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Complementarity between innovation knowledge sources: Does the innovation performance measure matter?

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Abstract We analyse complementarity between different knowledge sources (internal, external and/or cooperation) employing a wide range of innovation performance measures (product, process, organizational, and commercial). The empirical study uses 2014 Spanish CIS data and studies complementarities by performing conditional complementarity/substitutability tests. The results show evidence of conditional complementarity in product innovation performance between external and internal knowledge sources in absence of cooperation and of conditional substitute relationship between external and cooperation knowledge sources in presence of internal source. In product and process innovation performance we found a conditional substitute relationship between internal and cooperation sources when external source is used and not used, respectively. This relationship turns to conditional complementarity in organisational innovation in absence of external knowledge source. Therefore, when designing innovation strategy, managers must consider their objectives on a priority basis, since not all the strategies have the same effects on innovation performance.

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Introduction

Companies have gradually abandoned the concept of knowledge generation as a purely internal process and tend to

combine different sources in order to achieve all the capabilities needed to optimize their innovation activity (Teece, 1986; Hartung and MacPherson, 2000; Rigby and Zook, 2002). Although the idea that firms benefit from complementing internal with external knowledge sources is well accepted in the previous extensive literature on this topic (for example Cassiman and Veugelers, 2006; Schmiedeberg, 2008; Balot et al., 2015), a closer look reveals that existing papers

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about complementarity on innovation knowledge sources have offered an incomplete view of the topic, generating inconsistent results (Krzeminska and Eckert, 2016), a fact that suggests the need of more research about this issue.

Firstly, and in spite of the potential benefits of R&D cooperation source on innovation performance, our literature review has identified only one paper (Cassiman and Veugelers, 2002) that analyses complementarity considering all the available knowledge sources for a firm: internal (the firm generates and integrates new knowledge on its own), external (the firm accesses external knowledge through contractual arrangements in the market in order to gain knowledge unrelated to the firm's current areas of knowledge or to use knowledge that advances its existing technologies and products) and cooperation (the firm carries out innovation activities together with other partners). Consequently, a research gap exists regarding the analysis of complementary or substitute relationships considering all the three available knowledge sources for a firm. Secondly, although it is very difficult for a single measurement to capture all the complexity of innovation (Souitaris, 2002; Martinez-Sanchez et al., 2009), to date only few studies perform complementarity analysis of knowledge sources on more than one innovation performance measurement (Beneito, 2006; Schmiedeberg, 2008; Goedhuys and Veugelers, 2012; Ballot et al., 2015; Krzeminska and Eckert, 2016). Despite this scarcity in the variety of performance measurements, in some cases the opposite results reported in terms of complementarity (Schmiedeberg, 2008; Jirjahn and Kraft, 2006; Love and Roper, 1999, 2001) could be dependent on the type of performance measurement used, a factor that suggests the need for more research on the issue.

Given this situation the main objective of this paper is to study the existence of complementarity on innovation performance between the three innovation knowledge sources (internal, external and cooperation) employing different measures of innovation performance. We use data from Spanish companies collected by the Technology Innovation Panel (PITEC) as part of the Community Innovation survey (CIS) for the year 2014. The present work aims to provide a more comprehensive and integrated vision of this issue, contributing to existing literature along two directions. Firstly, the paper extends the analysis of complementary or substitutability relationships between internal and external knowledge sources to the R&D cooperation source. In our analysis, and in line with recent research (Ballot et al., 2015; Guisado-González et al., 2017), we adopt the supermodularity framework to directly study complementarities between more than two variables performing conditional complementarity tests. Secondly, the paper performs complementarity of knowledge sources incorporating a wider range of innovation performance measurements, some of them scarcely used in previous studies, such as those of organizational and commercial innovation, in order to investigate the possible effect of the performance variable on the results obtained in terms of complementarity or substitutability between knowledge sources.

In order to achieve our objectives, the next section of the paper deals with the review of literature on the subject. The third section presents a theoretical and methodological discussion of complementarity. The fourth section presents

the data source and variables and fifth section presents the results, while the final section concludes.

Literature review on complementarity of innovation knowledge sources

In the literature analysing the relationship between knowledge sources and innovation outputs a significant strand has emerged focused of studying whether innovation knowledge sources are bound together by a complementarity or substitutability relationship (Catozzella and Vivarelli, 2014a), revealing the existence of various arguments and mixed empirical evidence in favour of the one or the other.

Beginning with the theoretical arguments supporting the complementarity nature between innovation knowledge sources – the simultaneous adoption of different sources being more valuable than the use of each of them separately –, a relevant factor is the existence of what Cohen and Levinthal (1990) called “absorptive capacity” within the Organization Industrial Theory. This concept shows that external knowledge source is more effective for the innovation process when the firm engages in its own R&D, which allows the firm to absorb, evaluate and use that external information (Cohen and Levinthal, 1990; Arora and Gambardella, 1994). Mowery and Rosenberg (1989), for their part, propose that cooperative research programs alone are insufficient, and firms also need the development of sufficient internal expertise to utilize the results of external research.

Along this line, Rigby and Zook (2002) argue that the ability to open innovation processes to external flows of knowledge – known as “open innovation” (Chesbrough, 2003a,b) – is a critical new source of competitive advantage, an approach shared from the perspective of Resource-Based View. The statement is based upon the argument that the combination of various sources for the development of innovation facilitates the construction of new organizational competencies (Teece, 1986). Companies with higher levels of absorptive capacity are more likely to generate competitive advantages, which may in turn positively reflect on the company's innovation performance (Damanpour et al., 2009).

These theoretical arguments are empirically supported in Veugelers and Cassiman (1999), Cassiman and Veugelers (2006), Hagedoorn and Wang (2012) and Catozzella and Vivarelli (2014a,b) for complementarity between internal and external knowledge sources, and in Cassiman and Veugelers (2002) for complementarity between internal R&D and cooperation. However, the empirical results in Berchicci (2013), suggest that the substitution effect is larger for firms with greater internal innovation capacity.

The literature has also shown arguments supporting the substitutability between innovation knowledge sources. Thus, the Transaction Costs Economics (TCE) has focused particularly on the choice between internal and external development, which is known as “Make or buy decision” (Veugelers and Cassiman, 1999). According to this theory, the choice of the innovation strategy, defined as a combination of one or more innovation knowledge sources, is determined for the costs and risks associated with each strategy. On the one hand, the external knowledge source

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