



# Applications of fuzzy logic for determining the driving forces in collaborative research contracts<sup>☆</sup>



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## ABSTRACT

This study examines various factors (human capital, experience, attraction capacity, and profile) of technology centers that, according to the literature, affect the performance of science–industry R&D partnerships. The measure of performance is the income that R&D contracts generate divided by the number of clients that the research center has. The data sample considers technology centers operating in the region of Catalonia that act under the TECNIO umbrella brand. The analysis uses fsQCA methodology, which allows identifying a combination of causes that lead to the outcome. Results support the argument that different causal paths explain profitable R&D contracts.

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## 1. Introduction

R&D activities are of strategic importance for the innovative performance of firms (Howells, Gagliardi, & Malik, 2008). The organization of these activities can be either internal or external to the firm. According to the literature of open innovation (Chesbrough, 2003), firms need to open themselves up to external knowledge relations to gain new and fresh ideas that allow them to innovate and leverage markets. No company is smart enough to know exactly what to do with every new opportunity; and no company has enough resources to pursue all the opportunities that the firm might execute (Wolpert, 2002).

Because research institutions are relevant knowledge-intensive organizations, research portrays the establishment of collaborative science–industry partnerships as one of the primary means by which firms can gain access to and acquire significant knowledge (Spithoven & Teirlinck, 2014). Such alliances reinforce the idea that firms might not conduct all R&D activities internally, forcing them to expand and look outside their own boundaries to complement their in-house R&D efforts (Lin, 2014).

R&D alliances materialize in a variety of forms (Odagiri, 2003). For the purpose of this study, the terms “R&D partnerships” and “R&D

alliances” designate an R&D agreement by which a firm contractually pays a research institution to perform R&D activities.

From the standpoint of firm capabilities, external and internal R&D complement each other (Lee, Ribeiro, Olson, & Roig, 2007; Ribeiro-Soriano & Castrogiovanni, 2012). Firms tend to outsource R&D activities in which they are not specialists, but which may still be important as support (Kogut & Zander, 1992); in this way, firms can concentrate on those tasks they do best (Narula, 2001). However, the outsourcing of more core-related R&D activities may also be beneficial, as external resources and knowledge can close the gaps in firms' internal capabilities (Kang, Wu, Hong, & Park, 2012).

Several studies report the benefits arising from collaborative science–industry agreements (Teirlinck & Spithoven, 2013). First, these partnerships are imperative for the firm because partnerships facilitate knowledge acquisition and exploitation of novel scientific discoveries, the possibility to complement firms' scarce internal resources, and the opportunity to enlarge firms' social networks (Audretsch, Leyden, & Link, 2012). Second, science-based institutions need the industry's knowledge of the market to come up with new, applicable, and successful technology developments (Ribeiro-Soriano & Urbano, 2010). Furthermore, such collaborations gain research centers' additional funding support, which is fundamental to safeguarding the viability of future research endeavors (Baba, Shichijo, & Sedita, 2009; Lai, 2011).

Although research institutions encompass different types of centers, the vast majority of previous works analyzing science–industry R&D alliances restrict their analysis to research institutions that belong or hold affiliation to a university (Bruneel, D'Este, & Salter, 2010; Perkmann, Neely, & Walsh, 2011). Aiming at covering this research gap, this

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study posits that both university-affiliated and non-affiliated research institutions can achieve successful R&D science–industry partnerships, although these institutions might follow different paths. Accordingly, this study examines how the profile of the research institution in combination with other factors that the literature lists as determinants for R&D partnership (namely, human capital, experience, and attraction capacity) affect the performance of such alliances.

The data sample considers as research institutions the technology centers (TCs) operating in the region of Catalonia (Spain) that act under the TECNIO umbrella brand. As a measure of performance, the empirical application considers the income resulting from R&D contracts per client. A configurational comparative method, fsQCA, allows meeting this objective. The findings suggest that although university-affiliated TCs may have different ways that lead to productive R&D partnerships, non-affiliated centers can also obtain some causal paths.

## 2. Theoretical underpinnings

Literature on science-based collaborative R&D partnerships suggests different factors that help explain the performance of such alliances. An in-depth description and discussion of each of these factors follows.

### 2.1. Human capital

Research portrays organizations that are intensive in scientific and technical human capital as the ideal partners for collaborative R&D activities. Although research institutions usually have advanced facilities and machinery that require a considerable investment and are only available to very few companies, highly skilled human capital resources that these institutions possess are what really makes them attractive for firms. Indeed, because nothing can take away knowledge from individuals, knowledge, abilities, and capabilities constitute key determinants for firms when those firms look for their R&D partner. Thus, the higher the research institution's level of expertise, the greater the institution's ability to attract firms. Therefore, the skill composition of the academic board of a research institution seems to play an important role (Feng, Chen, Wang, & Chiang, 2012). This hypothesis is consistent with the idea that researchers with a greater level of human capital are intellectually mature, which in turn may lead to a greater facility for developing fresh ideas, building new knowledge, and establishing stronger working networks.

Accordingly, the availability of qualified human resources at research institutions might act as a catalyst, attracting firms' interest for the establishment of fruitful R&D partnerships.

### 2.2. Experience

Previous experience gives people the specific knowledge and capabilities that can help them develop successful strategies. On the one hand, the effective implementation of the knowledge stock can represent the starting point for future advances, reducing the time spans necessary to develop new activities (Anderson, Daim, & Lavoie, 2007). On the other hand, experience captures the dynamic knowledge spillovers resulting from past activities, which develop appropriate managerial capabilities that facilitate the production of outputs in the present.

One way to account for experience is measuring how active the research institution is in conducting cutting-edge advances. According to economic and sociological theories, external perceptions of an organization's current performance affect the probability of potential buyers to transact with that organization (Weigelt & Camerer, 1988; Wilson, 1985). In the context of science–industry alliances, a firm's decision to ally with a university depends on academic performance (Laursen, Reichstein, & Salter, 2011; Sine, Shane, & Di Gregorio, 2003; Soh & Subramanian, 2014). Because knowledge generation entails

some degree of uncertainty, firms will be more willing to transact with research institutions that have a more solid reputation (Kathoefer & Leker, 2012; Sine et al., 2003). If research achievements have an impact within the scientific community, the capacity of the research institution to generate firm awareness will increase, thereby enhancing the likelihood that firms will know about that organization.

Consistent with previous studies, this study argues that experience in the form of records of accomplishment and historical successes is key to attract funding and partners; hence, experience positively contributes to more profitable R&D partnerships. For the purpose of this study, experience takes the form of patents and publications. Both patents and publications capture the quality of this research and stimulate future research activity (Mowery, Sampat, & Ziedonis, 2002).

In the case of patents, researchers willing to apply for a patent receive the assessment of their research institution about the possibilities of the technology and must pass different stages that guarantee the quality and uniqueness of their invention. Only those invention disclosures that successfully pass all controls continue with the process. In the next stage, a public organism performs a second evaluation of the suitability of patenting the technology. This process is much more strict and complex than the former. Thus, the patenting activity is an appropriate proxy for the quality and the potential applicability of the research.

The case of articles' publication in academic journals is similar. According to Kao and Hung (2008), publications in well-known indexed journals not only reflect quantity but also quality aspects of the research. This role of articles is possible because researchers submit papers to journals with a double-blind peer review system and journals publish those papers following the quality standards of the academia. Thus, restricting the research productivity to only those scientific articles appearing in top journals is a suitable approach.

### 2.3. Attraction capacity

Because the marketing function is fundamental for finding new partners, researchers have to take either a direct or an indirect role in promoting the quality of the research activities that takes place within their centers. However, although scientists are very competent in providing new knowledge and technological advances, how to market best their research results is usually outside their experience (Gray, 2011).

From a relationship marketing perspective, advertising is an activity of the organization rather than the function of a particular unit (Rivers & Gray, 2013). Although researchers need to participate in this process of advertising, a specific unit or technical staff in charge of marketing activities is paramount to ensure the visibility of the research center. Research institutions can use different formulas to accomplish this purpose. Publishing and patenting are a first step; however, research institutions need to develop appropriate marketing strategies aiming at communicating, delivering, and exchanging offerings with potential value for partners.

Although prior studies suggest that informal networks are sufficient to trigger future successful science–industry relationships (Kreiner & Schultz, 1993; Liebeskind, Oliver, Zucker, & Brewer, 1996), complementary strategies are necessary to capture firms' attention (Batonda & Perry, 2003). By scanning the environment and targeting potential partners, this study proposes that further strategies need to concentrate on generating firms' awareness, and converting this awareness into new customers.

Research shows that a combination of different communication channels, including both social networking and transactional marketing approaches, are effective methods for identifying prospects; hence, these methods are appropriate mechanisms for spreading the activities that research institutions carry and, more importantly, for making publicly available their technological portfolio offer. Efforts are effective

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