



# R&D subsidies & external collaborative breadth: Differential gains and the role of collaboration experience



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## ABSTRACT

External collaboration breadth is important for firms to acquire the knowledge needed to innovate. In this paper, we combine cross-sectional and longitudinal data from the Spanish Panel of Technological Innovation Survey (PITEC) to examine the indirect impact of R&D subsidies on firm external collaboration breadth. We contribute to understanding of the indirect impacts of R&D subsidies by first providing strong evidence of an economically significant average positive impact of R&D subsidies on firm external collaboration breadth. Second, our results advance understanding of the differential impacts of R&D subsidies by revealing the vast heterogeneity of the impact at the firm level, where approximately only half of treated firms experience a positive collaboration impact from R&D subsidies, while the remainder experience no impact or a negative effect. Finally, we advance understanding of the characteristics explaining the differential impact of R&D subsidies on external collaboration breadth by utilising the organisational learning literature to demonstrate the important role of firm collaboration experience.

## 1. Introduction

Governments commit substantial resources to R&D subsidies to stimulate firm innovation activities, for example, in Spain (the context of this study) more than 3 billion Euros were allocated between 2011 and 2013 (Fernandez-Zubieta, 2014, 2015). Consistent with the direct aim of R&D subsidies, vast empirical research has emerged showing that R&D subsidies stimulate firm R&D expenditure (e.g., Czarnitzki and Lopes-Bento, 2013; Dimos and Pugh, 2016). Beyond directly intended impacts, interventions typically also have *indirect* (unintended) impacts on organisations. While the behavioural additionality literature has postulated that R&D subsidies, through for example stimulating learning processes, induce important indirect impacts on organisations alongside their intended effects, we know little about the nature of these *indirect* impacts (Autio et al., 2008; Clarysse et al., 2009; Cunningham et al., 2016). Particularly, while the indirect impact on external collaboration has attracted some attention (Afcha, 2011; Busom and Fernández-Ribas, 2008), reflecting its importance for innovation, our understanding of this relationship remains limited.

This paper advances understanding through examining the *indirect* impact of R&D subsidies on firm external collaboration *breadth* (Busom and Fernández-Ribas, 2008), which we define as the number of partner

types with which firms collaborate (e.g., Laursen and Salter, 2006). It is well established that as the knowledge needed for innovation has become increasingly complex and distributed across the innovation value chain (Chesbrough, 2006; Lakhani et al., 2013), that external collaboration *breadth* is central for firms to acquire the knowledge needed to innovate (e.g., Dahlander and Gann, 2010; Laursen and Salter, 2006). As such, we first examine the (average) indirect impact of R&D subsidies on external collaboration breadth, arguing that R&D subsidies, through enhancing firm absorptive capacity, generating new technological opportunities, and easing firm access to external finance, help stimulate firm external collaboration breadth. Second, we drill further into this relationship by explicitly considering both the *average* and *differential* impact. Existing research has predominately focused on the average effect, however, this is an important limitation since it is unlikely most participants obtain this effect, or close to it, given inherent differences in underlying firm characteristics (Cunningham et al., 2016; Lee, 2011). As such, by considering both the *average* and *differential* impact we advance the literature toward more nuanced understandings of the (in) direct impacts of R&D subsidies. Finally, we advance understanding of the characteristics explaining the differential (collaboration) impacts of R&D subsidies by examining the important influence of collaboration experience, which existing research shows is an

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important antecedent of firm collaboration behaviour (Badillo and Moreno, 2016; Belderbos et al., 2012; Gulati, 1999). We argue that collaboration experience, through developing firm alliance formation capabilities, search capabilities, and signalling their quality, magnifies the *indirect* impact of R&D subsidies on external collaboration breadth.

We believe advancing this understanding is important for several reasons. First, while research suggests R&D subsidies directly stimulate R&D expenditure (Beck et al., 2016), the beneficial effects are small (Dimos and Pugh, 2016) and we know little about the *indirect* behavioural additionality impacts, particularly for external collaboration, despite its importance for innovation (Busom and Fernández-Ribas, 2008; Clarysse et al., 2009). Considering policymakers' finite resources (Gupta and Guerguil, 2014; Mazzucato, 2013) and existing alternative interventions to R&D subsidies (e.g., R&D tax credits (Guerzoni and Raiteri, 2015), obtaining more comprehensive understanding of the (in) direct impacts of R&D subsidies is important for informing future innovation policymaking. Second, the established innovation benefits of external collaboration have stimulated policymaker attention and programmes focused on encouraging external collaboration (Chesbrough et al., 2011; Fabrizi et al., 2016). Given the significant resources currently devoted to R&D subsidies, advancing understanding of their utility to indirectly stimulate external collaboration, alongside their intended impacts, could inform and aid policymaker efforts to design effective policy mixes for stimulating external collaboration. Third, despite the importance of external collaboration breadth for firms to access the knowledge needed to innovate (Beck and Schenker-Wicki, 2014; Dahlander and Gann, 2010; Laursen and Salter, 2006), the limited existing research has focused on the *indirect* impact of R&D subsidies on firm propensity to collaborate (Busom and Fernández-Ribas, 2008), with little attention to the impact on the *breadth* of external collaboration. Finally, despite some attention to the differential impacts of R&D subsidies (Cunningham et al., 2016; Lee, 2011), empirical evidence on both the *extent* and *drivers* remains extremely limited (Beck et al., 2016; Clarysse et al., 2009; Hottenrott and Lopes-Bento, 2014). Redressing this is important to obtaining more nuanced understandings of who experiences the (in) direct impacts of R&D subsidies and what characteristics magnify (or weaken) the impacts. This understanding could inform policymakers about the types of participants for which R&D subsidies could be a useful instrument to stimulate greater external collaboration breadth.

To examine our questions, we utilise data from the PITEC on Spanish manufacturing and service firms, and a two-stage methodology. In the first stage, we use data from 2007 to 2013 in estimating a matching procedure to examine the *average* and *differential* impact of R&D subsidies on external collaboration breadth, while accounting for selection bias on observables. The robustness of the matching results to selection on unobservables is examined using instrumental variable regression. In the second stage, we use further data from 2002 to 2010 on firm collaboration experience in estimating OLS regressions examining whether collaboration experience magnifies the indirect impact of R&D subsidies on external collaboration breadth. In additional models, the *extent* and *age* of the collaboration experience are also considered.

This paper proceeds as follows. In Section 2, we outline our conceptual framework, which considers the average and differential impact of R&D subsidies on external collaboration, and the role of collaboration experience in magnifying this impact. Section 3 overviews our data and methods. Section 4 overviews our key empirical findings and Section 5 discusses our contributions to the literature and the implications of our findings for policymakers, organisations and future research.

## 2. External collaboration, innovation & R&D subsidies

External collaboration is a crucial innovation search strategy for organisations to acquire novel technologies and knowledge to sustain, enhance and accelerate their innovation efforts (Belderbos et al., 2004;

Chesbrough, 2006). Existing research has shown external collaboration with a *breadth* of external partners is particularly important for innovation (Beck and Schenker-Wicki, 2014; Laursen and Salter, 2006; Roper et al., 2017). The importance of breadth stems from the technology and knowledge needed for innovation becoming increasingly complex and spread across the innovation value chain, such that collaborating with a breadth of diverse partners increases the odds firms will acquire the technology and knowledge needed to innovate successfully (Leiponen and Helfat, 2010). A significant body of empirical evidence has amassed demonstrating the innovation benefits of external collaborative breadth (e.g., Beck and Schenker-Wicki, 2014; Laursen and Salter, 2006; Love et al., 2014; Roper et al., 2017).

### 2.1. The indirect impact of R&D subsidies on external collaborative breadth

We argue that R&D subsidies indirectly stimulate increases in firm external collaboration breadth drawing on three mechanisms. First, through providing greater access to additional financial resources. Existing research shows that R&D subsidies, through providing a 'certification effect' about the quality of subsidised firms, enable them to more easily obtain additional finance from private investors (e.g., banks) (Cerulli et al., 2016; Kleer, 2010; Meuleman and Maeseineire, 2012). Participating in a breadth of external collaboration imposes significant financial costs for firms because it requires companies to expand their alliance management skills, which affects their cost structure (Cassiman and Valentini, 2016; Faems et al., 2010; Hottenrott and Lopes-Bento, 2016). Thus, we argue that by relaxing financial constraints, R&D subsidies can help firms expand their external collaboration breadth (Busom and Fernández-Ribas, 2008; Cano-Kollmann et al., 2017). For example, the greater access to external finance could be used to fund the costs of acquiring and developing the personnel and internal structures needed to support and expand their external collaboration breadth (Belderbos et al., 2012; Faems et al., 2010; Leiponen, 2005). Empirically, Park et al. (2002) demonstrate the importance of financial resources in increasing external collaboration breadth.

Second, firms gain new R&D experiences through performing their R&D subsidy-funded project, which increase supported firms' stocks of knowledge (Buisseret et al., 1995). The formation of these stocks provides supported companies with greater ability to identify, assimilate and apply external knowledge that is associated with the technological fields related to these stocks (Lee, 2011). This idea is coherent with the concept of absorptive capacity, according to which the degree of external knowledge utilisation is a function of the level of prior related knowledge a firm accumulates (Cohen and Levinthal, 1990). Additionally, as R&D subsidies typically fund far from market projects (Clausen, 2009; Santamaria et al., 2010), while managers prefer those closer to market, the knowledge gained in R&D subsidies is likely to be novel to firms' current knowledge stocks, thus increasing their diversity. Moreover, R&D subsidies encourage firms to perform more technologically challenging projects (DITRA, 2006; Falk, 2007; Hsu et al., 2009), which through learning processes can further increase the diversity of their knowledge stocks. The increased diversity of knowledge stocks is associated with improved absorptive capacity, with firms' ability to identify external knowledge being a function of their absorptive capacity (Lee, 2011; Cohen and Levinthal, 1990).

Thus, we argue that through increasing firm absorptive capacity R&D subsidies enhance their ability to identify diverse external collaborative partners. Enhanced absorptive capacity extends the knowledge and technological landscape within which firms can recognise and assimilate knowledge (Cohen and Levinthal, 1990). As such, firms can search and monitor knowledge and technological developments across multiple fields and recognise (potentially) valuable new developments that offer opportunities for collaboration (Zhang et al., 2007; Zhang, 2016). Thus, absorptive capacity can increase firms' availability of

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