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R&D collaborations: Is diversity enhancing innovation performance?

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ABSTRACT

We develop a theoretical framework which builds on the existence of a feedback loop relationship between internal innovation efforts and the diversity of types of R&D collaborations. Such a feedback loop allows for decomposing the total effects of both internal and external knowledge sources on innovation performance in direct and indirect effects. We argue that such feedback loop lies in the heart of the interplay between the benefits and costs associated with generating knowledge internally and accessing knowledge from diverse external knowledge sources. In particular we argue that anticipated benefits from accessing knowledge from diverse external knowledge sources may be outweighed by (i) costs associated with accessing increasingly diverse knowledge through collaboration and (ii) a negative network effect on firms' internal innovation efforts. We employ Structural Equation Modelling on a bespoke dataset of Greek R&D active manufacturing firms; empirical results confirm the existence of an idiosyncratic feedback loop relationship and show that internal innovation efforts positively influence firm innovation performance. On the other hand, diversity in external collaborations has a negative impact on internal innovation efforts, elevating the importance of the optimal balance between internal R&D investments and the diversity of R&D collaborations. The same picture emerges when examining the corresponding direct and indirect effects of internal and external knowledge sources on innovation performance.

1. Introduction

External collaborations and open innovation play an increasingly central role in firm innovation management and performance (e.g. Chesbrough, 2006; Lakemond et al., 2016). Extant literature has mainly explored how external collaboration, acting in tandem with internal knowledge generation efforts, may improve innovation performance (e.g. Alexy et al., 2016; Chesbrough, 2006; Kale and Singh, 2009; Wassmer, 2010; Wuyts and Dutta, 2014; Zidorn and Wagner, 2013). In this line, Lakemond et al. (2016) suggest that knowledge integration through open innovation collaboration can be essentially perceived as a knowledge governance problem. Hence, firms' decisions on the management of partners and knowledge inflows and outflows will have an impact on their innovation performance. Despite the opportunities that external collaborations offer to acquire or to access complementary and supplementary knowledge, the literature finds mixed evidence on their role in innovation performance (e.g. Abramovsky et al., 2008; Chun and Mun, 2012; Faems et al., 2010; Laursen and Salter, 2006). This is mainly due to external collaborations carrying costs of search, coordination, management and knowledge exchange which can outweigh the benefits of accessing external knowledge (Teece, 2006). Such costs can be aggravated by the need to establish management mechanisms to prevent any unintended spillovers towards the innovation partners. (Laursen and Salter, 2014).

Most of the literature assumes exogeneity of R&D activities and external knowledge sources when investigating their influence on innovation performance; however, their interrelationship has been often acknowledged by incorporating a moderating effect of internal R&D activities on the breadth and depth of external knowledge sources (Cassiman and Veugelers, 2006; Laursen and Salter, 2006; Hagedoorn and Wang; 2012; Lin et al., 2012). In this paper, we argue that even such moderation effects may offer only a weak approximation to the complex interplay between internal innovation efforts, knowledge sourced from R&D collaborations and firm innovation performance. Indeed, these elements of firm innovation strategy and performance are co-determined and co-evolve and this introduces interrelationships among them (Dosi and Nelson, 2014; Teece, 2006). Such interrelationships imply that internal innovation efforts and knowledge sourced from external R&D collaborations not only have direct effects on firm innovation performance but also exert indirect effects through influencing and mediating one another.

This paper proposes that such complex interrelationships can be captured in an integrative way where allowing for endogeneity, i.e. a

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feedback loop, between internal innovation efforts and the diversity of external R&D collaboration offering the opportunity to capture direct and indirect effects on innovation performance, otherwise ignored in relevant literature. We frame such complexity by examining the conditions that enable firms to leverage benefits from accessing knowledge from diverse external knowledge sources and how such benefits may be outweighed by: (i) costs associated with accessing increasingly diverse knowledge through collaboration and (ii) a negative network effect on firms' internal innovation efforts. In particular, internal investments in knowledge generating activities are allowed to directly influence both the diversity of external knowledge sources and firm innovation performance; at the same time, we explore the indirect effect of internal innovation efforts via the diversity of external knowledge on innovation performance. Furthermore, knowledge sourced from external R&D collaborations can have both a direct and an indirect effect on firm innovation performance, through its impact on internal knowledge generation efforts.

Our empirical exploration relies on a sample of Greek Manufacturing R&D active firms for the period 2010, highlighting the fact that the Greek economy and particularly the Greek Innovation System shares many commonalities with other Eastern and Southern small European peripheral countries (OECD, 2012, 2014; Souitaris, 2002). We formulate and empirically test our hypotheses employing Structural Equation Modelling. Empirical findings corroborate the complexity ruling the internal – external innovation nexus which is depicted on their influence on innovation performance; perhaps more importantly, empirical findings dispute the notion of a positive influence of external R&D collaborations and offer a narrative based on the pivotal role of firms internal innovation efforts in generating and appropriating benefits from external collaborations.

The remainder of this paper is structured as follows: Section 2 presents the theoretical and empirical literature forming the background to our framework and empirical hypotheses. Section 3 discusses the context of our study, and specifically the peculiarities of the Greek innovation system together with our methodology, data collection and main empirical variables. Section 4 presents our empirical model in depth, Section 5 presents and discusses the empirical estimates, and finally Section 6 concludes the paper.

2. Background and hypotheses

2.1. Background and research framework

In the main, the literature that offers insights on framing and understanding the relationship between internal, external knowledge and innovation performance (Chesbrough, 2006; Laursen and Salter, 2006; Teece, 1986; Veugelers and Cassiman, 1999) stems from the Resource (Barney, 1991; Wernerfelt, 1984) and Knowledge Based (Grant, 1996; Szulanski, 1996) views, as well as the transaction cost approach (Belderbos et al., 2004; Das and Teng, 2000; Rawley, 2010). In particular, two interrelated concepts have dominated the theoretical and empirical analyses of the management of external technological and other knowledge sources.

First, on the one hand are the benefits stemming from the interplay between internal and external knowledge creation processes, manifested as the ability to form capabilities of the 'learning to learn' variety (Collis, 1994). These capabilities may reflect organizational, integrative, combinative and/or dynamic capabilities which are beneficial in boosting firms' innovation performance (Belderbos et al., 2004; Weigelt, 2009). Second, on the other hand, are the costs associated with accessing diverse types of external knowledge sources. Such costs can be further decomposed in: (i) costs incurred due to increased operational and managerial costs i.e. search, coordination, monitoring, transaction and adjustment costs, and (ii) costs attributed to a network effect which results in loss in "knowledge uniqueness" (Rochet and Tirole, 2006). Hence, the greater the diversity of the external knowledge sources accessed, the higher are the costs of leveraging the newly accessed knowledge (Nasiriyar et al., 2013) and the lower is the probability that the externally acquired knowledge is unique and results in significant yields in terms of firms' innovation performance (Armstrong, 2006; Parker and Van Alstyne, 2005). We argue that such costs occur because an underlying highly interactive process exists from the point of accessing new knowledge, to the point of internalizing and redeploying such knowledge internally and embedding it together with existing organizational routines (Veugelers et al., 2010; Weigelt, 2009; Zahra and George, 2002). Therefore, the processes of innovation, capability creation and the costs associated with pursuing diversity in external collaborations co-exist and jointly influence firm innovation performance (Teece, 2006).

According to extant literature, the causal relationship between internal innovation efforts and firm's diversity of R&D collaborations remains ambiguous (Rycroft, 2007). In this paper, we argue that the relevant literature has sidelined the potential endogeneity between internal innovation efforts and diversity in R&D collaborations portfolio. In such an endogeneity framework internal innovation efforts and diversity in R&D collaborations are co-determined and such *feedback loops* between them can be appropriately captured by a *system of structural equations*.

Within this context, the potential feedback loop between internal innovation efforts and the diversity of the types of R&D collaborations allows the existence and investigation of, otherwise hidden, indirect effects on innovation performance which in turn highlight the underlying complexity ruling this relationship. Fig. 1 below provides a representation of such an endogenously determined system. In this context, both internal innovation efforts and the diversity of external knowledge sources may have, except for a direct impact, substantial indirect effects on innovation performance. In technical terms, both knowledge sourcing variables (i.e. internal R&D and R&D collaboration diversity) simultaneously cause and mediate each other's effect on innovation performance. The existence of mediators differs to the case of moderation examined in extant literature (Berchicci et al., 2016; Lin et al., 2012) and reflects the presence of endogeneity among the variables in the system of Fig. 1.

In the following section, we, first, develop hypotheses on the relationships between internal R&D and diversity of external R&D collaborations (paths "a" and "b" in Fig. 1). Second, we develop hypotheses on the total effects of internal R&D and diversity of R&D collaborations on innovation performance after allowing each other to act as mediators (paths "c × e" and "d × f" respectively in Fig. 1).

2.2. Hypotheses: internal R&D, diversity in types of R&D collaboration & firm innovation performance

Cohen and Levinthal (1989) established a relation between internal knowledge and a firm's ability to identify, absorb, and utilize external knowledge. Existing knowledge determines the remit and level of relevant external knowledge that firms are able to perceive as useful, subsequently internalize and exploit, suggesting that there is path dependence in organizational learning. This main premise of absorptive capacity has been extended to the context of alliances and collaborations, whereby some level of commonality between partners' knowledge bases is required for effective knowledge transfer in alliances (Lane and Lubatkin, 1998; Mowery et al., 1996). Based on the above we expect a positive effect between a firm's internal innovation efforts and the diversity of its R&D collaboration portfolio. Broader and deeper investments in internal innovation efforts not only make external search more astute but also enable firms to identify the potential of more varied and broader sources of external knowledge, hence increasing the diversity of R&D collaborations (Cohen and Levinthal, 1989; Faems et al., 2010; Mowery et al., 1996). Existing research suggests a positive effect of a firm's investments in R&D on the extent of its collaborative partnerships (Dahlander and Gann, 2010; Lin et al., 2012; Lokshin et al., 2008). As a result the following hypothesis is formulated: