooperating with firms within the same enterprise group is substantially reduced risk of opportunistic behavior. Firms can cooperate with other firms in the same group on organizational innovations as well on marketing innovations, such as those related to pricing and marketing strategies (Pippel, 2014).

Empirical evidence on the impact of cooperation on firm performance

Extending the division suggested by De Faria *et al*. (2010) and Un, Cuervo–Cazurra, and Asakawa (2010), we note that empirical studies in the R&D and innovation cooperation literature can be divided into several categories: i) determinants of R&D and innovation cooperation (e.g. Miotti and Sachwald, 2003; Belderbos *et al*., 2004a; Arranz and de Arroyabe, 2008; López, 2008); ii) the effect of knowledge spillovers on cooperation (e.g. Cassiman and Veugelers, 2002; Chun and Mun, 2012); iii) the impact of cooperation on innovation performance (e.g. Zeng *et al*., 2010; Lasagni, 2012; Tomlinson and Fai, 2013; Pippel, 2014; Sánchez–Gonzáles, 2014); and iv) the impact of cooperation on firm performance (e.g. Belderbos *et al*., 2004b; Faems, van Looy, and Debackere, 2010; Lasagni, 2012; Zeng *et al*., 2010). The focus of this research is on the third and fourth research strands. Yet, the empirical findings on both the innovation and performance effects of cooperation are ambiguous (Belderbos *et al*., 2004b). Nonetheless, a generic conclusion can be derived from the literature; namely, that a portfolio approach to cooperation for innovation is adopted by many firms (Faems *et al*., 2010) and that different cooperative partners have heterogeneous effects on firms' innovation performance.

Tomlinson and Fai (2013) found that, in the UK, SME cooperation with competitors is insignificant for both forms of technological innovation, cooperation with customers marginally increases the probability of product innovation, and cooperation with suppliers yields a highly significant positive impact on both product and process innovations. These conclusions partially confirm previous findings that cooperating with customers and suppliers enhances product and process innovations (Kaminski, de Oliveira, and Lopes, 2008; Nieto and Santamaria, 2010).

Comparing inter-firm cooperation with other forms of cooperation, Zeng *et al*. (2010) report that cooperation with customers and suppliers has a larger positive impact on the innovation performance of Chinese SMEs than does cooperation with government agencies, universities and research institutes. Similar results are found in Nieto and Santamaria (2010) for Spanish SMEs. However, some studies indicate an increasing importance of research organizations in firms' innovation activities. For instance, Lasagni (2012), analyzing a sample of SMEs from six European countries, reports that both inter-firm cooperation with suppliers and customers and cooperation with research organizations have equally significant impacts on product innovation.

Empirical studies on the impact of cooperation on non-technological innovations are even more scarce (Pippel, 2014; Sánchez–Gonzáles, 2014). Moreover, to our knowledge, no study explores this issue for SMEs. Sánchez–Gonzáles (2014) reports positive effects of cooperative ties with suppliers, customers, competitors, experts and universities on both organizational and marketing innovations. Conversely, Pippel (2014) emphasizes performance heterogeneity with respect to the various cooperative partners: cooperative relations with suppliers, consultants, universities and other firms within an enterprise group all positively affect both organizational and marketing innovations; yet cooperation with customers increases the probability of introducing organizational innovation without any effect on marketing innovation. Finally, cooperation with government research institutes and competitors do not affect non-technological innovation performance.

Empirical studies in this literature are still scarce and far from establishing a set of "stylized facts". Moreover, coverage by type of firm and sector is not yet comprehensive.

METHODOLOGY

Cooperation for innovation can influence innovation output, which our survey measures in twoways: first, by the introduction of product, process, organizational and marketing innovations; and, second, by the proportion of sales due to product and process innovations (innovative sales). To date, both theoretical and empirical research in the innovation literature has been almost exclusively focused on technological product and process innovations, although Schumpeter (1947) had earlier identified other non-technological forms of innovation (such as, organizational innovation and opening up of new markets) (Kaivo–oja, 2009, p. 206; Pippel, 2014). Moreover, Schumpeter suggested a positive correlation between product and process innovations, which has been confirmed in recent empirical studies (see for example: Miravete and Pernías, 2006; Martinez–Ros and Labeaga, 2009; Doran, 2012). In contrast, few studies explore whether technological and non-technological innovations are interrelated and, if so, how. To investigate this possibility, we use a multivariate probit model that allows all types of innovation to be related (Schmidt and Rammer, 2007; Pippel, 2014).

The underlying assumption of multivariate probit is similar to the seemingly unrelated regression (SUR) approach; in our model, firms may engage simultaneously in each of four innovation outcomes, which are associated both by common observed and, potentially, by common unobserved determinants. In a similar vein, when analyzing the impact of technological collaboration on product and process innovations, Nieto and Santamaría (2010) apply a bivariate probit model and find that product and process innovations are dependent on each other. Concerning non-technological innovations, Sánchez–Gonzáles (2014) also utilize a bivariate probit model to investigate the effects of cooperation on organizational and marketing innovations, and the results reveal that these types of innovation are also correlated. In our analysis, we combine arguments from these two streams of research and, following Schmidt and Rammer (2007), investigate the hypothesis that all four types of innovation are correlated. This approach most closely builds upon Doran (2012) who, in a sample of Irish firms, explored whether product, process and organizational innovations are substitutes or complementary. His study reports either a complementary relationship between these three types of innovations or no relationship, and conversely finds no evidence of substitutability between different forms of innovation.

Data

This study employs a survey dataset gathered in 2010. The survey questionnaire covers the period 2005-2009. The sample of 312 SMEs is dominated by innovating firms,[6] as almost all firms (94%) had engaged in innovative activities by introducing some type of technological (product and process) and/or non-technological (organizational and marketing) innovations (for definitions, see the *Oslo Manual*, OECD, 2005). Moreover, the sample includes SMEs from seven EU regions and mainly (80%) belonging to one of six manufacturing industries strongly represented in these regions.[7]

Descriptive statistics are presented in Appendix Table A1. The largest number of firms introduced process and product innovations (83 % and 81% respectively). In addition, more than half engaged in non-technological innovations (68 % in organizational innovation and 61% in marketing innovation). The modal firm in the sample had 36 employees. Slightly more than one fifth (23 %) of firms had experienced "very strong" competitive pressure. On average, the surveyed SMEs exported 20 percent of their sales. Slightly more than a third (36%) of firms invested more resources in innovation in 2009 than in 2005. With respect to firms' innovation capabilities in 2005, the largest number of firms (26%) self-reported above

[6] Our definition of SMEs is in accordance to the new European Commission (2008) guidelines, whereby small firms employ fewer than 50 employees, while medium-sized firms have between 50 and 250 employees.

[7] The regions: West Midlands (United Kingdom), North Brabant (Netherlands), Saxony-Anhalt (Germany), Limousin (France), Norte-Centro (Porto/Aveiro, Portugal), Comunidad Valenciana (Spain) and Emilia-Romagna (Italy). The industries: leather and leather products; ceramics or other non-metallic mineral products; textiles and textile products; mechanical/metallurgy or basic metals and fabricated metal products; automotive or motor vehicles, trailers and semi-trailers; and food products and beverages. For detailed information about sampling and the survey, see http://www.gprix.eu/.

average or leading capabilities in product innovation, whereas the smallest number (13%) reported above average or leading capabilities in organizational innovation. Regarding cooperation partners, the largest number of firms stated that they engaged in vertical cooperation (34% of firms cooperated with customers and 32% with suppliers), followed by cooperation with universities and HEIs (31%) and with private sector (consultants, commercial labs and private R&D institutes) (24%). Although the literature suggests that mostly large firms tend to cooperate with government labs and HEIs (Mohnen and Hoareau, 2003; Lasagni, 2012), while both SMEs and large firms focus their cooperative efforts on vertical cooperation along the supply chain (Laursen and Salter, 2004; Lasagni, 2012), SMEs in our sample tend to cooperate with HEIs to almost the same degree as with customers and suppliers and to a greater extent than with public sector institutions (31% compared to 21%). Conversely, only a small number of firms stated they engaged in horizontal cooperation with their competitors (9%). Although not a main concern of our study, we note that this feature of our sample firms is more consistent with the resource-based view of the firm, which predicts vertical cooperation with other firms, than with the transactions costs view, which predicts horizontal cooperation with other firms. As we have noted, the transactions cost prediction is supported mainly by evidence from high-tech sectors. Our survey evidence suggests that this prediction may not apply to firms in general. Finally, regarding the breadth of cooperation, on average, firms cooperate with two cooperative partners, while there are no firms that cooperate with all seven potential partners.

The survey questionnaire was piloted and amended in response to findings from interviews conducted on a basis of an initial pilot questionnaire. Whilst the response rate among SMEs was around 3%, this lack of any expected higher figure may be explained through cultural barriers, as most SMEs in the targeted sectors have not had any contacts with universities, with most managers and owners not having participated in higher education themselves. As data were self-reported, common method variance, arising from the measurement method, could bias the estimates due to systematic measurement error (Podsakoff and Organ, 1986). To check internal validity of the data, we conducted the Harmon's one-factor test (Podsakoff and Organ, 1986). The test encompasses an explanatory factor analysis of all independent variables by using unrotated principle component factor analysis. When the common method bias is unlikely to occur, the first unrotated factor (i.e. factor with the largest share of variance) should account for less than 50% of the total variation in other explanatory variables within the model. In our model, the first factor accounts for around 18% of total variation, which suggest that the common method bias raises no great concern in our model (for the recent application, see Love *et al*., 2014).

Model specification

The four dependent variables in the multivariate probit model are binary indicators measuring firms' engagement in technological and non-technological innovations: the dependent variable *Product innovation* is equal to 1 if the firm introduced any new or significantly improved goods and services in the period 2005-2009 (zero otherwise)[8]; *Process innovation* is equal to 1 if the firm implemented a new or significantly improved production process, distribution method, or support activity for its goods or services (zero otherwise); *Organizational innovation* is equal to 1 if the firm introduced new business practices for organizing procedures, new methods of organizing work responsibilities and decision making or new methods of organizing external relations with other firms or public institutions (zero otherwise); and *Marketing innovation* is equal to 1 if the firm introduced significant changes to the design or packaging of a good or service, new media or techniques for product promotion, new methods for sales channels or new methods of pricing goods or services

[8] The survey questionnaire does not include a question on whether firms introduce radical or incremental innovations, thus we are not able to distinguish between these two types of product innovation.

(zero otherwise). In addition, we separately investigate the impact of cooperation for innovation on innovative sales measured as the share of total sales accounted for by sales arising from new products and/or processes introduced since 2005.[9]The variable *Innovative sales* is a categorical variable: = 1 when innovative sales is equal to 0 percent; =2 when innovative sales ranges from 1 percent to 5 percent; =3 from 6 percent to 10 percent; =4 from 11 percent to 15 percent; =5 from 16 percent to 25 percent; =6 from 26 percent to 50 percent; and =7 when innovative sales are more than 50 percent of total sales.

The explanatory variables of interest measure firms' cooperation activities as dichotomous variables equal to 1 if the firm cooperates with the following potential partners (and zero otherwise): within group (*Coop_within_group*); suppliers (*Coop_suppliers*); customers (*Coop_customers*); competitors (*Coop_competitors*); consultants, commercial labs, and private R&D institutes (*Coop_private sector*); HEIs (*Coop_HEIs*); and government institutions and public research centers (*Coop_public sector*). Moreover, to capture the breadth of cooperation and to explore its relationship with firms' innovation performance, we construct the variable *Breadth*, which is equal to the number of cooperative relationships. That is, the variable is equal to zero if the firm does not cooperate for innovation with any of the seven potential partners, and is equal to seven if the firm cooperates with all of the potential partners (Cronbach's alpha coefficient = 0.61). Looking at Appendix Table A1, we see that none of the surveyed firms cooperates with all seven cooperative partners (the maximum value of *Breadth* variable is six). Finally, the variable *Breadth* is squared (*Breadth_sq*), to enable us to test whether the relationship between the breadth of cooperation and innovative performance is curvilinear (taking an inverted U shape).

[9] Negassi (2004) suggests that innovative sales (as a turnover-based measure) could be more appropriate than the technological aspects of innovation (i.e. introduction of product and process innovation) in capturing the effect of non-R&D innovation inputs which, we can assume, are pertinent to SMEs in traditional manufacturing sectors. Moreover, Love *et al*. (2014) note that innovative sales is the most frequently used measure of innovation output.

Control variables include a continuous variable (*Size*) to account for the heterogeneity of SMEs. We model exporting activities (*Export*) as a continuous variable measuring the share of total sales sold abroad in 2009. Exporting firms might be more innovative than their counterparts, as international competition creates more pressure on firms to innovate (Nieto and Santamaria, 2007; Belderbos *et al*., 2015). In addition, the model includes a variable measuring competitive pressure (*Competition*), which is equal to 1 if the firms responded 'Very strong' to the question: "How would you judge the competition in your main market(s)?", and zero otherwise. The theoretical industrial organization literature predicts that higher competitive pressure negatively affects innovation, because it reduces monopoly rent generated by innovating firms (Aghion *et al*., 2005).

Following Blundell, Griffith, and Van Reenan (1995), our models include firm-level "quasi fixed effects" (or initial conditions). These initial conditions control for firms' time invariant unobserved effects on innovation, i.e. firms' innovative capacity with respect to technological and non-technological innovations at the beginning of the period covered by the survey (see also Hagedoorn and Wang, 2012). By controlling for past innovative capacity, we take into account firms' absorptive capacity (see for example: Miotti and Sachwald, 2003). These effects are modeled by the following variables:

- the dummy variable that measures the resources invested in innovation in 2005 relative to 2009 (*Resources*) (DV = 1 if the firm's response to the question "Five years ago did you devote?" was 'Fewer resources to innovation'; = 0 if 'About the same' or 'More');
- dummy variables measuring the firms' innovation capacities for introducing product/process/organizational/marketing innovations within the industry in 2005 (respectively *Capacity_product*, *Capacity_process*, *Capacity_org* and

Capacity_marketing) (DV = 1 for 'Above average' and 'Leading'; = 0 for 'Average' and 'Lagging');

Finally, to control for industry heterogeneity, sectorial dummy variables were included for all six industries of interest: automotive; ceramics; leather; metallurgy; textile; and food processing. The base category is other manufacturing industries. In addition, the model includes six country dummy variables for Germany, Italy, France, Portugal, Spain and the Netherlands (with the United Kingdom being the base category).

EMPIRICAL RESULTS AND DISCUSSION

The correlation matrix showing the Pearson correlation coefficients among the independent variables is presented in Appendix Table A2. The correlations are overall weak to moderate (Taylor, 1990). The estimation of the multivariate probit model with individual cooperative partners (Model 1) is presented in Table 1.[10]

Insert Table 1 about here

Concerning the impact of cooperative relationships on technological innovation, cooperation with competitors, with HEIs and with public sector institutions are each significantly associated with greater probability of product innovation. Cooperation with competitors is beneficial, as it can lead to cost reduction (Belderbos *et al*., 2004b), while universities can facilitate firms' product innovation given their broader knowledge base compared to other partners (Un *et al*., 2010) and both HEIs and public sector institutions enable cooperation with low risk of knowledge leakage (Cassiman and Veuglers, 2002). In

[10] Following Cappellari and Jenkins (2003), in the case of a small sample size, as in our study, when estimating a multivariate probit model using the GHK simulation method for maximum likelihood estimation, the recommended number of replications (i.e. random draws) is equal to the square root of the sample size (thus, in Models 1 and 2, the number of draws is 16) (for another application, see, for instance, Ziegler and Nogareda, 2009).

contrast, only cooperation with public sector institutions appears to increase the likelihood of undertaking process innovation, which is also consistent with the importance of concerns over knowledge leakage.

Our empirical results regarding the effects of vertical and horizontal cooperation on technological product and process innovations conflict with Tomlinson and Fai (2013), who report the largest and most significant impact of cooperation with suppliers among UK manufacturing SMEs with no effect of horizontal cooperation, but are in line with their reported insignificant impact of cooperation with customers on process innovation. This dissimilarity may reflect different country coverage; for example. our study includes data from seven EU regions, while Tomlinson and Fai (2013) focus solely on UK SMEs. . Nonetheless, our findings are consistent with those of Nieto and Santamaria (2010), who observe that process innovations are less attractive for SMEs and, in line withthis argument, found no significant impact of vertical cooperation on process innovation.

Reviewing non-technological innovations, cooperation with suppliers, private sector institutions and with public sector institutions each increase the probability of introducing organizational innovation, while cooperation within an enterprise group is the only form of cooperation that affects marketing innovation (and only marginally, at the 10% level of significance). These findings are partly in line with Pippel (2014), who reports a positive impact of cooperation with suppliers, consultants, other firms within an enterprise group and universities on both organizational and marketing innovations, while cooperation with customers only affects organizational innovation.

Overall, these results suggest that cooperation with public sector institutions is the only cooperative tie to affect all three of product, process and organizational innovations (but not marketing). Although only 21 percent of SMEs in our sample cooperate with the public sector, which is in line with Mohnen and Hoareau (2003), who report that mostly large firms tend to cooperate with government labs and HEIs, we can see that this type of cooperation increases not only product and process innovations but also organizational innovations. Finally, cooperation with customers does not appear to significantly impact innovation, irrespective of its type.

Concerning the control variables, firm size has a positive effect on organizational innovation, i.e. medium-sized firms are more likely to introduce this type of innovation than are smaller firms. Exporting activities have negative effects on process innovation. In relation to our theoretical expectation this is anomalous (see above, “model specification”); however, in view of the weak statistical significance of this estimate, we do not attempt interpretation. Very strong competitive pressure reduces the probability of introducing technological product and process innovations, but has no effect on non-technological innovations. These two estimates are each statistically significant at the 1 percent level and consistent with the industrial organization prediction that high levels of competition adversely affect innovation.

With respect to the quasi fixed effects, an increase in the total resources dedicated to innovation is beneficial to introducing process, organizational and marketing innovations, but, rather surprisingly, has no effect on product innovation. In contrast, the most significant impact (at the 1% level) on product innovation is found where established innovation capacity regarding this type of innovation exists. In other words, the probability of undertaking product innovation is associated with firms' established innovative capacity (initial conditions) for product innovation. Established capacity for product innovation also has an impact on firms' current marketing innovation, consistent with the requirement for new products to be marketed.

These findings are consistent with the resource-based view of the firm and the importance of absorptive capacity for firms within our sample. Yet our results also point to more subtle effects, whereby established capabilities may also exert negative effects on innovative outcomes: our results suggest that pastinnovation capacity in process innovation has an adverse effect on the current introduction of product innovation; and that established capacity for organizational innovation exerts a detrimental effect on the current introduction of process innovation. These negative influences from initial conditions or established innovation capacity in firms are consistent with "lock-in" effects (path dependency) (Teece, 1986) and suggest that SMEs in traditional manufacturing industries may experience considerable inertia in their processes and organization.

Model estimates with the breadth of cooperation as the variable of interest are shown in Model 2 (Table 1).[11] The impact and significance of the control variables is similar to those reported in Model 1 (Table 1). The results show that the breadth of cooperation (i.e. the number of cooperative relationships) is positively and significantly associated with the probability of introducing all but one type of innovation (marketing, which is not quite significant at the 10% level; p=0.11). In addition, while our results in each case hint at a curvilinear relationship between the breadth of cooperation and technological and non-technological innovations (positive linear effects are consistently matched by the hypothesized negative quadratic effects), only linear effects are statistically significant (similar findings when innovation output is measured by innovative sales are reported in Love *et al*., 2014).

This finding suggests that the hypothesized curvilinear relationship may not apply to SMEs generally. The manufacturing SMEs in our sample benefit from having broad and extensive cooperative ties with different partners, but we do not find evidence that the positive innovation effects diminish and eventually reverse as the number of partnerships reaches a certain level (i.e. there is no turning point).

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[11] A separate model has to be estimated, because the breadth of cooperation is an exact linear combination of all seven cooperative partners.

Table 2 reports the diagnostic statistics for Models 1 and 2. Each correlation coefficient ρ represents a pairwise correlation between the error terms of the four equations in each model. If the coefficient is statistically significant, that implies that the error terms are correlated and that the two equations should be estimated jointly (Greene, 2012, p. 747). In other words, a correlation coefficient measures the correlation between the outcomes after the observed heterogeneity (i.e. observed firm characteristics) is taken into account. Given that all the correlationcoefficients are highly statistically significant, we conclude that multivariate probit is the appropriate model for our sample.

Insert Table 2 about here

The economic interpretation of these uniformly positive and highly significant correlations between each pair of error terms is two-fold:

1. all four types of innovation have significant common unobserved factors; such that
2. if a positive change in an unobserved influence increases one type of innovation then, via positive correlations, it will increase the other three types also.

This provides unambiguous evidence that all four types of innovation activities are complementary (Schmiedeberg, 2008). This complementarity is a contemporaneous effect – i.e. the unobserved influences act on all four types of innovation at the same time. Of course, this does not exclude the possibility of “lock-in” effects on one or more types of current innovations, from capabilities established in the past.

Table 3 shows the results of the ordered logit models for the dependent variable *Innovative sales* (Model 3 with individual cooperative partners and Model 4 with the breadth of cooperation and breadth squared as the variables of interest). The Model 3 estimates suggest that cooperation with customers, private sector institutions and HEIs positively and significantly increase innovative sales from product and process innovations, with cooperation with customers having a highly significant impact (at the 1% level). Therefore, while cooperation with customers was the only cooperative tie without any effect on technological and non-technologicalinnovations (Table 1), it exerts the largest and a highly significant effect on innovative sales, which measures the commercial success of technological product and process innovations (Love *et al.*, 2014). Miotti and Sachwald (2003) found that vertical cooperation in a sample of French firms, unlike cooperation with competitors and public institutions, was the only form of cooperation that increases innovative sales, whilst Von Hippel (1988) identified cooperation with customers as relevant for mitigating the risk inherent to the market introduction of innovation (Belderbos *et al.*, 2004b). Our findings on the impact of cooperation with customers on innovative sales are consistent with these previous contributions to the literature. In addition, a significant influence of cooperation with private sector institutions and HEIs could be explained by both a low likelihood of knowledge leakage (that is, no commercial risk), coupled with a broad knowledge base that these cooperative partners can provide to firms.

Insert Table 3 about here

Overall, the findings reported in Model 3 coincide with those of Harris, Coles, and Dickson (2000), who argue that cooperation for innovation is important in facilitating innovation activities, but does not necessarily result in commercial success. In other words, cooperative partners that influence the introduction of technological innovation do not significantly affect the commercial success of this form of innovation.

Although not all types of cooperation prove to be statistically significant promoters of commercial success, the Model 4 estimates imply that breadth of cooperation has a highly positive effect on innovative sales (at the 1% level), without exhibiting a statistically significant non-linear relationship with this measure of innovation output. Therefore, looking at both Models 2 and 4, we conclude that SMEs benefit from diverse cooperative networks, which is reflected in higher innovation performance as well as in the commercial success of innovation. Given that most SMEs in our sample are innovative firms, this conclusion echoes that of Freel (2000), who argues that innovative small firms engage in diverse and extensive cooperation with a number of partners, although the impact of cooperation with each individual partner might not be necessarily beneficial to small firms.

Lookingat the impact of other explanatory variables in Models 3 and 4, it can be noted that very strong competitive pressure is again negatively associated with innovative sales, while initial conditions with respect to total resources devoted to innovation activities and to firms' established innovation capacity for product innovation positively affect innovation performance measured by innovative sales.

Table 4 presents the marginal effects for Model 3. These reveal striking results for the influence of our variables of interest on firms' abilities to achieve commercial success through innovation: devoting more resources to innovation (*Resources*), above average or leading capacity for product innovation (*Capacity_product*), cooperation with customers (*Coop_customers*), and cooperation with private-sector institutions (*Coop_private sector*) all reduce the probabilities of firms being in the lower categories of innovative sales (0%, 1-5% and 6-10%) while increasing the probability of being in the higher categories (16-25%, 26-50% and >50%). In each case, these results are uniformly statistically significant, while in no case is there a statistically significant effect for the median category of 11-15 percent. In addition, the same pattern appears for above average or leading capacity for organizational innovation (*Capacity_org*) and for cooperation with HEIs (*Coop_HEIs*), although these estimates are not uniformly statistically significant. Finally, these estimates also contribute to understanding the effects of competition on the ability of firms to achieve commercial success through innovation: very high competitive pressures increase the probability of firms being in the lower categories while reducing the probability of being in the higher categories. Of course, marginal effects can be interpreted quantitatively. In each case, the estimated effects are neither too large to be implausible nor too small to be economically irrelevant: statistically significant estimates range from the effect of cooperating with HEIs on the probability of a firm being in the lowest category of commercial success (a reduction of 1.8%) to the effect of cooperating with customers on the probability of being in the highest category of commercial success (an increase of 12.2%). These are economically substantial effects. In all respects, the marginal effects for Model 4 are similar (see Appendix Table A3). The one addition is the effect of breadth of cooperation on commercial success: an additional cooperative partner is associated with reductions of between 2.8 and 6.9 percent in the probabilities of a firm being in one of the three lower categories and increases of between 4.5 and 6.0 percent in the probabilities of being in one of the three higher categories. (Once again, there is no statistically significant effect with respect to the median category).

Insert Table 4 about here

CONCLUSIONS

In this study we investigate how cooperation with different partners affects the innovation performance of SMEs in traditional manufacturing industries in the European Union. Innovation performance is measured in two ways: as the introduction of technological and non-technological innovations; and as innovative sales, with this latter measurement reflecting the commercial success of technological innovations. Additionally, we report the impact of breadth of cooperation on both measures of innovation performance.

Summary statistics for our sample established that vertical cooperation (with customers and suppliers) is much more common than horizontal cooperation (with competitors). However, our estimates show that both can promote innovation. Accordingly, while this is not a major feature of our study, this evidence suggests that both resource-based and transaction costs perspectives receive support from our data and estimates.

Table 5 summarizes all of the estimated effects of cooperation reported in this study, by setting out the statistically significant effects of different types of cooperation on the different measures of innovation performance. Our study provides four substantive conclusions. The first is that cooperation promotes innovation by SMEs in traditional manufacturing industry. This is demonstrated most clearly by the uniformly positive impact of additional partnerships (*Breadth*) on both the types of innovation enacted and on the commercial success of technological innovation: additional partners are associated with firms enacting higher levels of product, process and organizational innovation as well as with reduced probabilities of achieving low levels of increased innovative sales and increased probabilities of achieving higher levels of innovative sales. Moreover, the estimated magnitudes (see Table A4) suggest that these estimated commercial effects are economically substantial.

Insert Table 5 about here

Our estimates do not provide statistically significant support for the commonly observed non-linear ("inverted-U") relationship between the breadth of cooperation and innovation performance. A little microeconomic theorising may help to relate this finding to known specifics of SMEs in traditional manufacturing industries. We assume: (1) that for a representative firm the total innovation benefit (TIB) is a positive function of search effort (proxied by the number of cooperative external relationships) subject to diminishing returns (perhaps reflecting absorptive capacity as a fixed factor); (2) that total innovation costs (TIC) rise linearly in proportion to the number of cooperative external relationships; and (3) that for the first cooperative external relationship TIB>TIC (otherwise the optimum private number of cooperative external relationships is zero). The corollary is that the total innovation return (i.e. the difference between TIB and TIC) at first rises with each successive cooperative external relationship and then falls. Eventually the marginal innovation return becomes negative once the "oversearch" threshold level of search – at which TIB=TIC – is exceeded. In the light of this reasoning, our findings have implications for both business and public policy. First, because cooperation is less well established among SMEs in traditional manufacturing industries than among firms more generally (the mean number is 1.6 in our sample), the number of partnerships is starting from a low base and thus the innovation effects are less subject to diminishing returns. If so, then the level of cooperation among traditional sector SMEs is not only low in a numerical sense but also in the economic sense that such firms typically have not yet reached a level of search that is optimal from the perspective of innovation. Secondly, policy makers need have no fear that policies designed to induce marginal increases in external cooperation by traditional sector SMEs will push them towards "oversearch" from either a private or social perspective.

These findings emphasize the importance of diverse and extensive cooperative networks for European SMEs in traditional manufacturing industry. For owners and managers, the emergent message appears to be that innovation performance can be enhanced if a portfolio approach to cooperation is adopted. This approach to cooperation promotes both innovation and its commercialization.

The second conclusion is that among individual types of cooperation the performance effects are heterogeneous. First, with respect to types of enacted innovation, most of the estimated positive effects (four from seven) arise from cooperation either with Higher Education Institutions (such as universities) or with other public-sector knowledge providers. This is consistent with public support measures designed to promote partnerships between SMEs and external knowledge providers (through for example, "innovation vouchers").

Secondly, our estimates consistently indicate that cooperation with customers, private-sector knowledge providers and, albeit not so strongly, HEIs promote technological innovation with commercial impact, but do not provide evidence for positive performance effects from other types of partner.

In spite of our particular focus on SMEs in traditional industries, our findings on the innovation effects of particular forms of cooperation are broadly in line with studies using less restrictive samples. First, in common with Miotti and Sachwald (2003) we find that cooperation with customers has a highly positive impact on innovative sales; although, contrary to other studies (e.g. Nieto and Santamaria, 2010; Lasagni, 2012; Tomlinson and Fai, 2013), we found that vertical cooperation with customers and suppliers has no impact on product and process innovations. Second, our finding of a positive effect of horizontal cooperation with competitors on product innovation but not on process innovation is, in part, consistent with Tomlinson and Fai (2013), who report an insignificant effect of cooperation with competitors on both forms of technological innovation. Third, our finding that cooperation with public sector knowledge providers is positively associated with product, process and organizational innovations is consistent with Lasagni (2012), who found a positive influence of cooperationwith research organizations on product innovation. Likewise, our converse finding, that cooperation with public sector knowledge providers does not enhance the commercial success of technological innovations, is consistent with Zeng *et al*. (2010). Finally, concerning non-technological innovations, our findings partly coincide with Sánchez–Gonzáles (2014), who reports a positive impact of each cooperative partner (suppliers, customers, competitors, experts, and universities), but are more in line with Pippel (2014), who found heterogeneous performance effects of cooperation on non-technological innovations.

The third conclusion extends our discussion of heterogeneity. Namely, cooperative partners that influence the introduction of technological innovation do not necessarily affect the commercial success of this form of innovation; and vice versa. For example, while cooperation with customers was not found to affect technological innovations, it exerts the largest and a highly significant effect on innovative sales.

The fourth conclusion arises from the finding that all four types of innovation have significant common unobserved factors. Accordingly, if a positive change in an unobserved influence at firm level (e.g. a change in management) increases one type of innovation then it will increase the other three types as well. This provides unambiguous evidence that all four types of innovation activities are complementary. For policy makers this suggests that public support programs to promote SME innovation in traditional manufacturing industry should be demand-led (i.e. flexible with respect to SME needs) rather than supply led (i.e. narrowly prescriptive with respect to one or other aspect of technological or non-technological innovation). Correspondingly, owners and managers are best advised to take a holistic approach to innovation (i.e. to be aware that innovation in one area may well require complementary innovations elsewhere).

As well as new findings for our variables of interest, the estimated effects of the control variables are either consistent with the existing literature (e.g. on the effects of competition and absorptive capacity) or suggest further lines of enquiry (e.g. with respect to the “lock in” effects of established innovative capacities). We find that very high levels of competitive pressure tend to reduce firms' innovativeness, which is in line with the Industrial Organization literature. We also find that established absorptive capacity can have both positive and negative impacts, depending on the type of innovation. This finding might be relevant for owners and managers, as it may indicate an adverse "lock-in" effect.

We recognize some inherent limitations to our study. First; the survey questionnaire did not contain a question on the intensity of cooperative ties, which would have enabled exploration of the innovation effects of depth of cooperation.

Second; although, within the limitations of cross-section survey data, we do control for firms' time-invariant (or slowly moving) characteristics – panel data with at least four or five waves would be required to explore the medium and long-run effects of cooperation for innovation (Belderbos *et al*., 2004b; Pittaway *et al*., 2004; Aschhoff and Schmidt, 2008). And finally, because our dataset is restricted to SMEs, it was naturally notpossible to compare results between small and large firms.

REFERENCES

Aghion, P., N. Bloom, R. Blundell, R. Griffith, and P. Howitt. 2005. Competition and Innovation: an Inverted U Relationship. *Quarterly Journal of Economics* 120(2): 701–728.

Arranz, N., and J.C.F. de Arroyabe. 2008. The choice of partners in R&D cooperation: An empirical analysis of Spanish firms. *Technovation* 28(1–2): 88–100.

Aschhoff, B., and T. Schmidt. 2008. Empirical Evidence on the Success of R&D Cooperation—Happy Together? *Review of Industrial Organization* 33(1): 41–62.

Azagra–Caro, J.M., F. Archontakis, A. Gutierrez–García, and I. Fernández–de–Lucio. 2006. Faculty support for the objectives of university–industry relations versus degree of R&D cooperation: The importance of regional absorptive capacity. *Research Policy* 35(1): 37– 55.

Barney, J. 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management* 17(1): 99–120.

Belderbos, R., M. Carree, B. Diederen, B. Lokshin, and R. Veugelers. 2004a. Heterogeneity in R&D cooperation strategies. *International Journal of Industrial Organization* 22(8-9): 1237–1263.

Belderbos, R., M. Carree, and B. Lokshin. 2004b. Cooperative R&D and firm performance. *Research Policy* 33(10): 1477–1492.

Belderbos, R., M. Carree, B. Lokshin, and J.F. Sastre. 2015. Inter-temporal patterns of R&D collaboration and innovative performance. *Journal of Technology Transfer* 40(1): 123–137.

Bessant, J., and H. Rush. 1995. Building bridges for innovation: the role of consultants in technology transfer. *Research Policy* 24(1): 97–114.

Bidault, F., C. Despres, and C. Butler. 1998. New product development and early supplier involvement (ESI): the drivers of ESI adoption. *International Journal of Technology Management* 15(1/2): 49–69.

Blundell, R., R. Griffith, and J. Van Reenan. 1995. Dynamic Count Data Models of Technological Innovation. *Economic Journal* 105(429): 333–344.

Bogers, M., A. Afuah, and B. Bastian. 2010. Users as innovators: A review, critique and future research directions. *Journal of Management* 36(4): 857–875.
Bruce, M., and B. Morris. 1998. In house, out-sourced or a mixed approach to design. In *Management of Design Alliances: Sustaining Competitive Advantage*, ed. M. Bruce and B. Jevnaker, 39–64. Chichester: John Wiley & Sons.
Cappellari, L., and S.P. Jenkins. 2003. Multivariate probit regression using simulated maximum likelihood. *Stata Journal* 3(3): 278–294.
Cassiman, B., and R. Veugelers. 2002. R&D cooperation and spillovers: Some empirical evidence from Belgium. *American Economic Review* 92(4): 1169–1184.
Chen, J., Y. Chen, and W. Vanhaverbeke. 2011. The influence of scope, depth, and orientation of external technology sources on the innovative performance of Chinese firms. *Technovation* 31(8): 362–373.
Chun, H., and S.-B. Mun. 2012. Determinants of R&D cooperation in small and medium-sized enterprises. *Small Business Economics* 39(2): 419–436.
Cohen, W.M., and D.A. Levinthal. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly* 35(1): 128–152.
Cohen, W.M., R.R. Nelson, and J. Walsh. 2002. Links and impacts: the influence of public research on industrial R&D. *Management Science* 48(1): 1–23.
Chesbrough, H. 2003. *Open Innovation*. Cambridge, MA: Harvard University Press.
De Faria, P., F. Lima, R, and Santos. 2010. Cooperation in innovation activities: The importance of partners. *Research Policy* 39(8):1082–1092.
De Propris, L. 2002. Types of innovation and inter-firm co-operation. *Entrepreneurship and Regional Development* 14(4): 337–353.
Doran, J. 2012. Are differing forms of innovation complements or substitutes? *European Journal of Innovation Management* 15(3): 351–371.
Ebersberger, B., C. Bloch, J.S. Herstad, and E. Van de Velde. 2012. Open Innovation Practices and Their Effect on Innovation Performance. *International Journal of Innovation and Technology Management* 9(6): 1–22.
European Commission. 2008. The *New SME Definition: User Guide and Model Declaration*. Enterprise and Industry Publications: European Union Publications Office.
Faems, D., B. van Looy, and K. Debackere. 2005. Interorganizational Collaboration and Innovation: Toward a Portfolio Approach. *Journal of Product Innovation Management* 22(3): 238–250.
Fitjar, R.D., and A. Rodriguez–Pose. 2013. Firm collaboration and modes of innovation in Norway. *Research Policy* 42(1): 128–138.
Fontana, R., A. Geuna, and M. Matt. 2006. Factors affecting university–industry R&D projects: The importance of searching, screening and signalling. *Research Policy* 35(2): 309–323.
Freel, M. 2000. External linkages and product innovation in small manufacturing firms. *Entrepreneurship and Regional Development* 12(3): 245–266.
Fujimoto, T., M. Iansiti, and K.B. Clark. 1996. External integration in product development. In *Managing Product Development*, ed. T. Nishiguchi, 121–161, Oxford: Oxford University Press.
Gemünden, H.G., P. Heydebreck, and R. Herden. 1992. Technological interweavement: a means of achieving innovation success. *R&D Management* 22(4): 359–375.
GPrix. 2011. *Deliverable 1.8: Innovation Pathways in SMEs of the traditional sectors*. Available at: http://www.business.staffs.ac.uk/gprix/docs/Del_1_8_Innovation_Pathways_SMEs_Traditional_Sectors.pdf

Greene, W.H. 2012. *Econometric analysis*. (7th ed.). Upper Saddle River: NJ: Prentice Hall.
Grimpe, C., and U. Kaiser. 2010. Balancing Internal and External Knowledge Acquisition: The Gains and Pains from R&D outsourcing. *Journal of Management Studies* 47(8): 1483–1509.
Gronum, S., M. Verreynne, and T. Kastelle. 2012. The Role of Networks in Small and Medium-Sized Enterprise Innovation and Firm Performance. *Journal of Small Business Management* 50(20): 257–282.
Hagedoorn, J. 1993. Understanding the rationale of strategic technology partnering: inter-organizationalmodes of cooperation and sectoral differences. *Strategic Management Journal* 14(2): 371–385.
Hagedoorn, J., and N. Wang. 2012. Is there complementarity or substitutability between internal and external R&D strategies? *Research Policy* 41(6):1072-1083.
Harris, L., A.M. Coles, and Dickson K. 2000. Building Innovation Networks: Issues of Strategy and Expertise. *Technology Analysis & Strategic Management* 12(2): 229–241.
Kaivo-oja, J. 2009. Integrating Innovation and Foresight Research Activities: Key Models and Challenges in Non-Technical and Non-Economic Innovation Actions. In *Non-technological and non-economic innovations: Contributions to a theory of robust innovation*, ed. S. Roth, 195–215. Peter Lang AG: Bern, Berlin, Bruxelles, Frankfurt am Main, New York, Oxford, Wien.
Kaminski, P.C., A.C. de Oliveira, and T.M. Lopes. 2008. Knowledge transfer in product development processes: a case study in small and medium enterprises (SMEs) of the metal- mechanic sector from São Paulo, Brazil. *Technovation* 28(1–2): 29–36.
Katila, R., and G. Ahuja. 2002. Something old, something new: a longitudinal study of search behavior and new product introduction. *Academy of Management Journal* 45(8): 1183–1194.
Kleinknecht, A., K.V. Montfort, and E. Brouwer. 2002. The non-trivial choice between innovation indicators. *Economic of Innovation and New Technology* 11(2): 109–121.
Lasagni, A. 2012. How Can External Relationships Enhance Innovation in SMEs? New Evidence for Europe. *Journal of Small Business Management* 50(2): 310–339.
Laursen, K. 2011. User-producer interaction as a driver of innovation: costs and advantages in an open innovation model. *Science and Public Policy* 38(9): 713–723.
Laursen, K., and A. Salter. 2004. Searching low and high: what types of firms use universities as a source of innovation? *Research Policy* 33(8): 1201–1215.
Laursen, K., and A. Salter. 2006. Open for innovation: The role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal* 27(2): 131–150.
Leiponen, A., and C.E. Helfat. 2010. Innovation Objectives, Knowledge Sources, and the Benefits of Breadth. *Strategic Management Journal* 31(2): 224–236.
Liker, J.K., R.R. Kamath, S.N. Wasti, and M. Nagamachi. 1996. Supplier involvement in automotive component design: are there really large US Japan differences? *Research Policy* 25(1): 59–89.
Lilien, G., P.D. Morrison, K. Searls, M. Sonnack, and E. von Hippel. 2002. Performance assessment of the lead user generation process for new product development. *Management Science* 48(8): 1042–1060.
Link, A.N., and J.T. Scott. 2005. Universities as partners in US research joint ventures. *Research Policy* 34(3): 385–393.
López, A. 2008. Determinants of R&D cooperation: Evidence from Spanish manufacturing firms. *International Journal of Industrial Organization* 26(1): 113–136.
Love, J.H., S. Roper, and P. Vahter. 2014. Learning from openness: The dynamics of breadth

in external innovation linkages. *Strategic Management Journal* 35(11): 1703–1716.

Mariti, P., and R.H. Smiley. 1983. Co-operative agreements and the organization of industry. *Journal of Industrial Economics* 31(4): 437–451.

Martinez–Ros, E., and J.M. Labeaga. 2009. Product and Process Innovation: Persistence and Complementarities. *European Management Review* 6(1): 64–75.

Miotti, L., and F. Sachwald. 2003. Co-operative R&D: why and with whom? An integrated framework of analysis. *Research Policy* 32(8): 1481–1499.

Miravete, E., and J. Pernías. 2006. Innovation Complementarity and Scale of Production. *Journal of Industrial Economics* 54(1): 1–29.

Mohnen, P., and C. Hoareau. 2003. What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. *Managerial and decision economics* 24(2-3): 133–145.

Neale, M.R., and D.R. Corkindale. 1998. Co-developing Products: Involving Customers Earlier and More Deeply. *Long Range Planning* 31(3): 418–425.

Negassi, S. 2004. R&D cooperation and innovation: a microeconometric study on French firms. *Research Policy* 33(3): 365–384.

Nieto, M., and L. Santamaría. 2010. Technological collaboration: bridging the innovation gap between small and large firms. *Journal of Small Business Management* 48(1): 44–69.

Nishiguchi, T., and M. Ikeda. 1996. Suppliers' innovation: understated aspects of Japanese industrial sourcing. In *Managing Product Development*, ed. T. Nishiguchi, 206–232. Oxford: Oxford University Press.

Ortega–Argilés, R., M. Vivarelli, and P. Voigt. 2009. R&D in SMEs: a paradox? *Small Business Economics* 33(1): 3–11.

OECD. 2005. *Oslo Manual: Guidelines for Collectingand Interpreting Innovation Data*. (3rd ed.). Organization for Economic Development and Co-operation, Paris.

Perez, M., and A. Sanchez. 2002. Lean production and technology networks in the Spanish automotive supplier industry. *Management International Review* 42(3): 261–277.

Pippel, G. 2014. R&D cooperation for non-technological innovations. *Economics of Innovation and New Technology* 23(7): 611–630.

Pittaway, L., M. Robertson, M. Kamal, D. Denyer, and A. Neely. 2004. Networking and innovation: a systematic review of the evidence. *International Journal of Management Reviews* 5(3-4): 137–168.

Podsakoff, P.M., and D.W. Organ. 1986. Self-reports in organizational research: Problems and prospects. *Journal of Management* 12(4): 69–82.

Ragatz, G.L., R.B. Handfield, and T.V. Scannell. 1997. Success Factors for Integrating Suppliers into New Product Development. *Journal of Product Innovation Management* 14(3): 190–202.

Raymond, L., and J. St–Pierre. 2010. R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification. *Technovation* 30(1): 48–56.

Robertson, M., and J. Swan. 1996. The role of networks in the diffusion of technological innovation. *Journal of Management Studies* 33(3): 333–359.

Sako, M. 1994. Supplier Relationships and Innovation. In *The Handbook of Industrial Innovation*, ed. M. Dodgson and R. Rothwell, 268–274. Cheltenham: Edward Elgar.

Sánchez-Gonzáles, G. 2014. Cooperation with External Agents and Non-technological Innovations. In *Management Innovation*, ed. H. Hervás–Oliver and M. Peris–Ortiz, 139–158. Switzerland: Springer Proceedings in Business and Economics, Springer International Publishing.

Santamaria, L., M.J. Nieto, and A. Barge–Gil. 2009. Beyond formal R&D: Taking advantage

of other sources of innovation in low–and medium-technology industries. *Research Policy* 38(3): 507–517.
Santarelli, E., and A. Sterlacchini. 1990. Innovation, formal vs. informal R&D, and firm size: some evidence from Italian manufacturing firms. *Small Business Economics* 2(3): 223–228.
Schmidt, T., and C. Rammer C. 2007. Non-technological and Technological Innovation: Strange Bedfellows? ZEW discussion paper 07–052. Centre for European Economic Research, Mannheim. Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1010301
Schumpeter, J. 1947/2010. *Capitalism, Socialism and Democracy*. New York: Harper and Row.
Shaw, B. 1994. User/supplier links and innovation. In *The Handbook of Industrial Innovation,* ed. M. Dodgson and R. Rothwell, 275–284. Cheltenham: Edward Elgar.
Schmiedeberg, C. 2008. Complementarities of innovation activities: An empirical analysis of the German manufacturing sector. *Research Policy* 37(9): 1492–1503.
Taylor, R. 1990. Interpretation of the Correlation Coefficient: A Basic Review. *Journal of Diagnostic Medical Sonography* 6(1) 35–39.
Teece, D.J. 1986. Profiting from technological innovation. Implications for integration, collaboration, licensing and public policy. *Research Policy* 15(6): 285–305.
Tether, B. 2002. Who cooperates for innovation and why. An empirical analysis. *Research Policy* 31(6): 947–967.
Tidd, J., and M. Trewhella. 1997. Organizational and technological antecedents for knowledge acquisition and learning. *R&D Management* 27(4): 359–375.
Tomlinson, P.R., and F. Fai. 2013. The nature of SME Co-operation and innovation: A multi-scalar and multi-dimensional analysis. *International Journal of Production Economics* 141(1): 316–326.
Un, C.A., A. Cuervo–Cazurra, and K. Asakawa. 2010. R&D Collaborations and Product Innovation. *Journal of Product Innovation Management* 27(5): 673–689.
Urban, G.L., and E. Von Hippel. 1988. Lead user analysis for development of new industrial products. *Management Science* 34(5): 569–582.
Vega–Juardo, J., A. Gracia–Guitierrez, and I. Fernandez–De–Lucio. 2009. Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry. *Industrial and Corporate Change* 18(4): 637–670.
Von Hippel, E.1988. *The Sources of Innovation*. New York: Oxford University Press.
Williamson, O.E. 1985. *The Economic Institutions of Capitalism*. New York: The Free Press.
Wintjes, R., D. Douglas, J. Fairburn, H. Hollanders, and G. Pugh. 2014. Beyond product innovation: improving innovation policy support for SMEs in traditional industries. UNU-MERIT working paper 2014–032. Maastricht Economic and Social Research Institute on Innovation and Technology. Available at: www.merit.unu.edu/publications/wppdf/2014/wp2014-032.pdf
Zeng, S.X., X.M. Xie, and C.M. Tam. 2010. Relationship between cooperation networks and innovation performance of SMEs. *Technovation* 30(3): 181–194.
Ziegler, A., and J.S. Nogareda. 2009. Environmental management systems and technological environmental innovations: Exploring the causal relationship. *Research Policy* 38(5): 885–893.

Table 1. Multivariate probit model: dependent variables *Product innovation, Process innovation, Organizational innovation, Marketing innovation*

	Model 1				Model 2				
Independent variables	**Product innovation**	**Process Innovation**	**Organizational Innovation**	**Marketing innovation**	**Product innovation**	**Process innovation**	**Organizational innovation**	**Marketing innovation**	
Size	0.000	0.004	0.008**	-0.001	-0.000	0.004	0.007**	-0.001	
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)	0.302
	(0.336)	(0.271)	(0.284)	(0.235)					
Coop_HEIs	0.648**	0.102	0.222	0.139					
	(0.312)	(0.262)	(0.252)	(0.227)					
Coop_public sector	1.209**	0.749**	0.748**	-0.029					
	(0.585)	(0.336)	(0.309)	(0.281)					
Breadth					0.429**	0.404**	0.464***	0.258	
					(0.195)	(0.182)	(0.176)	(0.161)	
Breadth_square					-0.010	-0.025	-0.013	-0.011	
					(0.045)	(0.041)	(0.042)	(0.036)	
Constant	0.081	0.223	-0.627**	-0.631**	0.015	0.033	-0.788**	-0.569*	
	(0.350)	(0.370)	(0.315)	(0.317)	(0.323)	(0.359)	(0.313)	(0.307)	
Industry DVs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Country DVs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
No of obs.	254				254				
Log pseudolikelihood	-381.20				-391.28				
Wald χ^2 (108)	517.88***				400.96***				

LR test on $\rho_{21}=\rho_{31}=\rho_{41}=\rho_{32}=\rho_{42}=\rho_{43}=0$; $\chi^2(6)=75.09$***	LR test on $\rho_{21}=\rho_{31}=\rho_{41}=\rho_{32}=\rho_{42}=\rho_{43}=0$; $\chi^2(6)=73.58$***

Notes: Robust standard errors in parentheses. The number of draws is 16. *** p<0.01, ** p<0.05, * p<0.1.

Table 2. Correlation coefficients for Models 1 and 2

Correlation coefficients	Model 1	Model 2
ρ_{21}	0.792*** (0.081)	0.762*** (0.076)
ρ_{31}	0.518*** (0.114)	0.488*** (0.124)
ρ_{41}	0.556*** (0.096)	0.522*** (0.101)
ρ_{32}	0.560*** (0.157)	0.582*** (0.163)
ρ_{42}	0.549*** (0.142)	0.523*** (0.125)
ρ_{43}	0.552*** (0.103)	0.499*** (0.110)

Notes: *** p<0.01; ρ_{21} denotes the correlation coefficient between the error terms of two equations *Process innovation and Product innovation*; ρ_{31} denotes the correlation coefficient between the error terms of equations *Organizational innovation and Product innovation*; ρ_{41} denotes the correlation coefficient between the error terms of equations *Marketing innovation and Product innovation*; ρ_{32} denotes the correlation coefficient between the error terms of equations *Organizational innovation and Process innovation*; ρ_{42} denotes the correlation coefficient between the error terms of equations *Marketing innovation and Process innovation;* ρ_{43} denotes the correlation coefficient between the error terms of equations *Marketing innovation and Organizational innovation.*

Table 3. Ordered logit model: dependent variable - innovative sales.

Independent variables	**Model 3**	**Model 4**
Size	-0.002	-0.003
	(0.002)	(0.002)
Export	0.002	0.003
	(0.004)	(0.004)
Competition	-0.706**	-0.668**
	(0.336)	(0.340)
Resources	0.518*	0.473*
	(0.285)	(0.270)
Capacity_product	0.867**	0.979***
	(0.351)	(0.327)
Capacity_process	0.518	0.502
	(0.369)	(0.350)
Capacity_org	0.805	0.743
	(0.502)	(0.469)
Capacity_marketing	-0.362	-0.335
	(0.403)	(0.379)
Coop_within group	0.047	
	(0.377)	
Coop_suppliers	0.364	
	(0.318)	
Coop_customers	1.176***	
	(0.334)	
Coop_competitors	-0.404	
	(0.499)	
Coop_private sector	0.616**	
	(0.286)	
Coop_HEIs	0.474*	
	(0.269)	
Coop_public sector	0.309	
	(0.334)	
Breadth		0.657***
		(0.231)
Breadth_square		-0.033
		(0.051)
Constant1	-2.231***	-2.152***
	(0.501)	(0.494)
Constant2	-0.672	-0.596
	(0.444)	(0.445)
Constant3	0.509	0.553
	(0.446)	(0.451)
Constant4	1.149***	1.172***
	(0.445)	(0.452)
Constant5	2.128***	2.119***
	(0.440)	(0.439)
Constant6	3.118***	3.089***
	(0.458)	(0.446)
Industry DVs	Yes	Yes
Country DVs	Yes	Yes
No of obs.	261	261
McFadden pseudo R^2	0.124	0.114
Log pseudolikelihood	-438.98	-443.93
LR χ^2	χ^2 (27) = 126.71***	χ^2 (22) =107.69***

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Marginal effects for Model 3

Independent variables	Outcome 1 Innovative sales 0%	Outcome 2 Innovative sales 1-5%	Outcome 3 Innovative sales 6-10%	Outcome 4 Innovative sales 11-15%	Outcome 5 Innovative sales 16-25%	Outcome 6 Innovative sales 26-50%	Outcome 7 Innovative sales >50%
Size	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Export	-0.000	-0.000	-0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competition	0.035*	0.080*	0.059**	-0.007	-0.056*	-0.057**	-0.053**
	(0.020)	(0.044)	(0.024)	(0.012)	(0.030)	(0.025)	(0.023)
Resources	-0.020*	-0.051*	-0.051*	-0.005	0.034*	0.045*	0.048*
	(0.011)	(0.028)	(0.029)	(0.006)	(0.019)	(0.026)	(0.028)
Capacity_product	-0.030**	-0.079***	-0.088**	-0.016	0.047***	0.076**	0.090**
	(0.012)	(0.031)	(0.037)	(0.014)	(0.016)	(0.033)	(0.045)
Capacity_process	-0.018	-0.049	-0.053	-0.008	0.031	0.046	0.051
	(0.012)	(0.032)	(0.039)	(0.011)	(0.020)	(0.034)	(0.040)
Capacity_org	-0.025*	-0.069**	-0.083	-0.020	0.037***	0.072	0.090
	(0.013)	(0.035)	(0.053)	(0.024)	(0.013)	(0.045)	(0.071)
Capacity_marketing	0.016	0.040	0.033	-0.002	-0.028	-0.030	-0.029
	(0.021)	(0.047)	(0.033)	(0.007)	(0.034)	(0.032)	(0.029)
Coop_within group	-0.002	-0.005	-0.005	-0.000	0.003	0.004	0.004
	(0.015)	(0.038)	(0.037)	(0.003)	(0.026)	(0.033)	(0.034)
Coop_suppliers	-0.014	-0.036	-0.036	-0.003	0.024	0.032	0.034
	(0.012)	(0.031)	(0.033)	(0.006)	(0.020)	(0.029)	(0.032)
Coop_customers	-0.042***	-0.109***	-0.115***	-0.020	0.062***	0.101***	0.122***
	(0.015)	(0.031)	(0.035)	(0.014)	(0.020)	(0.031)	(0.042)
Coop_competitors	0.019	0.045	0.035	-0.003	-0.032	-0.033	-0.031
	(0.028)	(0.060)	(0.037)	(0.012)	(0.044)	(0.038)	(0.034)
Coop_private sector	-0.022**	-0.058**	-0.063**	-0.010	0.036**	0.055**	0.062*
	(0.011)	(0.026)	(0.030)	(0.010)	(0.015)	(0.026)	(0.035)
Coop_HEIs	-0.018*	-0.046*	-0.048*	-0.005	0.031*	0.042	0.045
	(0.010)	(0.026)	(0.028)	(0.007)	(0.017)	(0.025)	(0.027)
Coop_public sector	-0.012	-0.030	-0.031	-0.004	0.020	0.027	0.029
	(0.012)	(0.032)	(0.035)	(0.007)	(0.020)	(0.030)	(0.034)

Notes: Robuststandard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Industry and country DVs included.

Table 5. Effects of cooperation partnerships on innovation outcomes

	Types of innovation				**Commercial impact of technological innovation**							
	Techno		**Non-techno**		**Change**	**Change in innovative sales by category**						
Types of cooperative partnership	Prod	Proc	Org.	Mkt.	Inn. sales	0%	1-5%	6-10%	11-15%	16-25%	26-50%	>50%
Coop_within group				+								
Coop_suppliers			+									
Coop_customers					+	-	-	-		+	+	+
Coop_competitors	+											
Coop_private sector			+		+	-	-	-		+	+	+
Coop_HEIs	+				+	-	-	-		+		
Coop_public sector	+	+	+									
Breadth	+	+	+		+	-	-	-		+	+	+

Notes: + denotes a statistically significant positive effect; - a statistically significant negative effect; and blank indicates no statistically significant effect

Source: Types of innovation – Table 1; Change in innovative sales – Table 3; and Change in innovative sales by category – Tables 4 and A3.

Appendix 1.

Table A1. Descriptive statistics

Variables	Mean	Standard deviation	Minimum	Maximum
Product innovation	0.811	0.399	0	1
Process innovation	0.827	0.379	0	1
Organizational innovation	0.681	0.467	0	1
Marketing innovation	0.610	0.489	0	1
Innovative sales	4.180	1.924	1	7
Size	35.563	45.205	0	230
Competition	0.232	0.423	0	1
Export	19.858	30.239	0	100
Resources	0.362	0.482	0	1
Capacity_product	0.264	0.442	0	1
Capacity_process	0.209	0.407	0	1
Capacity_org	0.134	0.341	0	1
Capacity_marketing	0.165	0.372	0	1
Coop_within_group	0.122	0.328	0	1
Coop_suppliers	0.323	0.468	0	1
Coop_customers	0.335	0.473	0	1
Coop_competitors	0.087	0.282	0	1
Coop_private sector	0.236	0.426	0	1
Coop_HEIs	0.307	0.462	0	1
Coop_public sector	0.205	0.404	0	1
Breadth	1.614	1.512	0	6
Leather industry	0.043	0.204	0	1
Ceramic industry	0.075	0.264	0	1
Textile industry	0.118	0.323	0	1
Mechanical/metallurgy industry	0.295	0.457	0	1
Automotive industry	0.106	0.309	0	1
Food processing industry	0.169	0.376	0	1
Other manufacturing industries	0.193	0.395	0	1
Spain	0.193	0.395	0	1
France	0.094	0.293	0	1
Germany	0.110	0.314	0	1
Italy	0.165	0.372	0	1
Netherlands	0.102	0.304	0	1

Portugal	0.055	0.229	0	1
United Kingdom	0.280	0.450	0	1

Table A2. Correlation matrix

Independent variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1. Size	1.000															
2. Competition	0.092	1.000														
3. Export	0.267***	-0.115**	1.000													
4. Resources	0.052	-0.103*	0.087	1.000												
5. Capacity_product	0.018	-0.085	0.107*	-0.033	1.000											
6. Capacity_process	0.072	0.029	-0.067	-0.064	0.529***	1.000										
7. Capacity_org	0.037	-0.050	0.036	0.014	0.435***	0.437***	1.000									
8. Capacity_marketing	0.038	-0.111*	-0.084	-0.004	0.400***	0.583***	0.456***	1.000								
9. Coop_within_group	0.238***	0.041	-0.041	-0.044	0.056	0.155***	0.065	0.173***	1.000							
10. Coop_suppliers	0.071	-0.126**	0.045	0.108*	0.099*	0.044	0.079	0.084	0.228***	1.000						
11. Coop_customers	-0.022	-0.056	-0.035	0.102*	0.054	0.129**	0.015	0.157***	0.199***	0.414***	1.000					
12.Coop_competitors	-0.074	-0.079	-0.105*	0.092	-0.065	-0.004	-0.058	0.018	0.092	0.067	0.193***	1.000				
13. Coop_private_sector	0.106*	-0.101*	0.150***	0.018	0.139**	0.160***	0.190***	0.200***	0.089	0.220***	0.128**	0.069	1.000			
14. Coop_HEIs	0.016	-0.103*	0.133**	0.096*	0.054	0.123**	0.058	0.183***	0.077	0.147***	0.206***	0.095*	0.334***	1.000		
15. Coop_public sector	0.061	-0.069	0.138**	0.124**	0.086	0.049	0.064	0.138**	0.016	0.062	-0.032	0.035	0.192***	0.342***	1.000	
16. Breadth	0.102*	0.091	-0.140**	0.141**	0.127**	0.183***	0.120**	0.265***	0.419***	0.621***	0.608***	0.354***	0.564***	0.627***	0.439***	1.000

Notes: ***p<0.01; **p<0.05; * p<0.1

Table A3. Marginal effects for Model 4

Independent variables	Outcome 1 Innovative sales 0%	Outcome 2 Innovative sales 1-5%	Outcome 3 Innovative sales 6-10%	Outcome 4 Innovative sales 11-15%	Outcome 5 Innovative sales 16-25%	Outcome 6 Innovative sales 26-50%	Outcome 7 Innovative sales >50%
Size	0.000	0.000	0.000	0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Export	-0.000	-0.000	-0.000	-0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Competition	0.034	0.077*	0.054**	-0.006	-0.051*	-0.054**	-0.053**
	(0.021)	(0.044)	(0.023)	(0.011)	(0.029)	(0.025)	(0.025)
Resources	-0.019*	-0.048*	-0.045*	-0.004	0.030*	0.041*	0.046
	(0.011)	(0.028)	(0.027)	(0.006)	(0.017)	(0.024)	(0.028)
Capacity_product	-0.035***	-0.091***	-0.096***	-0.019	0.047***	0.085***	0.109**
	(0.012)	(0.030)	(0.034)	(0.013)	(0.015)	(0.030)	(0.045)
Capacity_process	-0.019	-0.049	-0.050	-0.007	0.029	0.044	0.052
	(0.012)	(0.032)	(0.036)	(0.010)	(0.018)	(0.032)	(0.039)
Capacity_org	-0.025*	-0.067*	-0.075	-0.017	0.033***	0.065	0.085
	(0.013)	(0.035)	(0.049)	(0.020)	(0.012)	(0.041)	(0.067)
Capacity_marketing	0.016	0.037	0.029	-0.001	-0.025	-0.028	-0.028
	(0.020)	(0.045)	(0.030)	(0.006)	(0.031)	(0.031)	(0.029)
Breadth	-0.028**	-0.069***	-0.062***	-0.003	0.045**	0.056***	0.060***
	(0.012)	(0.026)	(0.023)	(0.007)	(0.018)	(0.021)	(0.023)
Breadth_sq	0.001	0.003	0.003	0.000	-0.002	-0.003	-0.003
	(0.002)	(0.005)	(0.005)	(0.000)	(0.004)	(0.004)	(0.005)

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Industry and country DVs included.