Determinants of innovation cooperation for manufacturing SMEs: evidence from a systematic review of the literature (1992–2015)

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Abstract: This paper summarises a comprehensive and systematic review of 29 quantitative studies from peer-reviewed journals published in ranked publications between 1992 to 2015 on the determinants of innovation cooperation for manufacturing SMEs. Applying a documented methodology, it crystallises acquired knowledge by identifying, synthesising and discussing 220 unique determinants stemming from a vast and heterogeneous body of literature. The article introduces an analytical framework integrating different perspectives to approach this concept presenting a holistic and integrated view of the topic. It provides a typology that sorts the determinants into six categories: 1) environmental characteristics; 2) industrial characteristics; 3) organisational characteristics; 4) individual characteristics; 5) partnership characteristics; 6) project characteristics. This systematic review also identifies current gaps in the literature. The provided research perspectives will allow researchers and policymakers to better foster innovation and guide researchers addressing this phenomenon in the future. It clearly lays a foundation for future research on the topic, organising and building upon the literature that has been published so far.

Keywords: innovation; cooperation; determinants; SME; manufacturing; systematic review; research and development; collaboration; firms; technology; management; research agenda.

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1 Introduction[1]

It is now widely accepted that organisations must innovate in order to be more competitive. To enhance their innovation capacity, firms increasingly partake in cooperative agreements with different types of partners to access external resources (Classen et al., 2012). Several studies have empirically demonstrated the growing importance of innovation cooperation (for instance, Bjerke and Johansson, 2015; Nunes et al., 2013; Sun and Cao, 2015). However, a plethora of terms refer to innovation cooperation which results in ambiguity regarding the way they are operationalised and utilised. Cooperation, collaboration, open innovation, strategic alliance and networking are all referring to the idea of joint projects with other organisations. In this work, we mobilised the term innovation cooperation as defined in the Oslo Manual [OECD, (2005), pp.79–80]:

> "Innovation co-operation involves active participation in joint innovation projects with other organizations. These may either be other enterprises or non-commercial institutions. The partners need not derive immediate commercial benefit from the venture. Pure contracting out of work, where there is no active collaboration, is not regarded as co-operation".

Cooperation is distinct from open information sources and acquisition of knowledge and cooperation as all parties take an active role in the work.

Besides, 'cooperative projects often benefit from the support of government agencies through several grant and subsidisation mechanisms' (Negassi, 2004). It is noted that industries differ in their innovation process and in their use of internal and external knowledge (Pavitt, 1984). There are significant differences with regards to the innovation cooperation between services and manufacturing companies with the service sector resorting more on cooperation (Pires et al., 2008). Because of these differences and in order to have a more targeted approach, this study focuses solely on the manufacturing sector in which nearly a quarter of manufacturing firms cooperate to innovate (Abramovsky et al., 2009).

It is particularly of interest for small and medium-sized enterprises (SMEs) since, according to Acs et al. (1994), external knowledge is an essential input to their innovation activity since they typically carry out less formal research and development (R&D) [Chun and Mun, (2012), p.419]. Within this literature field, special attention has been reserved to the SMEs (Kim and Vonortas, 2014) motivated from two factors:

1 'SMEs are understood to contribute critically into job creation, innovation and growth […]

2 'small companies are said to be challenged in terms of access to resources such as human and financial capital and access to broader markets' [which] 'may be alleviated by alliances' [Kim and Vonortas, (2014), p.795].

This literature puts more emphasis on technological innovation (product and process innovation) than marketing and organisational innovation. As Bayona et al. (2001) showed the reasons for cooperative R&D diverge overall between large and small firms. More precisely

> "For large-sized firms, it is the aspects related to technological developments and the particular characteristics of R&D (uncertain and costly) which lead them to cooperate in this sphere. By contrast, for small sized firms, these aspects do not appear to be significant on propensity to cooperate, with market considerations and questions related to the innovation process itself being more influential."

Nonetheless, 'the larger the size of the firm, the greater the propensity for cooperative R&D' (Bayona et al., 2001). Therefore, it is all the more important to focus on SMEs specifically in order to highlight their distinctiveness. Countries adopt different criteria to define SMEs, usually according to employment or sales between certain parameters. In this work, a paper was deemed focusing on SMEs if the firms were categorised as such by their authors.

SME managers are unlikely to make cooperation decision lightly given their inherent opportunities and drawbacks. Research has shown that managers take under consideration numerous internal and external factors in the decision-making process (Lohrke et al., 2006). These factors, qualified as determinants of innovation cooperation, are abundant and we can now contend that it is a growing stream of research. However, this body of knowledge is fragmented as highlighted by the variety of disciplines, authors and publications that are taking interest. Furthermore, scholars have explored numerous avenues so far to understand the determinants of innovation cooperation. As the literature is maturing, it is nonetheless hard to get a grasp on all of them, which make it difficult to have a clear understanding of what, has been accomplished and what are the research gaps. Therefore, it is timely to integrate the existing work to provide a clear picture of the state of the research on these determinants, which will bring forth condensed and unified insights.

Decision-making tools and diagnostics to identify the determinants of the phenomenon are lacking. To date, despite the fact that a significant number of studies have been conducted on the topic, little has been done in the way of producing a systematic review of the state of knowledge. Little prior research has been aimed at aggregating this knowledge systematically. In this sense, Wu et al. (2013, p.127) stated, "A promising avenue for future research could be a systematic investigation of the variables that have determined the observed organizational modes for innovation"; what they referred to as internal and external innovation. This systematic review will

ultimately address this research gap by identifying the determinants of innovation cooperation for manufacturing SMEs that have been studied empirically but remain dispersed across different disciplines, research communities and journals. Bringing all this work together will help draw conclusions as well as action lines to support researchers and policymakers involved in the development and promotion of innovation in firms in general, and SMEs in particular as it is currently scattered in a vast literature. To the knowledge of the authors, no systematic review exists focusing on the determinants of innovation cooperation for manufacturing SMEs.

The main objective of this work is to provide a clear picture of the findings of studies pertaining to the determinants of innovation cooperation for manufacturing SMEs. This paper contributes to the field of innovation cooperation research by progressing beyond its highly fragmented state to one that is more integrated by presenting for the first time, to the best of our knowledge, a holistic integrated view on the topic. To reach this goal, a systematic review of empirical articles published on the topic between 1992 and 2015 was performed.

The year 1992 was chosen as a start-off point for two main raisons. Firstly, it stems from the fact that the Organization for Economic Co-operation and Development (OECD) published the first version of the Oslo Manual (OECD, 1992). This is a pivotal date for the empirical research on innovation. This manual contains guidelines for the collection and interpretation of data on technological innovations. In the wake of its publication, several OECD countries quickly adopted the recommendations, making their studies more comparable.

Secondly, it is based on the chronology of the publication of the scientific articles on this research theme. A search of the ABI/Inform Complete database with the terms 'Cooperat*' and 'Innovat*' provides results from 1975. The article by Teece, published in 1992, is the first to examine the phenomenon of innovation cooperation within organisations from a more strategic perspective, focusing on the impact on the entire organisation. This article has been cited over 1,900 times. Thus, Teece (1992) published one of the founding articles on the subject of competition, cooperation, and innovation: competition, cooperation, and innovation: *organisational arrangements for regimes of rapid technological progress*.

The questions addressed by this systematic review are:

1 What are the different conceptual and operational definitions of innovation cooperation for manufacturing SMEs?

2 What are the determinants of innovation cooperation for manufacturing SMEs studied in the literature and how are they defined?

In doing so, this study advances our knowledge on the concept and identifies gaps in the literature.

The remainder of this article is organised as follows. First, the methodological procedures employed in the systematic review to identify and select the relevant data are described. Next, some characteristics of the reviewed articles are highlighted. The findings related to the dependent variable (innovation cooperation) and the independent variables (determinants of innovation cooperation) are then discussed before introducing the integrated conceptual framework of the determinants of innovation cooperation for manufacturing SMEs. This study concludes by presenting the main trends and research perspectives for researchers and policymakers.

2 Methodology: systematic review

A systematic review, defined as a 'review of the literature according to an explicit, rigorous, and transparent methodology' [Greenhalgh et al., (2004), p.582] was selected to identify peer-reviewed articles dealing with the concept of innovation cooperation. This is a scientific investigation in itself, including a planned methodology that brings together independent studies as the unit of analysis [Cook et al., (1997), p.377]. This method, increasingly employed in management literature (De Medeiros et al., 2014), was chosen because when compared to traditional literature reviews, it is considered the most efficient, accurate, and powerful way to identify and assess a vast literature (Mulrow, 1994). It is recognised as systematic, explicit, complete and reproducible [Fink, (2010), pp.15–16] as the methodology and scope are clearly defined and documented from the get-go and every article is considered indifferently (without any impact from citations for instances). We believe that applying this methodology and documenting each phase is more transparent and leads to a methodical and non-biased literature review. This proven method also limits bias, reduces the effect of chance and enhances the legitimacy of the process while providing reliable results (Becheikh et al., 2006). In addition, it helps identify promising avenues of research [Cook et al., (1997), p.378]. It was selected for this work, as it is the most dependable way to answer our research questions. The main limitation associated with this method is that the data is taken out of context since only excerpts of the original documents are preserved for analysis.

The structure of this review follows the three stage method from Tranfield et al. (2003) which was adapted from Khan et al. (2001). To respect standard journal format constraints, this article will focus on the highlights of this process and the results.

2.1 Identification of data

The search strategy to retrieve the pertinent data is composed of the five following components:

1 snowballing search in literature to identify the most relevant keywords to elaborate our database search strategy

2 electronic database search in the pertinent databases

3 manual search in selected publications with the most selected papers

4 contact of experts (corresponding authors of the final set of selected articles)

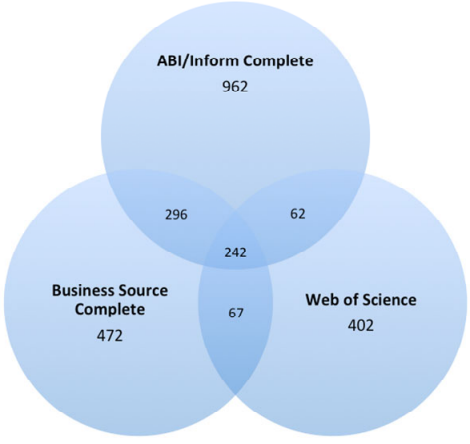
5 manual search in the references of the final set of selected articles.

2.2 Database search strategy

The terms selected for the database search strategy stem from a narrative review of the literature on the phenomenon performed on a limited number of articles (200) identified by the 'snowball' method ('pursuing references of references') (Greenhalgh and Peacock, 2005). The computerised search was conducted in three databases, namely ABI/Inform Complete of ProQuest, Business Source Complete of EBSCO and Web of Science of Thompson Reuters as per recommended by a librarian specialised in management literature. The first two databases selected are considered the two major databases in the

business field (Tucker, 2006). The multidisciplinary database selected broadens the spectrum of publications and results. The search strategy was performed in each database using a query adapted specifically to them using the Boolean operators 'AND' and 'OR'. The keywords pertaining to the concepts of 'innovation', 'cooperation' and 'SMEs' were researched in the title and abstracts as well as the subjects and keywords that are associated to each paper for a wider scope. The final version of each query that resulted from several iterations is provided in Table A1 in Appendix A. The selected database and query were validated by another librarian specialised in the systematic review method and two subject matter scholars with systematic review expertise. The reference and abstract of the 3,426 retrieved articles were managed in an EndNote X7 database. Ultimately, the number of articles obtained from the databases decreased from 3,426 to 2,503 meaning that 923 duplicates were removed following the imports (Figure 1).

Figure 1 Breakdown of the 2,503 unique articles by database (see online version for colours)



2.2.1 Criteria for selection of articles

To evaluate and choose the relevant studies, a sampling technique based on criteria was applied. To be retained for this review, a study had to meet all the inclusion and exclusion criteria without exception as well as the quality criteria. Each of them stemmed from the research objectives and a preliminary review of the literature.

a Inclusion criteria

The article must:

- Be an article published in English between 1992 and 2015 inclusively in a peer reviewed journal.
- Consider 'cooperation for innovation' as the dependent variable (the variable to be explained). Consequently, articles considering cooperation for innovation as an independent variable (explanatory variable) of another phenomenon like innovation performance were not included.

- Provide conceptual definitions and/or operational definitions of determinants of cooperation for innovation and study the determinants of innovation cooperation.
- Include a quantitative empirical study of a sample of SMEs as specified by the authors (exclusively or with results separated from large firms) belonging entirely in the private sector and operating in the manufacturing sector. We did not restrict the data analysis method used by the authors.

b Exclusion criteria

The document must not be:

- A dissertation, a thesis, a book, a book chapter, an editorial, a book review, conference proceedings, interview or a success story.
- A theoretical and conceptual study or a case study.[2]

c Quality criteria

- The journal in which the article is published must be part of at least one of three publications classifications extensively recognised by researchers in administration: Australian Business Deans Council (ABDC) Journal Quality List 2013, The Association of Business Schools (ABS) Academic Journal 2015 Guide and ISI Web of Knowledge Journal Citation Report (JCR) Social Science 2014.

To be noted that, in order to be retained, each paper analysed had to specify that the sample targeted SMEs based on their country's threshold (number of employee and/or income threshold) or present the results for SMEs separately from those of large firms.

A double screening strategy was conducted to select the pertinent articles based on the criteria. The first sort was performed on the title and the abstract of each paper and the second sort on the entire paper. The same criteria were applied in both instances with caution favouring to keep one article for the second sort, which might ultimately be rejected over rejecting one that should have been kept.

Here is the most frequent exclusion criteria applied during the sorting process:

1 Innovation cooperation is not the dependent variable but rather innovation in general, learning, etc.

2 The article focuses on the purpose of the cooperation (performance, etc.) and not on the determinants of cooperation (our objective).

3 The article does not consider the perspective of the firm but that of a partner.

4 A national innovation system is discussed and not the behaviours of firms (De Prato and Nepelski, 2013).

5. The article does not explicitly study SMEs or the size of the firms is not specified.

6 The manufacturing sector is not studied separately, for example, the service sector is also covered.

7 It is a qualitative article (e.g., Freitas et al., 2013; Smirnova et al., 2012).

2.2.2 Search strategies for other sources

Several experts, like McManus et al. (1998) recommend supplementing electronic search with other techniques to ensure exhaustivity. This systematic review was supplemented by: a manual search in the three publications with the most selected articles, the corresponding authors of the selected articles and a manual search in the references of the final set of selected articles. In doing so, the same criteria as for the database search were applied. First, all of the reference and abstract of the papers published between 1992 and 2015 in the three journals in which most of the selected articles were issued were also imported into this project's endnote database, namely *Journal of Small Business Management*, *Research Policy* and *Technovation*. The manual search executed allowed identifying one additional paper. Next, the corresponding authors of the final set of selected articles were contacted by e-mail and asked to provide additional papers pertaining to the subject. This step did not yield additional papers. Finally, we performed reference tracking on the final set of selected articles, meaning 'we scanned the reference lists of all full-text papers and used judgment to decide whether to pursue these further' (Greenhalgh and Peacock, 2005). This additional step provided three other relevant articles that met our criteria whose references were also verified. This is in line with Greenhalgh, and Peacock's (2005) observation that 'overall, the greatest yield was from pursuing selected references of references'. In total, four papers were added to our final list for extraction by supplementing our initial database search strategy with these additional search strategies. They were not initially identified because their abstract and keywords did not match our query.

2.3 Systematic review statistics summary

Following Moher et al. (2009), the statistics relating to the identification, screening, selection and inclusion phases of the review are summarised in the Prisma flow diagram shown in Figure 2. The complete list of the 29 selected articles is presented in Appendix B. The electronic database search allowed us to identify 25 (86.21%) of the articles included in the analysis. The manual search in the references of the selected articles and the publications provided the other 3 (10.34%) and 1 (3.45%), respectively.

Throughout the process, every scientific article was assigned a unique identification number. During the extraction phase, data relating to previously selected elements were collected in a single Microsoft Excel spreadsheet. Three sheets were used to simplify the approach:

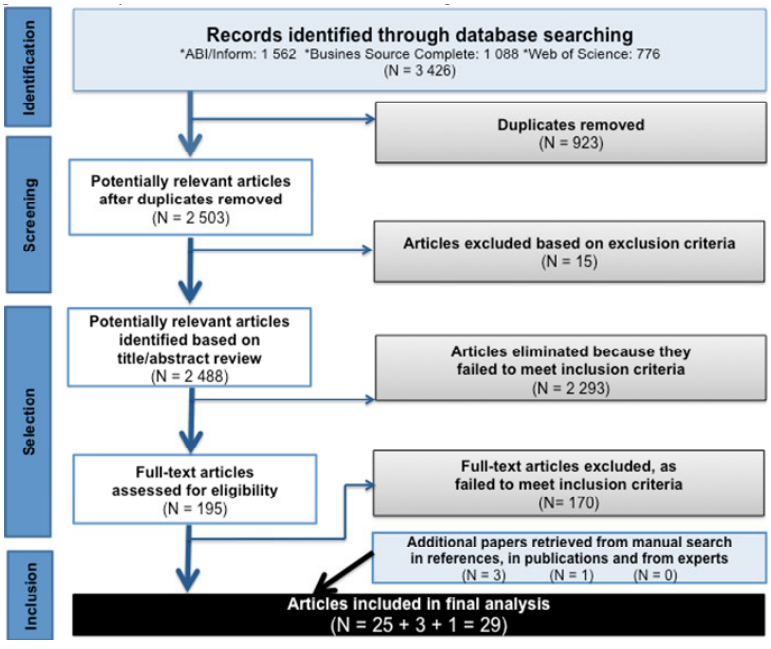
1 Dedicated to parameters by articles pertaining to: reference, theoretical context, cooperation characteristics, survey characteristics, population, analysis (one line per article).

2 Devoted to the determinants by article: name, conceptual and operational definitions, effect on cooperation and cooperation partner (one line per article).

3 Designated to the consolidation of all of the determinants by categories and sub-categories (one determinant per line and one column per article).

Several statistical analyses including pivot tables were finally conducted on the content in a dedicated spreadsheet to uncover trends.

Figure 2 Systematic review Prisma 2009 flow diagram (see online version for colours)



Source: Adapted from Moher et al. (2009)

3 Results

Among the benefits conferred by the adoption of a systematic review of the literature, there is the possibility of uncovering theoretical, publishing and methodological trends for which we will share a few highlights. These descriptive results allow a better contextualisation of the data extracted from the articles but also help to identify research gaps to address in future work. We will then address the findings pertaining to the dependent variable (innovation cooperation) and its determinants.

3.1 Descriptive results: theoretical grounding

Innovation cooperation has been studied from different viewpoints, as an example "those of industrial organization, game theory, transaction cost theory, organizational theory or strategic management, which have occasionally offered contrary arguments when seeking to explain it" [Bayona et al., (2001), p.1289]. As Tsang (1998) noted, the motives for embarking into such collaborative efforts can be quite diverse, therefore 'the various perspectives can be treated as complementary and not as substitutes' [Bayona et al., (2001), p.1289]. Nonetheless, it contributes to the fragmented nature of this field.

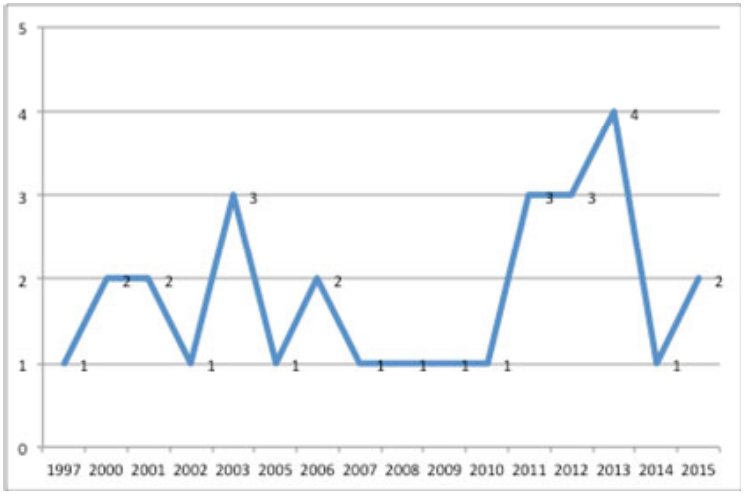
Although in many cases the authors mention one or more theories in the introduction of the selected articles, there is mostly no real integration of theories in the analysis; for the most part, they are simply named. Therefore, the theories have been applied but not so much contributed to. A third of the selected texts do not mobilise any theory (n = 10) (for instance, Fritsch, 2001). In the others, the authors mobilise most of the time more

than one theory (for instance, Bayona et al., (2001), p.1289]. However, two theories are more dominant in explaining the phenomenon under study: Coase's transaction costs theory (n = 12) and Penrose's resource-based view (n = 5). The fact that there is currently no real integration of the theories constitutes a distinct weakness of the literature assessed, as it is the foundation from which the knowledge is constructed while structuring and supporting its rationale. The phenomenon has not been amply addressed from several theoretical lenses and viewpoints (i.e., institutional and network theory) that would greatly enhance our comprehension. This provides opportunity for future research.

3.2 Descriptive results: publishing trends

This section provides a landscape of the published literature, which helps uncover the publications that are taking interest and the research gaps. The distribution of the selected papers by the publication year shows a broad time horizon from 1997 to 2015 (Figure 3) but the field is still relatively young. 2013 has the greatest number of articles respecting this study's criteria (n = 4). It is significant to note that the phenomenon is of sustained interest in literature; nearly half of the selected texts have been published in recent years.

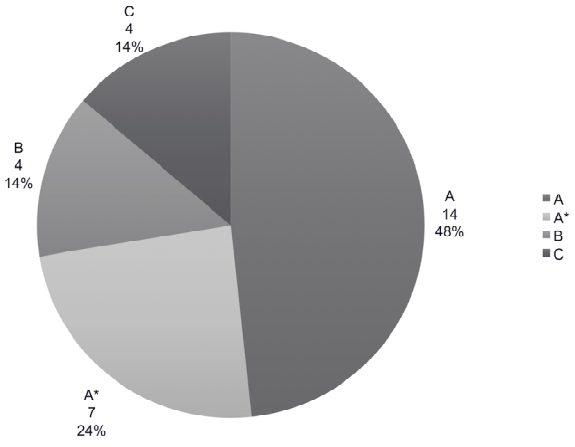
Figure 3 Publication trend by publication year (see online version for colours)



The selected papers were published in 18 different publications including a number of highly recognised journals. *Research Policy* (n = 4), *Technovation* (n = 4) and *The Journal of Small Business Management* (n = 4) published the most articles meeting our inclusion criteria. Conversely, twelve different publications only yielded one article each, which supports once again the notion that the literature on this subject is fragmented. As SME's innovation cooperation research will develop, it is likely that journals will dedicate special issue to the subject, which has not been the case yet to the best of our knowledge. Although this field of research is still young, we find that the vast majority (n = 21, 72%) of the texts that met our selection criteria were published in the highest and second highest quality journals according to ABDC (2013) as they are classified A (n = 14, 48%) or A * (n = 7, 24%). Therefore the selected papers contain a larger

proportion of higher rated publication categories since the category normally represents only around 25% of the classified journals.

Figure 4 Publication trend by journal classification



In total, the SMEs were studied in 24 different countries (n = 62 in total). Nearly three quarters of the selected articles dealt with only one country (n = 21) while two others focused on two countries and the remaining six articles studied four countries or more. The Netherlands (n = 5, 8.06%) and Norway (n = 5, 8.06%) are those that have been studied most often in the selected texts. Europe is the most represented continent in the articles selected (n = 42, 67.74%). It is followed by Asia (n = 9, 14.52%), America (n = 7, 11.29%), Oceania (n = 3, 4.84%) and finally Africa (n = 1, 1.61%). Further research in a broader range of countries could greatly enhance understanding and help determine if there are significant regional differences.

3.3 Descriptive results: methodological trends

This section provides a synthesis of the methodology pertaining to the selected papers, which helps uncover the trends and research gaps.

- *Data collection.* Innovation is studied in several countries as part of large national surveys such as the community innovation survey (CIS). 'CIS data have been used in many studies in economics and management' (Barge-Gil, 2010b). A significant finding that emerges from this systematic review is that the majority of the selected articles included surveys conducted by the authors with data that is not extracted from one of these large national surveys. As noted Freel and Harrison (2006) 'studies of firm-level innovation processes (such as CIS), as a result of concerns over data adequacy, response rates and issue relevance, invariably under-survey micro firms' which may perhaps explain why few articles written on SMEs result from these studies. No study adopted a longitudinal approach. Therefore, national surveys should make it easier to study the phenomenon in SMEs as well.
- *Quantitative analyses.* This study focused on published quantitative empirical work. The regressions are the type of quantitative analyses performed most often by the

researchers. Comparison of means tests and descriptive analyses were used to a lesser extent to explain the phenomenon. Other types of analyses were factorial and cluster analysis (Verbano et al., 2015), structural equations modelling (Westerlund and Rajala, 2010; Wincent and Westerberg, 2005) and conjoint analysis (Van Gils and Zwart, 2009). At this point, however, it is still possible to expand the type of quantitative analysis conducted to further understand the determinants that have a dominant effect for instance with qualitative comparative analysis (QCA) (c) (fuzzy-set analysis).

- *Innovation type*. The Oslo Manual also distinguishes four types of innovation: product, process, marketing and organisational (OECD, 2005). The type of innovation was not specified in almost half of the analysed texts (n = 12), which is a shortcoming, as it does not provide enough contextualisation to identify elements that diverge or converge. In other texts, it was mainly stated that it was product innovation and/or process innovation. However, Theyel (2013b) compared between product and process innovation. Some authors used the term 'technological innovation' or just 'R&D'. It represents a clear weakness of prior work that can easily be addressed in future research by clearly identifying the type of innovation. This simple remediation would greatly improve the contextualisation of the work going forward.
- *Cooperation partners.* Moreover, in the literature, one usually distinguishes three main types of innovation cooperation depending on the partners (as do Belderbos et al., 2004): horizontal (with competitors), vertical (with suppliers and customers) and institutional (with universities and research centres). The partner was not specified in half of the selected articles (for instance Steensma et al., 2000). In some articles, the authors put the emphasis on only one partner, mainly universities and research centres (for instance, Fontana et al., 2006) or compared the results for different types of partners (for instance, Chun and Mun, 2012; Muscio, 2007). However, in general, they studied the relation with several types of partners without distinguishing the results (for instance, Bayona et al., 2001). This weakness made it difficult to draw partner-specific conclusions but represents a clear avenue to undertake to better contextualise further research on the topic. Such clarification could provide insight pertaining to possible determinants having more or less impact depending on the cooperation partners.
- *Innovation output approach*. In the literature, there are two main approaches to obtain data on innovation outputs, "the 'object' approach focuses on patents or more directly on the analysis of specific innovative products or processes […] [while] the 'subject' approach is based on an analysis of firms' own perceptions of their innovative activity" [Hughes, (2001), p.159]. The firm is the unit of analysis used in all the texts selected. Thus, the subject approach dominates. It seems more appropriate in a SME context as "there is evidence to suggest that the object approach underestimates the innovative activity of smaller firms, in particular diffusion or incremental activity which the object approach may overlook" [Hughes, (2001), p.159].
- *Manufacturing sector.* The authors have not treated the manufacturing sector's subsectors uniformly in the articles selected. Several authors were very explicit about

the subsectors studied. They sometimes focused on one of them (for instance, Lin et al., 2003). However, in most cases, several subsectors were identified in the same text. Nonetheless, the terminology used by the authors to classify them varies greatly complicating the task when trying to aggregate results. This made it difficult to conduct subsector-specific analysis. Consequently, understanding is limited regarding specific subsectors. The field could greatly benefit from further studies focusing on specific subsectors and comparing the results at that level to uncover similarities and differences pertaining to the determinants. However, one of the strengths of several current contributions is that the results were analysed by categorising the firms according to their technological intensity. In the innovation literature, SMEs are typically classified according to typologies that stem from the sector to which the firm belongs or according to the level of technological innovation. There are two dominant classifications at this time, Pavitt (1984) and OECD (Hatzichronoglou, 1997). Let us recall that Pavitt (1984) has four categories: 'supplier-dominated', 'scale-intensive', 'specialised suppliers' and 'science-based'. Some studies, (e.g., Carboni, 2013; Piga and Vivarelli, 2003) have opted for that classification. The OECD International Standard Industrial Classification of All Economic Activities (ISCI), also groups them into four categories: low-technology industry, medium-low technology industry, medium-high technology industry and High-technology industry. This classification is based on a direct and indirect R&D intensity index. It has been used by several researchers interested in the phenomenon under study, (e.g., Bayona et al., 2001; Classen et al., 2012), which greatly facilitated comparisons and the aggregation of results. Notably, Hervas-Oliver et al. (2012b) opted for both.

- *Type of ownership.* When one analyses organisation, more particularly SMEs, the type of ownership and governance may be of interest, especially considering that there are significant disparities at each stage of the innovation process between family and non-family manufacturing SMEs (Classen et al., 2014). In some cases, it was reported that it was a sample of 'independent' firms. Nevertheless, the authors have largely not specified whether the SMEs were independent firms with one owner, a partnership between multiple owners or a publicly traded company. No distinction either pertaining to the fact that the firm was managed by its founder or not. Thus, the majority of the texts provided no specification contextualising the firms according to many concepts omnipresent in SMEs literature, which represent a fertile ground for improvement. However, Classen et al. (2012) brought on a distinction which was omitted from the other texts selected: whether or not it was a family firm. Research about family firm innovation management is limited and has for the most part been ignored by innovation scholars (Chrisman et al., 2015) which were confirmed by this systematic review.
- *Comparisons.* One of the major findings that emerges from this systematic review of the literature is the fact that researchers have opted several times for comparisons to refine our understanding of the phenomenon. On one hand, they compare the determinants of innovation cooperation to other options to innovation cooperation (internal R&D, outsourcing, etc.) and on the other; they compare the determinants in different innovation cooperation contexts (innovation, organisational and partnership characteristics). Comparisons between countries are those that are most observed, but many other types have also been carried out as evidenced by Table 1. Additional

comparisons represent a promising avenue to further understand the phenomenon. We posit that empirical evidence is lacking to uncover differences and similarities depending on the contexts. Therefore, we recommend further exploratory analysis to expose whether or not elements converge or diverge. Apart from building on the types of comparisons that have already been conducted, researchers could prioritise those that are currently missing, for instance comparisons of the determinants depending on the types of innovation cooperation partners.

Table 1 Types of comparisons performed in the selected articles

Types of comparisons	*Innovation project characteristics*		*Organisational characteristics*	
Determinants of innovation cooperation vs. other options				
Determinants of innovation cooperation pertaining to different contexts	Product innovation	Process innovation	Country A	Country B
			Small organisation	Large organisation
			With cooperation experience	Without cooperation experience
Types of comparisons	*Partnership characteristics*			
Determinants of innovation cooperation vs. other options	R&D cooperation		Outsourcing R&D	
	Internal R&D	R&D cooperation		R&D purchase
Determinants of innovation cooperation pertaining to different contexts	Local partner	Regional partner	National partner	Overseas partner

3.4 Synthesis of findings on dependent and independent variables

We will now present the highlights of this systematic review's findings pertaining to the dependent variable (innovation cooperation) and the independent variables (determinants of innovation cooperation). This will lead to our integrated conceptual framework.

3.4.1 Dependent variable: innovation cooperation

It should be noted that in the literature on innovation, the concept of innovation cooperation has primarily been regarded as an independent variable, for instance for competitiveness (Tamayo et al., 2015), innovation output (Sánchez-González and Herrera, 2015), product innovation (Antolin-Lopez et al., 2015), performance (Raposo et al., 2014), and radical innovation (Minguela-Rata et al., 2014). Nevertheless, our inclusion criteria stipulated that it had to be the dependent variable to achieve the objectives of this study. We wanted to uncover empirical evidences regarding the determinants of innovation cooperation for manufacturing SMEs. The term 'innovation cooperation ' was preferred in this study because it is recommended by the Oslo Manual Guidelines for collecting and interpreting innovation data and is widely used in the

literature on innovation performed in OECD countries. Nonetheless, several other terms referring to the notion of cooperation for innovation were also used in our query following a review of the literature though they are not used in the literature solely in an innovation context. Therefore, we made sure to retain them only when the article specified the notion of innovation as the purpose of the cooperation (collaboration, alliance, etc.).

Among the motivations for undertaking this systematic review, we discussed the fact that the literature on the phenomenon under study was fragmented. Now that the analysis is completed, the statistics relating to the terms used by the authors are very diverse to confirm this statement. Indeed, in the 29 selected texts, the authors used 27 different expressions to name the dependent variable. In addition, we often found that many of the words were employed in the same article in an undifferentiated way. This may lead to a lack of clarity and continuity to the use of the terms. These inconsistencies in labelling and operationalisation slow the advancement of knowledge on the topic.

The term 'R&D cooperation' is the one used most often with three occurrences as shown in Table 2. We grouped the dependent variables depending on the level of operationalisation: cooperation term in general, related to the content of the cooperation or to the partner. The dependent variable name referred mostly to the cooperation term in general (n = 17, 68%). However, 20% of the time they were specific to a partner type (n = 6) or its location and another 20% related to an aspect of the content of the cooperation (n = 6).

Table 2 Name of the dependent variables identified in the selected papers

#	*Dependent variable*	*Total*	*General*	*Partner*	*Content*
Cooperation					
1	Cooperation ventures	1	1		
2	Cooperation with universities and/or RTOS	1		1	
3	Cooperative R&D	1	1		
4	Horizontal cooperation	1		1	
5	Propensity to cooperate with different types of partners	1		1	
6	R&D cooperation	3	3		
7	Research cooperation	1	1		
	Total	9	6	3	0
Alliance					
6	1. Participated in an alliance at any level 2. […] at the national level 3. […] at the European level 4. […] at the international	1		1	
7	All alliances, support alliances, technology/manufacturing alliances	1			1
8	Alliance	1	1		
9	Alliance use	1	1		
10	Alliance use and multiple alliance use over time	1	1		
11	Alliance-partner selection – task related and alliance-partner selection – partner-related	1		1	

Table 2 Name of the dependent variables identified in the selected papers (continued)

#	*Dependent variable*	*Total*	*General*	*Partner*	*Content*
12	Intended future alliance use	1	1		
13	Technology alliance	1			1
	Total	8	4	2	2
Collaboration					
14	Collaboration	1	1		
15	Collaboration with other firms, with universities or research centres or with technology transfer centres (service centres) on innovation or business issues and number of different types of firm's collaborations (1 to 3).	1		1	
16	Network collaboration	1	1		
17	Perceived barriers to collaboration	1	1		
18	Technological collaboration	1	1		
	Total	5	4	1	0
Open innovation					
19	Exploratory openness ; exploitative openness	1			1
20	Openness on innovation process phases	1			1
	Total	2	0	0	2
Other					
21	Joint technology development; joint product development; joint manufacturing; sharing equipment; joint access to new markets; joint bidding for new contracts	1			1
22	Networking	1	1		
23	R&D partnerships	1	1		
24	Search breadth	1	1		
25	Technological development stage 1 to 4	1			1
	Total	5	3	0	2
	Grand total	29	17	6	6

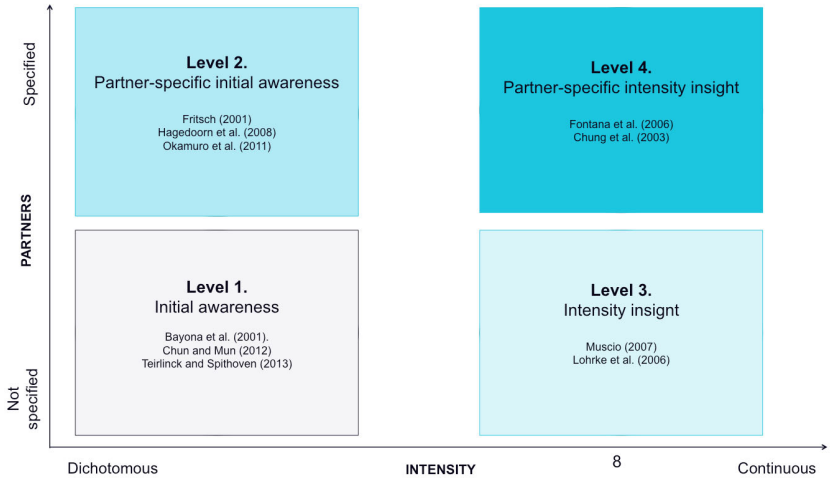
Table 3 provides some operational definitions collated from the selected articles, which were separated into two categories: dichotomous and continuous measures.

Following our review, we suggest a typology for labelling the operationalisation of innovation cooperation as presented in Cloutier and Amara (2018). We then categorised the dependent variables into four levels of analysis according to whether or not the dependent variable addresses the intensity level (dichotomous or continuous variable) or the cooperation partners (partner-specific or not). The four-operationalisation levels are shown in Figure 5. We believe a framework is now in place for researchers to provide more contextualisation on their empirical research.

- *Level 1. Initial awareness*: intensity of innovation cooperation is unqualified and the types of partners are not specified (Bayona et al., 2001; Chun and Mun, 2012; Teirlinck and Spithoven, 2013).

- *Level 2. Partner-specific initial awareness:* intensity of innovation cooperation is unqualified and the types of partners are specified (Fritsch, 2001; Hagedoorn et al., 2008b; Okamuro et al., 2011).
- *Level 3. Intensity insight:* intensity of innovation cooperation is qualified and the types of partners are not specified (Lohrke et al., 2006; Muscio, 2007).
- *Level 4. Partner-specific intensity insight:* intensity of innovation cooperation is qualified and the diversity of partners is specified (Chung et al., 2003; Fontana et al., 2006).

Figure 5 Levels of operationalisations of the intensity of innovation cooperation according to intensity and partners (see online version for colours)



Source: Adapted from Cloutier and Amara (2017, 2018)

3.4.2 Independent variables: determinants of innovation cooperation

We will now focus on the determinants of innovation cooperation (independent variables), before developing our integrated conceptual framework. In total, 277 determinants of innovation cooperation of manufacturing SMEs were compiled. Since some have been studied in more than one article, the total number of unique determinants is 220 (Table 4). Each determinant is presented in Appendix C.

In the selected texts, the determinants are generally presented in a list without any classification. To synthesise and provide a better evaluation of the accumulated knowledge in the field, we developed a typology. Our typology is based on categorisations gathered in the selected texts but also inspired by other texts that dealt with the phenomenon to enhance it as shown in Table 5. We therefore relied on the classification of Okamuro et al. (2011, p.731) and Verbano et al. (2015) identified in our systematic review. We enhanced their work with those of Kim and Lee (2003), Street and Cameron (2007a) and Schermerhorn (1975).

Table 3 Dichotomous and continuous operational definitions of innovation cooperation

Dichotomous variables	*Operational definitions*
Cooperation with universities and/or RTOS	'The firm has technological linkages with universities and public research organisations (RTOS)' [Hervas-Oliver et al., (2012a), p.63].
Cooperative R&D	1 Firm cooperates in R&D 2 Firm does not cooperate in R&D' (Bayona et al., 2001)
Networking	'Degree of networking in the strategic SME network : time spent on personal meetings or telephone conversations with other strategic SME members in terms of information, assistance and guidelines that concerned business development related to the focal firm, per year, per member of the network in the last-year period (time = working days, 8 hour packages) 1 no networking at all 2 half-a-day 3 2, 5 days 4 10 days 5 20 days, natural log number of that score' [Wincent and Westerberg, (2005), pp.278–279]
Research cooperation	'1. If the firm is engaged in research cooperation in the period 2004–2005; 0 otherwise'(Teirlinck and Spithoven, 2013)
R&D cooperation	1 'engaged in R&D cooperation with academic institutes (universities or public research institutes), or with business partners, including customers and suppliers' [Okamuro et al., (2011), p.731] 2 '1 if firm is engaged in at least one cooperative R&D activity with any type of partner'(Chun and Mun, 2012)
R&D partnerships	'A dichotomously coded variable for the occurrence of an R&D partnership for each year during the period 1991–1998. Each dependent variable takes the value of 1 when a pair entered into an R&D partnership and the value of 0 if this did not occur '(Hagedoorn et al., 2008a)
Continuous variables	*Operational definitions*
Alliance use	'The respondents were asked to indicate if their firm currently maintained an alliance relationship and if so, how many and what types of alliances did the SME maintain. The survey provided the respondents with a list of these various types of alliances with the respondent being asked to indicate if his or her firm currently held such an alliance and if so, how many. The alliance types provided included marketing, distribution and production agreements, licensing, outside contracting, export management or trading alliances, R&D process or product alliances, and purchaser – supplier alliances. Each type of alliance was clearly presented with separate questions. In order to arrive at the study dependent variables, responses across all alliance use questions were totalled for the 'total alliance use'variable and dichotomised into a yes/no variable for the 'alliance use' measure' [Dickson and Weaver, (2011), pp.132–134].

Table 3 Dichotomous and continuous operational definitions of innovation cooperation (continued)

Continuous variables	*Operational definitions*
Collaboration	'Number of R&D projects' (Fontana et al., 2006)
Exploratory openness and exploitative openness	'H1: the number of exploratory relationships in which firms are engaged' and 'H2: the number of exploitative relationships in which firms are engaged' (Xia, 2013).
Intended future alliance use	'Asked managers to assign a percentage (0-100) chance to the probability that their firm would form different types of alliance over the next year' […] 'what are the chances that your firm will use each of the following types of alliances in the next 12 months? Please put 0% for no chance to 100% for a certain chance for each type of alliance'. Joint ventures with other small businesses, joint ventures with large companies, outside contracting, licensing, long-term agreements (marketing, distribution, production), equity investments from other companies, technology alliances (R&D, product)' [Lohrke et al., (2006), p.25].
Joint technology development	'Joint technology development (to what degree is your company involved with joint technology development with customers/suppliers).
Joint product development	Joint product development (to what degree is your company involved with joint product development with customers/suppliers).
Joint manufacturing	Joint manufacturing (to what degree is your company involved with joint manufacturing with customers/suppliers)' (Theyel, 2013a).
Search breadth	'For each type of potential partner, respondents were asked whether or not their firms cooperated with them for innovation-related activities during the last three years. All six items were initially coded as binary variables, 1 being use of the type of partner and 0 being no use. The search breadth was then calculated as the sum of the six binary variables' (Classen et al., 2012).

Table 4 Distribution of the number of occurrences of determinants

Number of occurrences	*Total (all determinants)*	*%*	*Total (unique determinants)*	*%*
1	186	67	186	85
2	50	18	25	11
3	18	6	6	3
4	4	1	1	0
5	5	2	1	0
14	14	5	1	0
Total	277	100	220	100

As highlighted in Cloutier and Amara (2017, 2018), analysis and integration efforts were made to classify the determinants of innovation cooperation for manufacturing SMEs into six categories based on their definitions. They are, from general to specific:

1 environmental characteristics

2 industrial characteristics

3 organisational characteristics

4 individual characteristics

5 partnership characteristics

6 project characteristics.

This classification allows a better understanding of the state of knowledge regarding the phenomenon under study by allowing for instance the identification of areas that are less explored. The subcategories provided also enable more accuracy since some determinants' names might be similar but have a different meaning depending on the categories.

- '*Environmental characteristics (Street and Cameron, 2007b)*' refer to the determinants concerning the external environment at a macro level: financial context, legal context, etc. This includes for instance the country's GDP (Dickson and Weaver, 2011) and environmental regulations (Van Gils and Zwart, 2009).
- *Industrial characteristics (Okamuro et al., 2011)* include the activity sector and its technological intensity (Classen et al., 2012; Dickson and Weaver, 2011), the market characteristics, for instance industry growth (Classen et al., 2012) and market size (Van Gils and Zwart, 2009), and the technological context (Chun and Mun, 2012).
- *Organisational characteristics (Kim and Lee, 2003; Okamuro et al., 2011; Street and Cameron, 2007b; Verbano et al., 2015)* comprise the firm demographics, its markets and organisational attributes. Firm demographics comprise for instance the firm age (BarNir and Smith, 2002), the type of ownership (Classen et al., 2012), the firm size measured by either the number of employees (Verbano et al., 2015) or the sales (Blind and Mangelsdorf, 2013). Market includes the firm's main market (Xia, 2013) and its exporting practices (Freel, 2003). Organisational attributes detail the firm's resources [financial (Dickson and Weaver, 2011], etc. processes [formalisation (Lin et al., 2003) etc.], R&D capabilities [R&D employment (Fontana et al., 2006), number of patents (Blind and Mangelsdorf, 2013), etc.], strategic characteristics [inimitability of firm's capability (Verbano et al., 2015), etc.] and cooperation experience [previous cooperation experience (Cho and Yu, 2000) etc.].
- *Individual characteristics (Okamuro et al., 2011; Schermerhorn, 1975; Street and Cameron, 2007b)* correspond to attributes pertaining to employees, managers, management teams and founders. The employee characteristics comprise, for instance, their education (Muscio, 2007) and training (Teirlinck and Spithoven, 2013). The manager characteristics consider for instance their gender (Dickson and Weaver, 2011), their networking practices (BarNir and Smith, 2002) and their age (BarNir and Smith, 2002). The management team educational background (Classen et al., 2012) has also been previously studied. As for the founder attributes, they have been amply studied by Okamuro et al. (2011) who focused on their age, education, work experience, networking practices and innovation experience.
- *Partnership characteristics (Kim and Lee, 2003; Street and Cameron, 2007b)* pertain to the relational context and the strategic focus of the firm's innovation cooperation. The relational context includes the notion of trust (Birru, 2011), proximity (Birru, 2011), complementarity (Chun and Mun, 2012) as well as funding and resources (Goduscheit and Knudsen, 2015).

- *Project characteristics (Kim and Lee, 2003)* includes the innovation's attribute in the innovation cooperation context: innovation type (Hagedoorn et al., 2008a), cost (Chun and Mun, 2012), risk (Lin et al., 2003), complexity (Lin et al., 2003) and technological context (Cho and Yu, 2000; Cloutier and Amara, 2018).

3.5 Integrated conceptual framework of the determinants of innovation cooperation for manufacturing SMEs

Our integrated conceptual framework of the determinants of innovation cooperation of manufacturing SMEs (Figure 6) illustrates the major categories and subcategories of the 220 unique determinants that were identified in this systematic review of the literature. It is impossible to present clearly all of them in a single figure, as the font would be too small. Therefore, it comprises three main components: the categories and subcategories of determinants, the innovation cooperation partner types and the type of innovation. This conceptual framework serves the purpose of guiding researchers addressing the phenomenon in the future to enhance our understanding of the determinants and will also help researchers and policymakers to identify actionable levers and barriers to better foster innovation cooperation.

Figure 6 Conceptual model for considering the determinants of innovation cooperation for manufacturing SMEs based on a systematic review of empirical research (1992–2015)

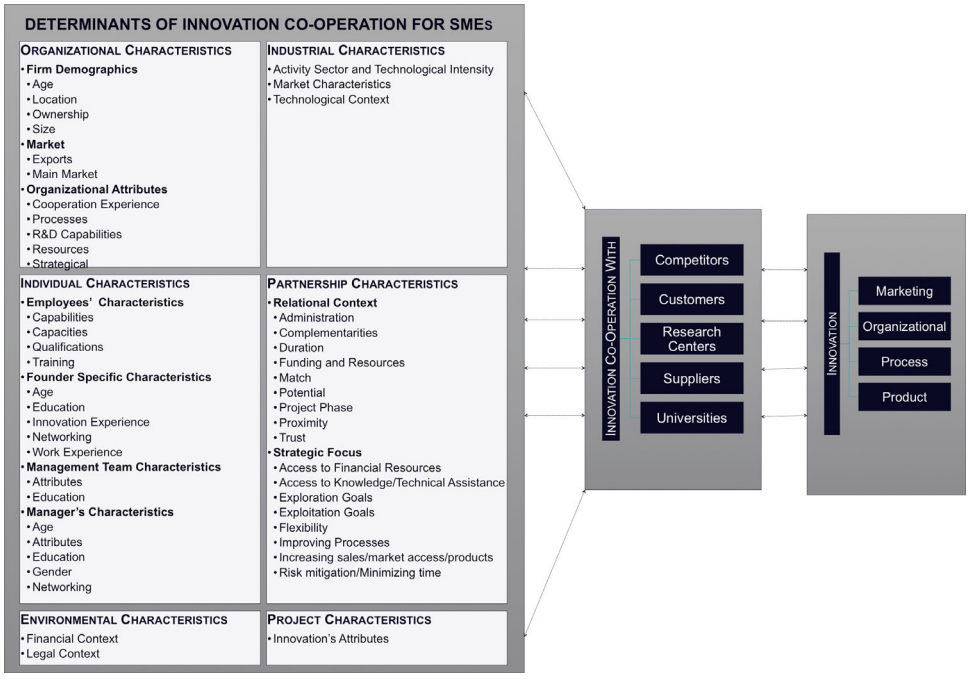


Table 5 Typologies of the determinants of innovation cooperation from selected articles of the systematic review and other selected articles

Articles	*Environmental characteristics*	*Industrial characteristics*	*Organisational characteristics*	*Individual characteristics*	*Partnership characteristics*	*Project characteristics*
Articles from the systematic review						
Okamuro et al. (2011)	N/A	Industry-specific characteristics	Firm-specific characteristics	Founder-specific characteristics	N/A	N/a
Verbano et al. (2015)	N/A	N/A	Firm-specific factors	N/A	N/A	N/A
Other selected articles						
Schermerhorn (1975)	N/A	N/A	N/A	Decision maker need Decision maker demand	N/A	N/A
Street and Cameron (2007)	Environmental characteristics	N/A	Organisational characteristics of the SME	Of the entrepreneur Of the manager	Organisational characteristics of the partner Relationship characteristics	N/A
Kim and Lee (2003)	N/A	N/A	Collaboration management practices	N/A	Partner characteristics	Project characteristics

The 220 unique determinants have overwhelmingly not been tested more than once in the texts studied. The fragmented nature of this literature certainly contributes to this situation; several terms and similar measures cannot be consolidated. Some analyses were performed to assess the frequency with which the determinants have been tested so far in the literature by setting thresholds (Table 6). Those tested on one or two occasions were deemed *barely tested*, those who were on three or four instances were considered *sparsely tested*, those who had been 5 to 9 times were regarded as *moderately tested* and finally those who were tested more than ten times were deemed *heavily tested*. In light of these criteria, we have found that of the 220 unique determinants collected, 210 (95.45%) have been barely tested from 1992 to 2015 and only one was heavily tested. These statistics demonstrate the obvious potential for continued empirical research on the phenomenon within manufacturing SMEs. This systematic review therefore bears an important potential for researchers who want for instance to test the identified determinants in other contexts (country, sector, type of innovation, different partners, etc.).

Table 6 Qualification of the number of occurrences per unique determinant

Qualification of the number of occurrences	*Total*	*Percentage*
Barely tested (1 to 2)	210	95.45
Sparsely tested (3 to 4)	8	3.64
Moderately tested (5 to 9)	1	0.45
Heavily tested	1	0.45
Total	220	100

Table 7 Distribution of unique determinants by category

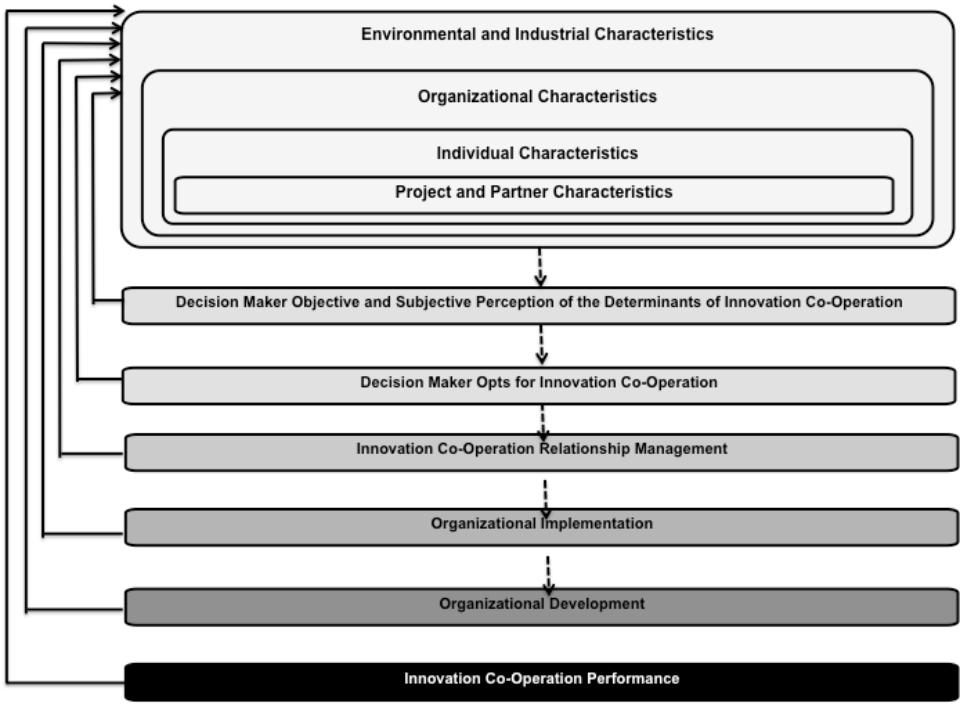
Categories	*Number of unique determinants*	*%*	*Total of determinants*	*%*	*Gap (#)*	*Gap (%)*
Environmental characteristics	6	2.72	6	2.16	0	–0.560
Individual characteristics	37	16.82	39	14.08	2	–2.739
Industrial characteristics	33	15.00	43	15.52	10	0.52
Organisational characteristics	63	28.64	102	36.82	39	8.187
Partnership characteristics	64	29.09	66	23.83	2	–5.264
Project characteristics	17	7.73	21	7.58	4	–0.146
Total	220	100	277	100	+57	N/a

More than a third of the 277 collated determinants pertain to organisational characteristics (n = 102, 37%); they are not only more abundant but are also those that have been studied the most repeatedly as shown in Table 7. The environmental characteristics (n = 6, 2.72%) and the project characteristics (n = 21, 8%) are barely tested so far. As for the other categories, they comprise of 14 to 24% of the determinants. This clearly shows that researchers have concentrated their efforts so far on organisational characteristics and partnership characteristics to a lesser extent. Much gain can still be made though to get a better grasp on the other types of determinants that are significantly under researched at the present time. Especially in the context of SMEs, a stream of literature posits that the performance of firms stems from the psychological

characteristics and personality traits of managers [Wincent and Westerberg, (2005), p.271], which upholds the importance of investigating it further in that context.

As Edwards et al. (2005, p.1120) noted, "despite the voluminous literature on innovation in SMEs […] the aggregate benefits has, it might be argued, been marginal in explaining the innovation process in SMEs". We also propose a conceptual framework of the process leading to innovation cooperation (Figure 7) drawing inspiration from Street and Cameron (2007a). It comprises firstly the major categories of determinants stemming from our systematic review. It then asserts how firm managers must assess the determinants subjectively and objectively. Then, if the firm opts for innovation cooperation, it must put in place the processes required to manage this relationship and implement it. It results in organisational development which ultimately helps lead to innovation projects which is the subject of innovation cooperation. The firm must ultimately evaluate the innovation cooperation performance. The continuous analysis of the determinants pertaining to the internal and external environments of the firm influences each of these steps.

Figure 7 Conceptual framework of the process leading to the innovation cooperation



Source: Adapted from Street and Cameron (2007)

4 Vote counting analysis

The vote counting method, which is widely applied (Bickman and Rog, 2008), 'probably constitutes the most common quantitative techniques used in research reviewing'

[Hedges and Olkin, (1980), p.359]. It allows appraising if the overall impact of a determinant is positive, negative or not significant in the articles selected in relation to preset thresholds. Among its advantages, we note that it is 'easy to use, require a minimal amount of statistical data from each study to be integrated, and permit merging the analyses of different studies' [Hedges and Olkin, (1980), p.359]. Thus, it was put to use to identify the dominant effects in the literature associated with the various determinants. However, this method has some limitations. Carlton and Strawderman (1996) have shown that it can lead to draw the wrong conclusions (Littell, 2008). As Bushman (1994) pointed out, it also ignores the sample size which can lead to overweight certain outcomes (Littell, 2008). Nevertheless, it provides a useful summary of data.

In conducting this analysis, we applied these two criteria:

1 the determinant must be included in an explanatory empirical model of innovation cooperation

2 we assumed the presence of a dominant effect when it was oriented in a direction (positive or negative) in a proportion of 60%.

When the regression was performed on multiple dependent variables in the same article, (e.g., cooperation with universities, cooperation with competitors, etc.), we considered the overall effect (use of general cooperation without specifying the partner) when this information was provided. Otherwise, we considered that the effect was generally positive or negative if it was mainly the case for all the dependent variables of the same article for a determinant using the same threshold (60%). If no dominant effect could be found, we indicated, 'not significant'.

The fact that over 95% of the determinants identified have not been tested more than twice substantially reduces the potential for analysis at this level. The empirical evidence is insufficient to determine the presence or absence of a dominant effect. Therefore, we could only examine the 5% remaining determinants tested three times or more. To apply our first criteria, we counted the number of occurrences where the determinants analysed more than three times had been tested by regressions. In doing so, we found that three determinants were investigated by conjoint analysis or cluster analysis. Such was the case for two determinants for which the number of occurrences was originally three. Therefore, the number of occurrences that resulted was too small to determine an overall effect and we could not proceed for the following: 'competition intensity/extent of competition' and 'investment risk'. The table summarises the results of the vote counting analysis (Table 8).

We find that of the nine determinants selected, two of them had not been sufficiently studied in explanatory models in order to distinguish a possible effect. For the seven remaining, no dominant overall effect is observed for the majority (n = 4). However, for three determinants, the analysis reveals an overall positive dominant effect. They are 'size (number of employees)', 'continuous R&D' and 'environment uncertainty/general uncertainty'. Two of them are related to the characteristics of the organisation and one to environmental characteristics. We will comment further on these three determinants.

The size of the firm, measured by the number of employees, is the determinant studied the most in the selected texts (n = 13). The size was also measured by the sales in two others selected studies. Generally, in the literature, we find that size is positively correlated with innovation. Specifically, in the context of innovation cooperation, it is also observed that as the number of employees increases, the firm tends to cooperate for

innovation since the dominant overall effect is positive. Only Teirlinck and Spithoven (2013) among the selected texts, refined their analyses into three subgroups according to firm size: very small (1–19 employees), small (20–49 employees) and medium (50–250). Their work reveals that there are significant differences by size of SMEs with respect to the determinants of innovation cooperation. The results suggest that midsize firms cooperate more than very small firms.

Table 8 Vote counting analysis

Determinants	*Number of indicators*	*Number of regressions*	*Recurrence of the significant impact*			*Presence of a dominant overall effect*
			-	+	*N.S. or no dominant effect*	
Firm size (number of employees)	13	13	0	8	5	DOE +
Age	5	5	1	1	3	DOE ?
R&D intensity	4	4	0	2	2	DOE ?
Competition intensity/extent of competition	3	2	N/A	N/A	N/A	DOE ?
Continuous R&D	3	3	0	3	0	DOE +
Environment uncertainty/general uncertainty	3	3	0	3	0	DOE +
Investment risk	3	2	N/A	N/A	N/A	DOE ?
R&D expenditures	3	3	1	1	1	DOE ?
Research manpower (share of R&D personnel in total firm personnel)	3	3	0	2	1	DOE ?

Note: DOE : Dominant overall effect/

By *continuous R&D*, we refer to 'if the firm has a research department' (Chun and Mun, 2012) or 'it employs at least one full-time researcher every year in this activity' [Bayona et al., (2001), p.1289]. Its overall dominant effect observed (n = 3) is positive so the presence of a research department or a full-time researcher stimulates the use of innovation cooperation. In the literature, it is emphasised that 'firms continuously involved in R&D can have higher absorptive capacity and thus obtain more benefits from R&D cooperation (Cassiman and Veugelers, 2002; Miotti and Sachwald, 2003; Tether, 2002; Chun and Mun, 2012).

The observed overall dominant effect (n = 3) for *environment uncertainty (general uncertainty)* is also positive. The more firms consider evolving in an uncertain environment, the more they tend to resort to innovation cooperation. Dickson and Weaver (1997) and Dickson and Weaver (2011) used a scale to evaluate the environment uncertainty. The "scale items focus on behaviour, assessing environmental perceptions relating to general uncertainty, technological demand and volatility, predictability of markets, and the potential for future growth and profits" (Dickson, and Weaver, 1997). Lee (2014) specifies that:

> "The construction of the measurement of environmental uncertainty was primarily based on Dickson and Weaver (1997), Duncan (1972), and Miller (1992). Four items were selected to measure how the characteristics of the external environment influence the behaviour of alliance partners; the external characteristics of the environment are such things as the unpredictability of competitors' behaviour, the effect of competitors' behaviour on a firm's performance, and the sensitivity of environmental change."

5 Trends and future research directions

We will now shift our attention to the trends and future research directions that stem from this analysis. Innovation cooperation is a multidimensional process influenced by several internal and external determinants. This systematic review reaffirmed its intricateness by identifying multiple explanatory variables sorted into six categories. The research community has already made several contributions on the topic. At the present time, the diversity of definitions and measures makes it challenging to compare and consolidate their work. The main limit of this study stems from the selection criteria:

1 it is solely based on articles published in English in peer-reviewed journals; conceptual papers and qualitative work were excluded from the analysis. Despite these limitations, we identified several trends and avenues of research to help researchers and policymakers to better foster innovation and guide researchers in steering their efforts when tackling this phenomenon in the future, which we will address in the following paragraphs.

5.1 Improve contextualisation

There is a sustained interest nowadays for researchers in investigating the determinants of innovation cooperation by manufacturing SMEs. Currently, the numerous definitions and measures collated in the literature make it difficult to enable comparisons. This issue should be addressed by opting for standardised definitions for the key variables. Also, the literature has reached a point where scholars need to better contextualise the frame and scope of their research:

1 whether they will focus on one partner or compare the relation to different types of partners in a single study

2 identify the type of innovation for which the SMEs are cooperating (following OECD, 2005)

3 specify the type of ownership of the firm (following Classen et al., 2012)

4 define the manufacturing subsector studied and its technological intensity (Pavitt and/or OECD typology)

5 refine the size of the firms into subgroups: very small, small and medium-sized firms (following Teirlinck and Spithoven, 2013).

An important finding is that researchers in the selected texts have not yet fully studied the temporal horizon of the cooperation as Classen et al. (2012) posited in their avenue of research. For instance, Belderbos et al. (2015) gave attention to the dynamic pattern of

the collaboration by differentiating being 'recently formed', 'persistent' or 'recently discontinued' collaborations. Do the determinants vary depending on the cooperation type? Particularly for SMEs, it will be of interest to consider as well in the future the 'size difference between the companies in a pair. Several researchers have already shown that the size of companies influences the extent to which they form a partnership (Hagedoorn, 1996; Mytelka, 1991)' yet in the selected literature, only Hagedoorn et al. (2008b) considered a size ratio ('the total number of employees of the largest company in a pair divided by the total number of employees of the smallest company in the pair').

5.2 Refine the portrait

This systematic review shows that empirical work on innovation cooperation is mainly based until now on dichotomous measures (Yes/No). Indeed, the data often only indicates whether or not the firms cooperate on innovation. This restricts the ability to measure the extent of the cooperation and to adequately depict the specificities of the partnership. There certainly remains much room to further refine the portrait of firm's innovation cooperative behaviours providing an interesting avenue for future research [Barge-Gil, (2010a), p.195]. Also, numerous studies analyse cooperation as a dyad between the firm and a partner. The reality is often more complex however; organisations can enter into agreements for an innovation project with more than one partner or partner type. New research in this area must therefore approach the concept considering the notion of a network sometimes inherent to innovation. Also, Gulati et al. (2009) distinguish the general experience of partnership, 'which reflects all previous alliances of a business', and the experience with a partner, 'which refers to the experience of the alliance with a specific partner'. This is fertile ground for further research.

5.3 Tackle the research gaps

In the previous section, we underlined several research gaps while analysing the results. Scholars are particularly invited to enrich the current understanding of the determinants by focusing on those pertaining to other categories than the organisational characteristics. For now, the determinants relating to individual characteristics have been far less explored in the selected papers. So far, only a few individual characteristics related to the founder of the firm and its managers have been studied. Yet in smaller firms, the CEO or entrepreneur is generally considered to play an important role in the development of the firm. A whole literature assumes that the performance of firms stems from the psychological characteristics and personality traits of managers [Wincent and Westerberg, (2005), p.271]. There is currently a clear gap on that aspect. This reaffirms the importance to further investigate those determinants to better help foster innovation cooperation. There is also still much to learn on the determinants pertaining to the individual, environmental and project characteristics for which much less evidence was collated leading us to the main unanswered questions. Hence, a main contribution for future research in this area should be towards allowing a better understanding of those determinants.

Table 9 Main findings of the systematic review and gaps identified in the literature

Themes		*Main findings*	*Main research gaps*
Theoretical grounding	Mobilised theories	One third of the selected texts do not mobilise any theory in their analyses and there is no real integration of theories in the analyses.	It would be wise to mobilise theories to structure and support the rationale. Several theories and viewpoints have not been amply used yet (i.e., institutional and network theory), providing opportunity for future research.
Publishing trends	Sample distribution	Concentration of the studies in Europe	American and emerging countries are under-researched; comparative and international studies are needed.
Methodological trends	Data collection	The selected articles come from polls carried out by the authors	Major national innovation surveys should make it easier to take SMEs into account in analyses.
	Quantitative analyses	Regression analyses dominate this field	It is possible to expand the type of quantitative analysis conducted to further understand the determinants and identify those that have a dominant effect for instance with QCA.
	Innovation type	The type of innovation was not specified in 41% of the analysed texts	It is necessary to contextualise the data and to specify the type of innovation studied to better understand the similarities and differences according to the type of innovation.
	Cooperation partner	The partner was not specified in half of the articles selected	There is a need to better contextualise the data and specify the type of cooperation partner to understand the similarities and differences according to partner type.
	Manufacturing sector	The understanding is currently limited by manufacturing sub-sectors but technological intensity classifications are allowing comparisons.	There is a need to better contextualise the data and specify the firm's technological intensity to understand the similarities and differences of family firms.

Table 9 Main findings of the systematic review and gaps identified in the literature (continued)

Themes		*Main findings*	*Main research gaps*
Methodological trends	Type of ownership	The authors generally did not provide details on the ownership of the firm even though it is shown that there are significant disparities between family and non-family firms.	There is a need to better contextualise the data and specify the ownership type to understand the similarities and differences of family firms.
	Comparisons	The researchers made several types of comparisons in their analyses in order to refine the portrait of the phenomenon under study.	This is a fertile breeding ground to continue exploring as to this phenomenon as comparisons shed light on similarities and differences.
Dependent variable: innovation cooperation	Definitions and measures	Terms and measures abound and the literature remains fragmented. This may lead to a lack of clarity and continuity to the use of the terms. These inconsistencies in labelling and operationalisation slow the advancement of knowledge on the topic.	More consolidation would be beneficial to facilitate synergies in this literature
	Measures	Empirical work on innovation cooperation has so far essentially been based on dichotomous data (yes/no).	Measuring the phenomenon with a continuous dependent variable would refine the analyses.
Independent variable: determinants of innovation cooperation	Definitions and measures	The determinants have almost exclusively been barely or sparsely tested (99.09% on four occasions or less).	More consolidation would be beneficial to facilitate synergies in this literature. Building upon the provided conceptual framework, further studies on the subject are encouraged.
	Determinants categories	For the moment, the determinants of organisational characteristics dominate this literature; the other categories of determinants have been much less studied.	Future research could focus more on the categories of determinants that have not been amply explored so far, particularly the characteristics of individuals.

Going forward, additional efforts should be put forth to have a comprehensive understanding of the decision process that the firms go through before opting for innovation cooperation. Out of all of the determinants identified, we need to pinpoint those that serve as key inputs on the decision to cooperate on innovation in order to understand how these drivers effectively work. We believe that the next step in the research on innovation cooperation should specifically aim to identify those factors that hang heavier in the balance for decision-makers in order to provide actionable

information. To identify them, QCA (fuzzy-set analysis), a type of quantitative analysis, is well suited to identify the necessary and sufficient conditions for innovation cooperation. 'The QCA methods are gaining ground, as shown by the increasing number of scholars using them in publications' [Skaaning, (2011), p.392]. However, to the best of our knowledge, they have not been used to study this phenomenon on this population. From a theoretical and managerial perspective, it would be relevant to know which determinant contributes most to innovation cooperation and opting for this type of analysis could further our understanding.

The design of this study made it so that we analysed solely the phenomenon from a unilateral perspective being the determinants of innovation cooperation for an SME with a partner. However, this stream of research could benefit from targeting this phenomenon by applying 'matching theory' analysis. 'Because alliances are used to combine heterogeneous resources held by multiple organisations, research on alliance formation and partner selection can benefit from applying matching theory to interorganisational contexts' (Mitsuhashi and Greve, 2009). There is also room to further integrate different theoretical perspectives and contribute to their advancement on this subject.

The thorough analysis of the reviewed articles allowed us to unearth gaps in the literature that could be tackled in future research as shown in Table 9.

6 Conclusions

This work set out to identify the different conceptual and operational definitions of innovation cooperation for manufacturing SMEs. It also sought to uncover the determinants of innovation cooperation for manufacturing SMEs studied in the literature.

This systematic review contributes to the field of innovation cooperation research by increasing our knowledge of the definitions of the phenomenon and the determinants of innovation cooperation for manufacturing SMEs. It does so in five significant ways. First, it provides an analysis of the levels of operationalisation of innovation-cooperation as defined in previous work. Secondly, it provides an evidence-based conceptual framework of the 220 unique determinants collated and categorised in a comprehensive typology. Thirdly, it draws attention to the research gaps to be addressed, reinforcing the need for further research and consolidation on the topic. Fourthly, it provides guidelines and a transferable methodology for systematic updates in the future. Fifthly, it maps the publication trends on the subject and clearly identifies the researchers that have tackled the topic. Finally, as we previously noted, one of the main challenges for researchers who are interested in this phenomenon, is the diverse terminology used in the literature. The integration efforts of the present review contribute to a better understanding of innovation determinants that were empirically studied and will facilitate the work of researchers on this subject matter by providing a clear landscape of this literature. We believe the highlights of this systematic review open the discussion for further integrated research on the topic. The research community is encouraged to test the proposed model of determinants.

Finally, we propose the following avenues to expand our future research directions on this subject for which there is a sustained interest in the literature:

1 empirically test this integrated framework on SMEs operating in the manufacturing sector

2 empirically enhance the conceptual framework with additional determinants according to this typology focusing on the research gaps

3 highlight, from this list of determinants, the configuration of necessary and sufficient conditions associated with the use of innovation cooperation

4 anchor this work with theories.

This paper lays a foundation for future research on the topic by organising and building upon the literature that has been published so far. Further progress on better understanding the phenomenon will certainly be eased because of this foundation.

Appendix C is available on request by emailing the corresponding author or can be obtained under https://figshare.com/articles/dataset/dx_doi_org_10_6084_m9_figshare_6025748/6025748.

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Notes

1 Parts of this research are based on work previously presented in the following empirical paper: Cloutier, A. and Amara, N. (2018) 'Determinants of propensity vs. intensity of innovation cooperation for SMEs', *International Journal of Innovation Management*, Vol. 22, No. 5, p.1840004 (which was partially presented at the Administrative Sciences Association of Canada 2017 Conference).

2 Case studies are outside the scope of this analysis as they may give too much weight to exceptional cases.

Appendix A

Database search strategy and results

Table A1 Database search strategy and results

Strategies		ABI/inform complete	Business source complete	Web of Science
1	Innovation	*1,019,334*	*945,163*	*272,819*
		SU(“Industrial research” OR “Research & development” OR “R&D” OR “Innovations” OR “Technological change” OR “Product development”) *289,007*	DE (“INNOVATIONS in business” OR “RESEARCH & development partnership” OR “TECHNOLOGICAL innovations” OR “RESEARCH & development” OR “INDUSTRIAL research” OR “NEW product development”) *191,744*	TS=(“innovat*”) *272,819*
		OR	OR	
		ti,ab(“innovate” OR “innovated” OR “innovator” OR “innovators” OR “innovativeness” OR “innovation” OR “innovations” OR “innovating” OR “innovatively” OR “innovative” OR “research” OR “R&D” OR “new product development”) *962,106*	TI (“innovate” OR “innovated” OR “innovator” OR “innovators” OR “innovativeness” OR “innovation” OR “innovations” OR “innovating” OR “innovatively” OR “innovative” OR “research” OR “R&D” OR “new product development”) *138,764*	
			OR	
			AB (“innovate” OR “innovated” OR “innovator” OR “innovators” OR “innovativeness” OR “innovation” OR “innovations” OR “innovating” OR “innovatively” OR “innovative” OR “research” OR “R&D” OR “new product development”) *796,734*	
2	Cooperation	*678,258*	*696,412*	*676,910*
		SU(“Joint ventures” OR “Alliances” OR “Cooperation” OR “Collaboration” OR Partnering) *122,598*	DE (“STRATEGIC alliances (Business)” OR “COOPERATION” OR “INDUSTRIAL cooperation” OR “JOINT ventures” OR “PARTNERSHIP (Business)” OR “PARTNERING between organisations”) *138,960*	TS=(“Joint venture” OR Alliance$ OR cooperat* OR co-operat* OR collaborat* OR partner* OR interfirm OR inter-firm OR interorganisation OR inter-organisation OR interorganisation OR inter-organisation) *676,910*
		OR	OR	
		ti,ab(Collaborative OR collaboration OR collaborate OR cooperative OR “co operative” OR cooperation OR “co operation” OR cooperate OR “co operate” OR alliance? OR partner OR partnership OR Joint NEAR/1 venture? OR interfirm OR “inter firm” OR interorganisation OR “inter organisation” OR interorganisation OR “inter organisation”) *610,832*	TI (Collaborative OR collaboration OR collaborate OR cooperative OR co-operative OR cooperation OR co-operation OR cooperate OR co-operate OR alliance# OR partner OR partnership OR Joint N1 venture# OR interfirm OR inter-firm OR interorganisation OR inter-organisation OR interorganisation OR inter-organisation) *110,176*	
			OR	
			AB (Collaborative OR collaboration OR collaborate OR cooperative OR co-operative OR cooperation OR co-operation OR cooperate OR co-operate OR alliance# OR partner OR partnership OR Joint N1 venture# OR interfirm OR inter-firm OR interorganisation OR inter-organisation OR interorganisation OR inter-organisation) *649,106*	

Table A1 Database search strategy and results (continued)

Strategies	*ABI/inform complete*	*Business source complete*	*Web of Science*
3 SME	*149,842*	*102,299*	*34,777*
	SU("Small & medium sized enterprises" OR "Small business" OR "SME") *89,797*	DE ("SMALL business") *46,426*	TS=(SME$ OR (("Small and medium" OR "Small & medium" OR "small") NEAR/3 (enterprise OR business OR organisation OR firm))) *34,777*
	OR	OR	
	ti,ab(SME? OR ("Small & medium" NEAR/3 (enterprise? OR organisation OR organisation OR business OR firm)) OR ("Small and medium" NEAR/3 (enterprise? OR organisation OR organisation OR business OR firm)) OR ("Small" NEAR/3 (enterprise? OR organisation OR organisation OR business OR firm))) *99,754*	TI (SME# OR ("Small & medium" N3 (enterprise# OR organisation OR organisation OR business OR firm)) OR ("Small and medium" N3 (enterprise# OR organisation OR organisation OR business OR firm)) OR ("Small" N3 (enterprise# OR organisation OR organisation OR business OR firm))) *25,783*	
		OR	
		AB (SME# OR ("Small & medium" N3 (enterprise# OR organisation OR organisation OR business OR firm)) OR ("Small and medium" N3 (enterprise# OR organisation OR organisation OR business OR firm)) OR ("Small" N3 (enterprise# OR organisation OR organisation OR business OR firm))) *89,508*	
4 Limits	N/A		
	Timespan 1992–2015 Peer-reviewed	Timespan 1992–2015 Peer-reviewed	Timespan 1992–2015 Indexes=SCI-EXPANDED, SSCI, A&HCI
5 Results	N/A		
#1 AND #2 AND #3	3,753	1,655	1,331
#1 AND #2 AND #3 AND #4	1,562*	1,088	776
6 Dates			
Query	January 27, 2016	January 27, 2016	January 27, 2016
Import	January 27, 2016	January 27, 2016	January 27, 2016

Appendix B

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