Disentangling open innovation strategies in SMEs: a configurational approach

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Abstract
Increasing demand granularity and shortening product life cycles impose a heavier innovation load on companies. As product portfolios need to be expanded further and market demands new products more often, R&D and innovation require more resources and risk exposure. To address this challenge, collaboration for R&D and innovation emerges as a strategic capability. Company innovation strategies have recently been characterized indeed by a tendency towards more openness; with firms increasingly relying on outside information and collaborations to develop new products, services and processes. Open innovation changes therefore how businesses work together by combining internal resources with external ones to boost innovation. The first evidence of this model concern large high-tech manufacturing companies, such as IBM or Intel, which deliberately implemented this paradigm in their innovation strategy. In contrast, small and medium-sized enterprises have received scant attention in the open innovation literature. Our work aims at examining, through a quali-quantitative analysis, the innovation performances of SMEs and how they are connected to the recourse of external collaborations, using a sample of 181 manufacturing SMEs from the Veneto region. Results come from a configurational analysis conducted through the fsQCA 3.0 software.
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1. Introduction

The open innovation (OI) model is generally implemented as a necessary organizational adaptation to changes in the environment (Chesbrough, 2003). In a world of mobile workers, abundant venture capital, widely distributed knowledge and reduced product life cycles, many companies aren’t able to afford to innovate on their own and they recur to external sources.

Following more recent conceptualizations (Chesbrough, 2003, 2006a, 2006b; Dahlander and Gann, 2010; West and Bogers, 2014), a definition widely adopted in the academic literature for OI is “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization’s business model”. These flows of knowledge may entail knowledge inflows to the focal organization (using external sources through internal processes), knowledge outflows from the focal organization (leveraging internal knowledge through external commercialization processes) or both (coupling external sources and commercialization activities). Consequently, innovation can be driven by multiple sources of knowledge, both internal and external, such as suppliers, knowledge-intensive business services, research centres and universities, customers and competitors with complementary offerings. In general, the combination of these allow to deal with costs and risks more effectively while leveraging innovative development. Thus, the adoption of OI may be led by defensive reasons such as costs and risks reduction and offensive reasons as boosting knowledge and innovation.

OI has been linked initially to high-tech context, where companies create new business opportunities based upon external sources in order to realize new technologies. However, there are also other patterns of adoption of the new paradigm. For instance, product design, new market insights, customer intimacy and business model innovation are ways to benefit from OI non necessarily based on technological innovation, paving the way to a widespread adoption of the model also in low-tech environments. Procter and Gamble and Matsushita, for instance, are among the low-tech pioneers of inbound OI.

Moreover, initial research on the effectiveness of the paradigm was limited to large companies. Recent research works have studied the importance of collaborative innovation models for small and medium enterprises (SMEs), which may be able to develop valuable niche
technologies but lack the expertise to bring them to the market and. Our work aims at deepening the OI strategies of SMEs, evaluating the different configurations of collaborative patterns that lead to an equal innovation performance. Even though companies use a systematic approach with the simultaneous adoption of different external collaborations for innovation, existent academic contributions have devoted little attention to evaluate the advantages of several combinations of collaborations; focusing instead on the outcomes associated with the analysis of each type of collaboration taken in isolation. Therefore, the purpose of our research is to fill this gap and to investigate if there are one or more configurations of external collaborations for innovation leading to high innovation performances. In other word, we would like to find out which combinations of collaborations have a better influence on the firm’s innovation performance. Furthermore, we also desire to check which are the core and peripheral elements in achieving the desired outcome. Hence, we put forward two research questions:

RQ1: Are there one or more combinations of external collaborations for innovation that lead to high innovation performance of manufacturing SMEs?

RQ2: Which are the essential elements for the realization of a high innovation performance and which are instead the elements supporting the outcome but not essential?

Our work aims at examining, through a quali-quantitative analysis, the innovation performances of SMEs and how they are connected to the recourse of external collaborations, using a sample of 181 manufacturing SMEs from the Veneto region. Results come from a configurational analysis conducted through the fsQCA 3.0 software.

The paper proceed as follows. Section 2 presents a literature review of OI research focused on SMEs; Section 3 draws the basis of the configurational approach we adopted to detect the alternative strategies SMEs can adopt for enhancing their innovation performance; Section 4 presents some concluding remarks.

2. Open innovation in SMEs

OI has been widely studied in connection to large and multinational firms. Only recently, researchers revolved attention to the relevance and the specific nature of OI strategies in SMEs (Hossain, 2015). This is also because of the observation that, in Europe, the great majority of enterprises are SMEs, and a good number of these are innovators: 30.9% regarding process and/or product innovations, 34.9% regarding marketing and/or organizational innovations (European Commission, 2018). Moreover, not only high-tech and start-ups firms innovate, but
also low-tech and established SMEs play an important role in the innovation landscape (Santamaría et al., 2009).

Considering the innovation process of SMEs, some researchers pointed out the importance of external relationships and networks for increasing their innovation performance (Edwards at al., 2005; Macpherson and Holt, 2007). For instance, it has been studied that young biotechnology SMEs count on strategic alliances to innovate, allowing them to have access to critical resources, expand their knowledge base and build legitimacy and reputation (Chesbrough et al., 2014). Moreover, it has been discovered that SMEs involved in multiple ties are more innovative than the ones using only one type of tie (Baum et al., 2000); and, SMEs that are part of both formal and informal networks have a more positive impact on discoveries than others. Indeed, the presence of personal networks (meant as a wide variety of relationships of a member) supports the diffusion of innovation within SMEs (Chesbrough et al., 2014).

According to a study conducted by Büchel and Raub (2002), SMEs engage more frequently in informal knowledge networks; and these knowledge networks are often regional initiatives focused on sharing information with a wide range of parties such as start-up firms, incubators, venture capitalists or experts (Collinson and Gregson, 2003). A peculiar role in OI practices of SMEs is hold by the presence of a variety of formal and informal inter-organizational networks, which can be together effective drivers of innovation performance (Ceci and Iubatti, 2012; Edwards et al., 2005). Zeng et al. (2010) investigated the relationships between different cooperation networks and innovation performance of small firms (to be noted that they used the American Small Business Administration definition of SME, which considers firms with less than 500 employees). Through a structural equation modelling analysis out of a survey to 137 Chinese manufacturing SMEs, they observed a significant positive relationships between inter-firm cooperation, cooperation with intermediary institutions, cooperation with research organizations and innovation performance of SMEs, of which inter-firm cooperation has the most significant positive impact on the innovation performance of SMEs. Moreover, their findings confirm that cooperation with customers, suppliers and other firms plays a more distinct role in the innovation process of SMEs than cooperation with research institutions, universities or colleges, and government agencies.

However, even though SMEs can rely on these strong external relationships and interpersonal networks, often they do not have the internal capabilities to exploit them because of their inability to proactively articulate their needs for external knowledge and because sometimes these social relations turn out to be a barrier to innovate when the SME becomes too dependent upon them (Chesbrough et al., 2014). To conclude, inter-organizational relationships and networks are important in the innovation of SMEs; however, there is a “paradox” because even
if SMEs may have these strong ties, they have difficulties in using these links in the best way (Chesbrough et al., 2014).

According to some survey-based studies conducted by Drechsler and Natter (2012), as a matter of fact it exists a positive relation between firm size and firm openness, so that, the higher the size of the company, the more is the firm openness. However, even though large companies appear to be more open than SMEs, there are other schools of thought (e.g., Barge-Gil, 2010) highlighting the existence of an inverted U-shape relationship between firm size and search breadth or, again, even if large companies are more open, SMEs have a higher OI intensity, namely a greater concentration of OI practices (Spithoven et al., 2013). According to van de Vrande et al. (2009), SMEs implement OI strategies by means of the involvement of network partners, customers and employees; while licensing IP, venturing and participation in other firms are considered unusual activities. Considering the type of approaches, SMEs tend to adopt more inbound OI activities than the outbound ones (Chesbrough et al., 2014). With reference to inbound mechanisms, they prefer non-monetary activities such as networking and informal knowledge sourcing with respect to complex transaction-based modes like in-licensing or acquisitions. This because the latter are resource intensive and need a lot of expertise and control over several aspects, which SMEs regularly lack (Dahlander and Gann, 2010). In contrast, the outbound approach is less spread; even if some cases of technology-driven and venture-capital backed entrepreneurial firms consider out-licensing of know-how and technologies as a substitute choice for developing a product and then selling it on the market (Chesbrough et al., 2014). Finally, among SMEs there are a range of varied paths toward OI and, diverse combinations of external knowledge sources are used; so, for instance, some open up only along the value chain, while others seek help from universities and research centres (Chesbrough et al., 2014). In other words, it means there are different paths of sourcing since small firms have access to different knowledge innovation sources and the value expected in each case may vary significantly (Brunswicker and Vanhaverbeke, 2014). To conclude, due to their smallness and related resource constraints, SMEs are not able to cover all the innovation activities required to realize a successful innovation (mainly in terms of commercialization of innovation activities) and, therefore, innovation in SMEs presents usually an inter-organizational and boundary-spanning component (Brunswicker and Vanhaverbeke, 2014).

Less is known about the combination of activities and, in particular, the combination of external knowledge sources and partnerships that may lead to a positive result in terms of innovation performance. There is no universal optimal network structure as it depends on the goals of the network members. The only evidences emerged in literature are that weaker ties should be emphasized during the exploration or idea generation phase; while strong ties are more
appropriate for innovation implementation or exploitation. Furthermore, the diversity of network ties bring in SMEs additional external resources, allowing to innovate across a broader range of activities. Finally, according to Brunswicker and Vanhaverbeke (2014), it appears that the diversity and combination of innovation sources rather than their total number is crucial for the success of a firm’s sourcing strategy.

Tomlinson and Fai (2013) explored the relationship between innovation (both product and process) and types of co-operation along the vertical dimension (within the supply chain) and the horizontal dimension (with competitors). Based on a survey of UK manufacturing SMEs, the authors executed a hierarchical multivariate regression that informed of the fact that the strength of cooperative ties within the value chain are important facilitators of SME’s innovative capability whereas co-operation with rivals appears to have no significant impact on the innovation performance.

Ahn et al. (2015) studied the impact of OI on firm performance, on the base of survey data from Korean innovative SMEs. The study shows that broad and intensive engagement in OI and cooperation with external partners are positively associated with firm performance; technology and market-oriented OI modes (joint R&D, user involvement and open sourcing), involving relatively low level of changes, can positively contribute to performance enhancement; and, innovative SMEs benefit from working with non-competing partners, such as customers, consultancy/intermediaries and public research institutes.

3. Exploring the innovation network in SMEs

As emerged before, SMEs have a wide range of possible relationships, formal and/or informal, they can rely on, when adopting an OI approach. For instance, they could start collaborations with clients, suppliers, competitors, KIBS and/or universities. Since the aim of the collaborations is to develop and sustain the firm’s technological capability, the choice of the partner results crucial. Indeed, there are differences among the various partners and these can even influence the type of innovation achieved (Whitley, 2002). Lasagni (2012) proved that innovation performance is higher in SMEs that are proactive in strengthening their relationships with innovative suppliers, users, and customers. Furthermore, the author shows that SMEs will have better new product development results if they improve their relationships with laboratories and research institutes. In addition, the external knowledge sources may have a different impact according to the technology intensity of the single firm. For example, sources like universities, research centres and suppliers seem to be more appropriate for pioneering high tech small firms; while demand-oriented SMEs tend to interact mainly with customers and users
Because of this, developing an appropriate collaboration strategy, to pursue OI, is an important step, which should be evaluated carefully according to the specific needs of the firm and the potential advantages in relation to the potential problems of the selected knowledge source.

### 3.1 Collaboration with universities and research centres

Universities and research centres are relevant sources for inventive trends and preindustrial knowledge as science may significantly alter the search for inventions (Brunswicker and Vanhaverbeke, 2014). However, according to the Community Innovation Survey (CIS), it emerges that in Europe only a minority of SMEs use universities or research centres as source of information for innovation. Thus, it emerges a picture of a difficult relationship between universities and small firms. SMEs generally lack of the absorptive capacity (Cohen and Levinthal, 1990) necessary to benefit from academic knowledge (Spithoven et al., 2010). Whereas, from the university’s point of view, there is the tendency to prefer larger consortia and longer-term efforts rather than investing in the creation of an interface user-friendly for SMEs (Bodas Freitas et al., 2013). Further, there are also cultural differences such as the long-term scientific research versus exploitation-oriented research of companies and incompatible reward systems, with universities focusing on publishing and firm protecting results (Brunswicker and Vanhaverbeke, 2014). In addition, SMEs often are unable to detect their real needs or to communicate them, and research centres lack of experts with specific “techno-economic” capabilities to support SME’s innovation process (Rolfo and Calabrese, 2003). Nevertheless, even though there may be some obstacles for small firms to collaborate with universities and research centres, Zeng et al. (2010) found that Chinese manufacturing SMEs cooperating with research organizations have better innovation performance. In a similar vein Apa et al. (2018), based on a sample of manufacturing SMEs of the Veneto region and specialized in low-medium technology sector, found that collaborations with universities positively affect SMEs innovation performance. Again, in the same direction, Ahn et al. (2015) discovered that external collaborations with research institutes can contribute positively to performance in a sample of Korean manufacturing SMEs. Therefore, on the base of the above-mentioned evidences from the academic world, the impact of university-industry collaboration generally appear to be positively associated to innovation performances of SMEs.
3.2 Collaboration with KIBS

Knowledge-intensive business services (KIBS) are enterprises whose primary value-added activities consist in the accumulation, creation and transfer of knowledge for developing a customized service (Bettencourt et al., 2002; Miles, 2005). In other words, they are organizations offering high intellectual value-added services (Muller and Zenker, 2001) such as design, communication, R&D, ICT and advanced logistics services to their client firms (Di Maria et al., 2012). Therefore, thanks to their services, according to Miles et al. (1995), KIBS support the innovation process of their client firms (facilitator role), transfer existing innovations from one firm to their client firms (carrier role) or initiate and develop innovations in their client firms (source role). KIBS can be said to function as catalysts, which promote a fusion of generic and quasi-generic knowledge, and the tacit knowledge, located within the daily practices of the firms and sectors they serve (den Hertog, 2010). Manufacturing firms appear to be prone to engage in collaborations for innovation purposes with KIBS. As illustrated in Di Maria et al. (2012), KIBS have assumed an increasingly important role in term of creation and transfer of knowledge, innovations and technologies for manufacturing firms. The competitive advantage of these firms is therefore closely dependent to these collaborations for designing their products (consulting, R&D and design), the communication strategy (marketing services) and the market positioning (logistics and distribution). Empirical analyses starting from that conducted by Muller and Zenker (2001) showed that manufacturing SMEs interacting with KIBS are more oriented towards innovation than non-interacting firms are and that KIBS may be seen as potential co-innovators for SMEs.

3.3 Collaboration with customers and suppliers

Through vertical collaborations with clients and/or suppliers, firms may gain significant information about new technologies, markets and users’ needs (Whitley, 2002) with a great impact on both product and process innovation. Moreover, customer-supplier involvement offers significant advantages such as increased market share, inventory reductions, improved delivery service, improved quality, and shorter product development cycles.

Considering the cooperation with suppliers, Brunswicker and Vanhaverbeke (2014) highlighted it allows companies to gain usually technological expertise with the possibility to involve them in their new product development – see also Tsai (2009). This relationship permits companies to reduce the lead times of product development, while improving flexibility, product quality and market adaptability (Zeng et al., 2010). Using the French CIS-2 survey, Miotti and
Sachwald (2003) found that there is a positive effect of collaboration with suppliers on the share of innovative product turnover. Also Faems et al. (2005) have discovered that there is a positive association between suppliers and the proportion of turnover linked to improved products analysing Belgian manufacturing firms; or, again, in a survey of Spanish manufacturing firms, Nieto and Santamaría (2007) have shown a positive link between collaboration with suppliers and the degree of product innovativeness.

Looking at the collaborations with customers and clients, Zeng at al. (2010) explained that cooperation with them could be beneficial to develop more novel and complex innovations. In other words, this means that clients as sources of information should be used more frequently by firms when the innovation under development has a higher degree of novelty. This because, according to Brunswicker and Vanhaverbeke (2014), interaction with customers gives access to “sticky information” on customer needs, customer context and customer experience so that their involvement may provide new insights into new business opportunities beyond the existing products and markets. Indeed, cooperating with customers allows companies to better identify market opportunities for technology improvement and to reduce the probability of poor design in the early stages of development; thus increasing the chances of success of new products. Moreover, understanding the needs of potential customers may facilitate firms to obtain new ideas about products (Tsai, 2009). To confirm all this, the study conducted by Faems et al. (2005) pointed out that collaborating with customers has a positive impact on product innovation performance of Belgian manufacturing firms.

To sum up, existing literature sustains the existence of a general positive link between collaborations with suppliers and clients and the innovation performance of SMEs, especially for new product development (Kaminski et al., 2008).

3.4 Collaboration with competitors

In general, over 50% of collaborative relations are between companies within the same industry or among competitors (Gnyawali and Park, 2009). These collaborations may happen with the aim of carrying out basic research and establishing standards; and it may be possible when companies face common problems that are outside the competitor’s area of influence, for instance pre-competitive research programs or co-production arrangements (Tether, 2002). Through these collaborations, firms share technological knowledge and skills, producing a synergic effect on solving common issues. From another perspective, von Hippel (1987) suggested that competitors also collaborate when technological progress may be faster with joint efforts rather than individual ones, when combined knowledge offers better advantages
than the single one and, when a unique knowledge does not provide any major competitive advantage.

However, there might arise some difficulties when cooperating with competitors, especially in relation to the fact that joint commitments may be particularly vulnerable to opportunism and they may turn to be problematic if synergies are not easily transparent (Tomlinson and Fai, 2013). Indeed, some risks connected to collaborations with competitors such as the technology leakage to rivals and the loss of control over the innovative process should be considered (Ritala and Laukkanen, 2012). Consequently, in the literature, the impact of this type of collaboration on SMEs innovation performance appears to be ambiguous. On the one hand, according to a study conducted by Quintana-Garcia and Benavides-Velasco (2004) and based on a 5-year panel examination of 73 European SMEs in the biotechnology sector, it has been found that co-operation has a positive impact upon a firm’s innovative capacity. On the other hand, there are also some works arguing the contrary. For instance, the contribution of Tomlinson and Fai (2013) declares that co-operation with rivals in manufacturing SME has no significant impact upon innovation; whereas, the study by Nieto and Santamaría (2007) shows that collaboration with competitors has a negative impact on the novelty of innovation. The same result was obtained by De Propris (2002) and Freel and Harrison (2006) on the basis of two research works on UK SMEs. Moreover, according to Narula (2004), SMEs tend to prefer to use outsourcing rather than alliances, perhaps because of the higher risks, and costs of managing such a partnership.

4. Empirical setting: some considerations about the Veneto region

The Veneto region, located in the Northeastern part of Italy, is a setting particularly interesting for its peculiar characteristics. According to Apa et al. (2018), Veneto is a region in which SMEs strongly affect the local economy. Definitely, the majority of local companies in Veneto are small or medium companies (94.1% and 5.2% respectively, on the total number of active companies); and, the medium size is becoming an increasingly influential strata (Apa et al., 2018). Second, a lot of manufacturing firms, mostly specialized in low-tech manufacturing, are present in the Veneto region: from 2015, according to the evidences given by Apa at al. (2018), employment in manufacturing made up 38.7% of the total employment of the region. The region is then emblematic for the importance of networks (based on a long tradition of industrial districts). Indeed, the economy of Veneto is characterized by several industrial districts; meant as conglomerates of more SMEs, in a specific and restricted territory, specialized in different stages of product development within one or related industries and, where innovation processes...
are realized recombining knowledge acquired via the diverse collaborations (Apa et al., 2018). Finally, Veneto is among the most developed regions in Europe in terms of employment rate and GDP per capita. Additionally, according to the Regional Innovation Scoreboard Report (European Commission, 2017), it is quite innovative, with a rank of Moderate Plus Innovator; De Marchi and Grandinetti (2017) define it among the top 5 regions of the country. Nevertheless, the region is also a case of innovation “without research” (Colombo and Lanzavecchia, 1997), because of its low public and private investments in R&D. To confirm this, Apa et al. (2018) show that R&D expenditure in the business and public sector in Veneto is lower than the average of the regions defined as leader in the European Regional Innovation Scoreboard Report (European Commission, 2017).

5. Methods and data

First, regarding the unit of analysis, we consider the official definition of SME given by the European Commission Recommendations 2003/361/EC, which identifies SMEs by their “smallness”, which is legally defined in term of upper ceiling of number of full-time employees, yearly turnover, and/or annual balance sheet total. In particular, a SME employs less than 250 employees. In addition to this headcount ceiling, a firm is qualified as SME if it meets either the turnover ceiling of less than € 50 million or the annual balance sheet ceiling € 43 million; but not necessarily both (European Commission, 2003). Data are collected through a questionnaire addressed to 181 companies operating in the manufacturing sector in Veneto; considering that the reference population was made up of 5,166 manufacturing small firms in Veneto (at 01/01/2015), with a dimension between 10-250 employees, and registered in the AIDA database (Bureau Van Dijk). This sample was drawn from a stratified sampling procedure. Firstly, the entire population was split into different subgroups (or strata) by dimension of the firm (number of employees) and access to regional public funding for innovation. We considered four classes of firm size based on number of workers (10-19, 20-49, 50-99, 100-249) and two classes of access to public support (yes or not). Secondly, we selected firms through a proportionate stratification, until the achievement of a prefixed number of observations per each subgroup. In particular, we drew companies from each stratum in order to reach a minimum sample size of 200 SMEs. However, since some responses were missing, the number of observations dropped to 181 firms. Once obtained the sample, a survey was conducted through the administration of a structured questionnaire with the CATI (Computer-Assisted Telephone Interviewing) procedure, in order to investigate SME’s innovation activities over the years 2012-2014. In particular, phone
interviews with entrepreneurs and general directors of the firms were done in the period between 01/12/2015 and 31/01/2016. The questionnaire was composed of 40 items and included five sections of questions about main firm’s characteristics, innovation outputs, internal firm’s activities and resources for innovation, external resources for innovation and public support for innovation.

To analyse data we applied a fuzzy-set qualitative comparative analysis (fsQCA). This is an analytic technique introduced by Ragin in 1987, which allows finding some combinations of explanatory variables, called causal conditions, influencing the results of a dependent variable, called outcome. Therefore, it is appropriate to use when studying how causes combine to bring about outcomes (Ragin, 2000). These causal patterns are then studied through set-subset relationships between degree of membership in the outcome set and membership in the set of a particular combination of causal conditions through Boolean Algebra. Hence, according to Ragin (2000), measurement occurs both in terms of presence/absence (1/0, crisp sets) of the causal condition and in terms of the degree of membership in the set (values between 0 and 1, where the value 0 indicates the full non-membership whereas the value 1 stands for the full membership). As highlighted by Apa and Sedita (2017), fsQCA supplements conventional correlation analysis, such as the regression model, due to three main advantages: causal complexity, asymmetry relationships and equifinality. This means that, as described by Galeazzo and Furlan (2018), fsQCA first assumes conjunctural causation, according to which the analysis considers the combined effects that a variable could produce not trying to estimate its standing alone contribution. Second, fsQCA assumes equifinality, which means that different configurations of attributes may bring to the same outcome. Moreover, by allowing that multiple, equally effective, sets of attributes lead to the desired outcome, fsQCA enables to distinguish which attributes are relevant and how they combine to achieve the result (Galeazzo and Furlan, 2018). Finally, fsQCA allows for asymmetrical relations, for instance the fact that a configuration is associated with the outcome of interest does not imply that the absence of the same configuration explains the lack of the outcome. Therefore, it follows that the use of set-subset connections in fsQCA qualifies for a more nuanced understanding of the links between attributes and expected outcomes than conventional methods that use correlation analysis. Thus, on the basis of the advantages above presented, this methodology appears useful in investing the combination of conditions and pathways that lead to a performance (outcome) and, this is particularly relevant in the OI field, because OI practices involve complex relationships among the variables of interest. Moreover, due to the cost of conducting surveys about OI practices in SMEs, it is difficult to obtain a large and complete dataset and, therefore, a quantitative method cannot be always applied. On the other hand, a case study research, based
on small samples, permits in-depth studies, but the results can be difficult to generalize. Thus, in our case fsQCA provides a middle ground between statistical large-N-studies and case study analysis (Apa and Sedita, 2017).

6. Results

6.1 Descriptive statistics

The interviewed companies of the sample are located in the Veneto region and, precisely, in the province of Vicenza (39%), Padova (18%), Verona (14%), Treviso (10%) and Venezia (10%), with a small minority located in Belluno and Rovigo. To identify the sectors in which the companies operate, we use the first two number of the ATECO code; which is an alphanumeric classification of Italian business activities. We have 21 different sectors represented. The majority of the firms belong to the metal sector (22%), followed by the machinery and the NCA appliances (17%). Mineral manufacture, other manufacturing, leather, electrical equipment and plastics range between 9% and 6%; whereas, all the others show a percentage of 4% or lower. Moreover, according to the European classification of technology intensity of industries, in our sample, only 2% of the firms belong to high-tech industries; while, considering together high-tech and medium-high tech industries, the percentage rises about to 27%. The rest of the companies are therefore in the medium-low or low-tech industries; thus representing well the peculiar characteristics of the Veneto region, mostly specialized in low-tech manufacturing.

Considering the size, the majority of the companies (80%) are small firms (less than 50 employees) and, among these, a very small part (6 out of 181, which is barely a 3%) has only 10 employees. Then, the remaining 20% are medium-sized (between 50-250). Also in this case, the distribution of the firm is a good representative of the structure of most of the companies in the Veneto region (94.1% small and 5.2% medium). Dividing then the sample by age, and classifying as young firms with less than 25 years, adult between 25 and 50 years, and old with more than 50 years, the sample is composed mainly of adult (44% of the total sample), followed by young (32%) and last, old companies (24%).

Now, we focus our attention on the core objective of our analysis, that is studying the innovation capacity of SMEs. For a first understanding of the types of innovation introduced by the firms in the sample, we adopt the classification used in the CIS (Community Innovation Survey), according to which innovations can be product, process, marketing and organizational. On the basis of the responses collected, it emerges a high propensity for innovation: 91% of the firms has introduced at least one of the four types of innovations above mentioned in the period 2012-2014. In particular, the most spread typology of innovation introduced is the product innovation.
(83.4%), followed by process (74.6%), organizational (70.2%) and marketing innovation (56.3%).

We then focus on external resources for innovation (Table 1). The survey informed that sample firms use mainly collaborations with suppliers (59.7%) and with clients (68.0%); followed by collaborations with KIBS (39.8%). Whereas, competitors and universities collaborations are less spread (16.6% and 17.7%, respectively). This result aligns with the literature (i.e., Zeng et al., 2010; Brunswicker and Vanhaverbeke, 2014). On the other hand, considering the collaborations with competitors, Ritala and Laukkanen (2012) highlighted that there may be possible threats of technological knowledge leakage that hamper this type of relation.

**Table 1 - Recourse to external sources for innovation**

<table>
<thead>
<tr>
<th>Type of partner</th>
<th>Number of firms using it</th>
<th>Over total number of firms</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaboration with suppliers</td>
<td>108</td>
<td>181</td>
<td>59.7</td>
</tr>
<tr>
<td>Collaboration with clients</td>
<td>123</td>
<td>181</td>
<td>68.0</td>
</tr>
<tr>
<td>Collaboration with competitors</td>
<td>30</td>
<td>181</td>
<td>16.6</td>
</tr>
<tr>
<td>Collaboration with universities</td>
<td>32</td>
<td>181</td>
<td>17.7</td>
</tr>
<tr>
<td>Collaboration with KIBS</td>
<td>72</td>
<td>181</td>
<td>39.8</td>
</tr>
</tbody>
</table>

Note: more than one option was possible in the answer to this question

Source: Authors’ elaboration

Considering the innovation breadth, meant as the average number of the types of innovation (product, process, organizational, marketing) in the period 2012-2014, it emerges a clear difference between firms with R&D department (with an average of 3.7) and firms without R&D office, both with and without dedicated employees to innovation projects (2.6 as average). This evidence can be explained by the role of absorptive capacity: SMEs having a formal internal R&D department benefiting the most from collaborations (here, in term of the average number of types of innovations) than SMEs having only people dedicated to R&D without a structured department or even without R&D people and department. A lack of absorptive capacity (approximated here with the presence of a structured R&D department to indicate the internal R&D efforts of a company) may lead to problems in assimilating any externally acquired technological knowledge. The presence of absorptive capacity facilitates the acquisition of the partners’ knowledge (Tsai, 2009), since, as a matter of fact, absorptive
capacity amplifies the benefits of external innovation sourcing on innovativeness (West and Bogers, 2014).

6.2 Configurational analysis

The application of the fsQCA analysis requires a process of four steps, namely data calibration, analysis of necessary conditions, truth table analysis and truth table minimization. The first step is data calibration, needed to transform variables into fuzzy set scales of degrees of membership. According Ragin (2000), this means specifying three qualitative anchors: the threshold for full membership, the threshold for full non-membership and a crossover point of maximum ambiguity regarding membership (for more details, see the section about variables specification). To calibrate the measures and translate them into set membership ones, Ragin (2009) suggests to use a combination of standards based on social or scientific knowledge or on the knowledge acquired by researchers in the field. However, when no external criterion can be employed, more sample dependent methods can be used, such as percentiles of the distribution of the standard measure (Campagnolo and Cabigiosu, 2015). The second step is the analysis of the necessary conditions: which are conditions that must be present for the outcome to occur, even though their presence does not guarantee the occurrence of the outcome. Hence, the first thing is to check if there are some causal conditions that could be considered necessary conditions and then drop them from the truth table procedure (Apa and Sedita, 2017); which is essentially an analysis of the sufficient conditions (Ragin, 2009). Conventionally, a condition is necessary if its consistency score exceeds the threshold of 0.9 (Ragin, 2006). Then, the third step is the generation of a truth table, to test the sufficient conditions. This truth table has 2k rows, where k is the number of causal conditions used in the analysis. Each row of this table shows a specific combination of the causal conditions and, the full table lists all possible combinations. In order to find the best combination, the fourth step is the truth table minimization, which aims to reduce the number of possible combinations by using an algorithm based on Boolean algebra, to identify a set of simplified combinations. The lines of the truth table are reduced by taking into consideration all the combinations that can be associated with at least two firms (column number), following a minimum consistency-level criterion. Consistency, in this case, refers to the degree to which cases correspond to the set-theoretic relationship expressed in a solution. A consistency of 1.0 means that a specific configuration has no contradictions, while lower values imply an imperfect relationship between the configuration and the outcome. Following Apa and Sedita (2017), in order to consider a subset of relationships as relevant, we use a consistency threshold of 0.75. As explained by Ragin
(2009), after the minimization, this last step of the procedure produces three solutions: a “complex” solution (which is often hardly reduced in complexity and therefore it is not considered) and then, a “parsimonious” solution and an “intermediate” solution (which instead are both used in the data analysis).

6.2.1 Variables definition

In order to access the innovation performance of SMEs, we refer to the definition given by the OECD (2005) and used in the Community Innovation Survey, according to which there are four types of innovation. We therefore consider product innovation (a good or service that is new or significantly improved), process innovation (a new or significantly improved production or delivery method), marketing innovation (a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing) and organizational innovation (a new organizational method in business practices, workplace organization or external relations). In the questionnaire, the interviewed firms have self-evaluated the introduction of the four above-mentioned categories of innovation in a 0-7 scale. With the aim to define our innovation outcome (dependent variable), we use therefore these answers coming from the questions of the survey asking the innovation intensity on a 0-7 scale for each typology of innovation and then, we sum up these four variables to create a single innovation variable, indicating the overall level of innovation for each firm. This measure, called innovation capacity, can assume values from 0 to 28.

We avoided to use information on patent activity as a key indicator for innovation performance embracing the thesis suggested by Laursen and Salter (2006), and followed by Spinthoven et al. (2013). By doing so, we reduced eventual biases, related to the fact that patenting behaviour is sector dependent and is often related to the size of the firm, with the consequence that larger companies tend to patent more than smaller ones.

Figure 1 plots the distribution of the dependent variable, showing a nonlinear distribution with two major clouds of points: one in correspondence to low innovation capacity and one associated to a medium-high innovation capacity. In the sample of SMEs, therefore, it appears a polarized behaviour towards a minimal OI strategy and, on the opposite, a tendency towards an articulated one.

This result suggested further investigation upon the two clouds of points, in order to see if a relation between the innovation capacity and the number of collaborative ties could explain them. We checked if a lower innovation capacity is associated with less collaborations and, on the other hand, if a medium-high innovation capacity is related with more intense collaboration for innovation purposes. We ran a correlation analysis (see Appendix) through R software and
we discovered that there is a positive correlation (0.56) between the two variables. Through a Pearson test, we also verified the significance of the correlation and we found that it is relevant: the p-value was equal to 2.2e-16 and, given it is lower than 0.05, we rejected the null hypothesis (which indicates a non-correlation between the two variables).

![Figure 1 – Distribution of the innovation capacity variable](image)

Finally, speaking about the causal conditions of our model (independent variables), we chose to define them as different combinations of the types of collaboration for innovation, which have been detected in the survey as collaborations with suppliers, clients, universities, KIBS and competitors.

6.2.2 Variables calibration

The fsQCA methodology at this point requires the variables calibration. To transform the dependent variable innovation capacity (incapacity - Table 2) into a fuzzy variable, with values ranging from 0 to 1 (mirroring the degree of membership of this variable into a subset), we consider a sample dependent method. This because, as explained in the previously section about the fsQCA methodology and, in particular, with reference to the discussion carried out by Campagnolo and Cabigiosu (2015), more sample dependent methods about the distribution of the variable can be used, when it is not possible to apply an external combination of standards based on social or scientific knowledge. Therefore, we decide to look at the mean minus the standard deviation of the distribution for the full non-membership threshold (value 4), the mean
for the crossover point (value 12), and the mean plus the standard deviation for the full membership threshold (value 20).

Table 2 – Descriptive statistics for our outcome variable

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Minimum</th>
<th>Maximum</th>
<th>N cases</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>inncapacity</td>
<td>11.9337</td>
<td>7.657447</td>
<td>0</td>
<td>28</td>
<td>181</td>
<td>0</td>
</tr>
</tbody>
</table>

*Source: Authors’ elaboration*

Finally, considering the causal conditions (independent variables) of our model, as previously seen defined as different combinations of collaborations with suppliers, clients, universities, KIBS and competitors, we have chosen to calibrate each one with number 0 (when there is no collaboration) and with number 1 (in presence of collaboration).

6.2.3 Truth table construction and minimization

With the calibrated variables, we have then analysed the presence of necessary conditions; we have found that none of the types of collaborations exceeds the acceptable consistency level of 0.90, as suggested by Ragin (2006). Therefore, the next step is creating the truth table (Table 3) for sufficiency, from the fuzzy data, through the “truth table” algorithm. First, the innovation capacity is set as outcome and the five types of collaborations as causal conditions. The resulting table elaborated through this algorithm includes all the possible combinations of conditions and also specifies the number of cases in which a certain configuration is found (see column “number” in the table) and the consistency measure (column “raw consist.”), indicating the proportion of cases that display the outcome. These two indexes are particularly important among the others because they are used to minimize the truth table. As explained in Ragin (2017), the aim is firstly to develop a rule for classifying some configurations as relevant and others as irrelevant, based on the number of cases. Therefore, we select two observations as the cut-off for the minimum number of cases to be present and, consequently, we eliminate the rows with less than two cases. Then, the second step suggested by Ragin (2017) is to distinguish configurations that are consistent subsets of the outcome from those that are not; by determining a consistency threshold. As explained in the section about the fsQCA methodology, we follow Apa and Sedita (2017) and we set a minimum consistency value of 0.75. Hence, in the column “inncapacity”, for all the combinations with a consistency level that doesn’t meet the defined consistency threshold, we put a 0; whereas, we classify all combinations with consistency equal or above 0.75, with 1, meaning that these last ones are cases in which the outcome is consistently found.
From the truth table, through the “Standard Analysis” command, we obtain three solutions: a complex, a parsimonious and an intermediate solution. As already mentioned, only the parsimonious (representing the core elements essential for the realization of the outcome) and the intermediate (indicating the peripheral elements which support the outcome but are not essential) solutions can be interpreted. Consequently, we consider only these two types of solution and we exclude the complex one from the discussion.

The analysis of the intermediate and parsimonious solutions allows building a table that summarizes the results, where each column represents a combination of causal conditions leading to the specified outcome. Using symbols, different results are indicated:

- The black large circle stays for the presence of a certain element as core condition, meaning an element that is essential to achieve a high level of the selected indicator of performance. These core conditions are those that are part of both the parsimonious and intermediate solutions.
- The black small circle stays for the presence of a peripheral condition, meaning an element that is present in the combination and support the core conditions. These peripheral conditions are those that are eliminated in the parsimonious solution and thus are only present in the intermediate solution.
- The white crossed circle represents the absence of an element, meaning that an element must be absent from the combination in order to reach high levels of the chosen performance indicator.
- The absence of symbols means that the element can either be present or not in the combination, without any impact. It indicates a “don’t care” situation, since the causal condition does not really affect the realization of the outcome.

<table>
<thead>
<tr>
<th>Supplier</th>
<th>KB</th>
<th>Competitors</th>
<th>Clients</th>
<th>UNI</th>
<th>Number</th>
<th>Incapacity</th>
<th>Raw Consist.</th>
<th>PRI Consist.</th>
<th>SYM Consist.</th>
</tr>
</thead>
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<td>1</td>
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</tr>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<td>0.158088</td>
</tr>
<tr>
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<td>1</td>
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<td>0.42731</td>
<td>1.000000</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
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<td>0.702830</td>
<td>0.856322</td>
</tr>
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<td>0.421652</td>
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</tr>
<tr>
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<td>0</td>
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<td>1</td>
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<td>0.615000</td>
<td>0.554913</td>
<td>0.657534</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.766667</td>
<td>0.756842</td>
<td>0.844828</td>
</tr>
</tbody>
</table>

Source: Authors’ elaboration

Table 3 – Truth table
For each of the solution provided, the procedure further indicates the consistency index (measuring the degree to which solution terms and the solution as a whole are subsets of the outcome), the solution coverage (assessing the proportion of membership in the outcome that is explained by the complete solution), the row coverage (computing the proportion of membership in the outcome explained by each term of the solution) and, finally the unique coverage (which measures the proportion of membership in the outcome explained solely by each individual solution term).

Table 4 shows the results of our fuzzy-set analysis and identifies three “equifinal” combinations of causal conditions; meaning that one can substitute the other to obtain the same result, in this case, a high innovation performance. Furthermore, from a statistical point of view, all the solutions displayed can be considered both valid and significant, since all solutions together present an overall consistency above the threshold of 75% and an overall coverage around the threshold of 25% (Schneider and Wagemann, 2012).

<table>
<thead>
<tr>
<th>Table 4 – fsQCA results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Innovation Performance</strong></td>
</tr>
<tr>
<td>Configuration</td>
</tr>
<tr>
<td>Universities</td>
</tr>
<tr>
<td>Clients</td>
</tr>
<tr>
<td>Suppliers</td>
</tr>
<tr>
<td>Competitors</td>
</tr>
<tr>
<td>KIBS</td>
</tr>
<tr>
<td>Consistency</td>
</tr>
<tr>
<td>Raw coverage</td>
</tr>
<tr>
<td>Unique coverage</td>
</tr>
<tr>
<td>Overall solution consistency</td>
</tr>
<tr>
<td>Overall solution coverage</td>
</tr>
</tbody>
</table>

Source: Authors’ elaboration

Observing the different configurations leading to high innovation performance, we can note the presence of core, peripheral and “don’t care” conditions for each one. Specifically, the first
configuration indicates universities and KIBS as core elements, suppliers and clients as peripheral conditions, while the competitor variable is not relevant. Then, the second configuration includes three elements: universities and KIBS again are the core conditions, whereas suppliers’ collaboration is the only peripheral one. All the other variables are “don’t care” conditions. Finally, the third configuration shows as core condition the presence of collaborations with KIBS; as peripheral elements, the collaborations with suppliers and clients; and, as “don’t care” conditions, all the others variables.

7. Discussion

The analysis provides a strong and original evidence concerning the OI strategies and outcome of SMEs. In order to achieve a higher innovation performance, external collaborations for innovation purposes can’t be only pursued with suppliers (configuration 2) or, in alternative, with suppliers and clients (configuration 1 and 3), since they are peripheral conditions (supporting the outcome but not essential to it); but rather complemented with KIBS (configuration 3) or KIBS and universities (configurations 1 and 2). Moreover, when comparing the different configurations, we also discover that collaborating with KIBS is a core condition in common to all the three configurations; meaning therefore that this type of collaboration is essential to reach high innovation performance. Collaborations with universities, instead, appear as a condition that matters but that is not indispensable (since they are not present in all the three configurations). Finally, with regard to competitors, they are represented in all the three cases as a “don’t care” causal condition; hence, neither their presence nor their absence leads to the outcome of interest.

Therefore, our findings highlight that the collaborations along the value chain act as a support for the innovation process of SMEs. Suppliers, on the one hand, may provide their expertise to advance the components required by a firm (Tsai, 2009); while, clients, on the other hand, may allow companies to better identify technology improvement giving information about their needs (Brunswicker and Vanhaverbeke, 2014). However, based on our findings, what it is really needed to reach high innovation performance, is collaboration with organizations specialized in knowledge absorption, production and transfer. In particular, KIBS are a central condition to our outcome of interest, since they are present in all the three configurations; whereas, collaborations with universities matter, but they are not crucial since they are a core condition in only two cases.

This particular positive impact of KIBS and universities aligns with the literature. Indeed, Muller and Zenker (2001) have shown that SMEs interacting with KIBS are more oriented
towards innovation than non-interacting firms; while, according to Brunswicker and Vanhaverbeke (2014), collaborations with universities and research centres are seen as a way for firms to obtain inventive trends and preindustrial knowledge, as science may significantly alter the search for inventions. After the seminal contribution of Muller and Zenker (2001) other studies have highlighted the positive role of KIBS in supporting SMEs innovation (see, for instance, the review by Muller and Doloreux, 2009). The importance, but not the necessary presence of universities collaborations to reach successful innovation performances can be explained by the fact that there is still a difficult relationship between universities and SMEs. Indeed, as described above in the literature review, there may be some barriers to the successful implementation of this type of collaborations. On the one hand, SMEs generally lack of absorptive capacity to benefit from academic knowledge (Spithoven et al., 2010); on the other hand, research centres normally tend to prefer longer-term efforts rather than investing in the creation of an interface user-friendly for SMEs (Bodas Freitas et al., 2013). Whereas, the essentiality of KIBS emerged in our analysis can be explained by the contribution of den Hertog (2010). He declared that KIBS provide a point of fusion between more general scientific and technological information, dispersed in the economy, and more local requirements and problems of client firms. KIBS, therefore, function as catalysts that bridge more codified scientific and technical knowledge with more tacit and know-how knowledge, which is located within the daily practices of SMEs they serve (Grandinetti, 2018). Specifically, KIBS can act as brokers between university and SMEs (this could be the case of some firms represented by configuration 3 in Table 4), or can facilitate the relationship between a firm and specific academic resources (configurations 1 and 2).

Finally, with regard to collaborations with competitors, as already said above, it emerges they are a “don’t care” condition, since they don’t really affect the realization of the outcome. Again, this result aligns with previous academic contributions, according to which this type of interactions has an unclear impact on innovation performance. On one hand, collaborations with competitors may permit companies to gain technological knowledge and skills when carrying out basic research outside the competitor’s area of influence, for instance in pre-competitive research programs or co-production arrangements (Tether, 2002); however, on the other hand, they may present some difficulties, especially in relation to the risks of technology leakage (Ritala and Laukkanen, 2012). Indeed, in existing empirical explorations, the impact is ambiguous, showing only in the biotechnology sector a positive impact on the innovation performance (Quintana-Garcia and Benavides-Velasco, 2004). Whereas, in the manufacturing sector, Nieto and Santamaría (2007) found a negative impact, while Tomlinson and Fai (2013) pointed out a not significant impact.
8. Conclusions

Our research attempted to deepen understanding the relationship between OI strategies and innovation performance in SMEs, providing empirical evidence from a sample of 181 manufacturing SMEs in the Veneto region. Existing studies in innovation management literature limit their analysis on exploring the effect of each type of partner for innovation purposes on innovation performance through regression analyses, and fail to capture the interdependencies among multiple OI configurations of external collaborations for innovation purposes. The aim of our investigation was to fill this gap. Specifically, the originality of our work relies on the investigation of the possible combinations of external collaborations for innovation leading to high innovative performance. In addition, we also identified within the configurations the core and peripheral elements. To perform our analysis, we used the fsQCA method. This has allowed us to move beyond classical statistical analyses, which normally take in isolation the effect of each single OI collaboration on the innovation performance, and rather check if there are diverse configurations of external collaborations for innovation purposes, which differently combined, lead to a high innovation performance in SMEs. Therefore, in this way, our research provided a theoretical contribution to the innovation management literature by offering an alternative exploration to the open debate on the relationship between OI strategies and innovation performance. Indeed, thanks to the configurational approach we adopted, firstly, we were able to understand how different combinations of external collaborations causally interact among each other and lead to different performance outcomes; and, secondly, to point out whether relationships among external collaborations for innovation purposes were characterized by complementarity, additive, substitution or suppression effects. Based on the results obtained from our analysis, collaborations with customers and suppliers are supportive, but not essential in the contribution to high innovation performances; since collaborations with KIBS are the discriminating factor to successful innovation outcomes. Hence, this means that the innovation model of manufacturing SMEs is based on the role of intermediaries and, in particular, on the presence of collaborations with KIBS. Therefore, from these findings, it follows that managers should pay attention on resource allocation because a high innovation performance does not depend on the adoption of the whole sets of external collaborations for innovation purposes, but rather on the implementation of only few specific collaborations. Furthermore, our results also provide a useful guideline for policy makers. Specifically, since the collaboration for innovation purposes between SMEs and KIBS appears a central condition to obtain high innovation performances, more actions in favour of this linkage should be implemented. Finally, since from the fsQCA analysis it has also emerged that
the role of universities matters and, since this type of collaboration is one of the less adopted according to the descriptive analysis of our data, another valid suggestion for policy makers is to try to put emphasis on facilitating the university-SMEs collaboration, also leveraging KIBS as facilitators.

Nevertheless, our study has also some limitations; which however could represent interesting opportunities for future new researches. The first one is that our empirical results are derived from a sample of SMEs in the Veneto region; therefore, our data are geographically bounded and findings might be region-specific. Future studies could use samples of SMEs from other Italian regions to test and extend the generalizations of the findings at country level. Then, a second limitation is connected to the fact that we studied manufacturing SMEs in Veneto operating in a specific sector. However, future research may conduct a comparative analysis with other sub-populations of SMEs from other sectors, to gain more insights on the topic. Further, referring to the method used in our analysis, it should be said that some of the fuzzy set procedures are based on selections made by the researchers who conduct the analysis (for instance, the decision of the calibration method); for that reason, some interpretational biases must be acknowledged. Then, it should also be highlighted that the fsQCA methodology is constrained in the number of causal conditions it can include. Therefore, future studies might add contingent factors influencing firms’ context (for instance internal organizational facilitators of openness) to the investigation of configurations in OI collaborations. Finally, since our work showed that suppliers and clients are supportive while KIBS are a core condition for reaching high innovation performance, future research works may investigate, for instance, whether the role of suppliers and clients is connected to specific types of innovation (i.e. obeying to a problem solving logic for supporting the everyday working routine). Alternatively, they may discover that SMEs prefer relying on partners external to the value chain in order to introduce more radical innovations.

References


**APPENDIX**

Correlation between innovation capacity and number of collaborations

<table>
<thead>
<tr>
<th>Pearson's product-moment correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>data: x and y</td>
</tr>
<tr>
<td>t = 9.0994, df = 178, p-value &lt; 2.2e-16</td>
</tr>
<tr>
<td>alternative hypothesis: true correlation is not equal to 0</td>
</tr>
<tr>
<td>95 percent confidence interval:</td>
</tr>
<tr>
<td>0.4536097 0.6545103</td>
</tr>
<tr>
<td>sample estimates:</td>
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<td>r = 0.5623362</td>
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