The impact of the third sector of R&D on the innovative performance of entrepreneurial firms

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Abstract:

Entrepreneurial firms that rely on public research institutes, the third sector of R&D, are also firms that are more innovative in terms of introducing new or significantly improved goods or services to the market. This finding is based on an analysis of 4004 knowledge-intensive entrepreneurial (KIE) firms located in ten European Union countries. We interpret our findings as suggestive evidence of the importance of policymakers continuing to support financially public research institutions.

Keywords: research institute | third sector of R&D | innovation | KIE firms

Article:

Introduction

There is a vast and rich literature on the relationship between a firm's investments in research and development (R&D) and its innovative performance (Cohen 2010). As Cohen and Levinthal (1989) suggest, this relationship might be due to the direct effect of R&D investments on firm innovation and to the indirect effect coming from the enhanced absorptive capacity of the firm. However, there is another source of innovative behavior that has often been overlooked in the literature, namely technical knowledge coming from firm relationships with publicly funded research institutes, the so-called "third sector of R&D."[1]

In this paper, we offer empirical information about the performance impact of firms relying on public research institutes as a source of business-related knowledge and expertise, and we emphasize, based on our findings, the social importance of policymakers continuing to fund these institutes. In Section 2, we review the literature related to alternative sources of knowledge used by firms. In Section 3, we offer an empirical framework for the study of the relationship

[1] To wit, Hallonsten (2017, p. 21) points out that there is a "shortfall of scholarly work devoted to the history, organization, and politics of [publicly funded R&D] research institutes …." Hallonsten also offers a lucid discussion of three institute groups in Nordic countries, and he provides important institutional context for his and future studies of the third sector of R&D.

between such alternative sources and the innovative performance of firms, and we discuss the data used to implement this framework. In Section 4, we present our empirical findings, and our paper concludes in Section 5 with summary remarks and a discussion about the policy relevance of our findings.

The related literature

Our review of the literature reveals that only a handful of studies have examined the empirical link between innovative performance and the different sources of scientific and technical knowledge on which firms rely.

In an early contribution, Beise and Stahl (1999) explore the impact of publicly funded research on industrial innovations in Germany. Using a sample of more than 2000 German firms, the authors find that the propensity to adopt spillovers from public research increases with firm size and R&D intensity. The latter finding suggests that investments in internal R&D do increase a firm's absorptive capacity, which is the ability to internalize external sources of scientific and technical knowledge to leverage the development of new product and process innovations (Cohen and Levinthal 1989). As part of the survey used by Beise and Stahl (1999), firms were asked to identify innovations that would not have been developed without publicly funded research. Interestingly, among the firms that identified such innovations, public research institutes were cited almost as often as universities as an important external source of knowledge.

Tether and Tajar (2008) note that while university-firm interactions have been widely studied, other knowledge providers, such as public and private research organizations and consultants, may also be important to the innovation process and can thus complement internal investments in R&D. One of their main findings is that more innovative firms tend to form stronger links with external knowledge providers.

Barge-Gil and Modrego (2011) compare public research organizations (universities and public research centers) and technical institutes (private, non-profit organizations). Using a sample of 257 Spanish firms, they find that firms that collaborated with either type of organization indicated that the collaboration improved a range of economic, technical, and investment outcomes. Also, the effects of collaborating with a public research organization versus a technical institute were largely the same.

Gifford et al. (2015) and Gifford (2017) investigate the breadth and depth of external knowledge sourcing on the innovativeness of knowledge-intensive entrepreneurial (KIE) firms. Using the same data as we do in this paper—data from the AEGIS project as discussed in Section 3 below—these authors find that increased breadth and depth of knowledge sourcing—as measured by the number of different knowledge sources and the extent to which they are used—are generally associated with an increase in innovative activity.[2,3]

[2] See also Audretsch and Link (2018b) who associate theoretically and empirically alternative sources of knowledge with dimensions of entrepreneurial behavior. See also Hodges and Link (2018) and Audretsch and Link (2018a).
[3] Amoroso et al. (2018) also rely on the AEGIS dataset to study firm founders' human capital covariates associated with firms' use of alternative sources of knowledge.

None of the studies discussed above has systematically examined the link between the use of public research institutes (PRIs) as a source of knowledge and the innovative performance of entrepreneurial firms. This is the contribution of our study. Specifically, we empirically investigate the association between the value that these firms place on PRIs as a source of knowledge and their propensity to generate innovative new or significantly improved goods or services.

Data and empirical framework

Data

The data we use were collected as part of the Advancing Knowledge-Intensive Entrepreneurship and Innovation for Growth and Social Well-Being in Europe (AEGIS) project. This project, funded by the European Commission (EC), was active from January 2009 to September 2012 and focused on KIE firms and their mediating role between the generation of new knowledge and technologies and the creation of economic activity.[4] As part of this EC project, a survey of young firms, established in the period of 2001–2007, was conducted across 10 European Union (EU) countries, and information was collected on firms' characteristics, their use of various sources of scientific and technical knowledge, and on measures of innovative behavior and economic performance (Caloghirou et al. 2011).

Our dataset contains information on 4004 KIE firms. Using NACE (Nomenclature des Activités Économiques dans la Communauté Européenne) classification codes, we follow Caloghirou et al. (2011) and group firms into three sectors: high-tech, low-tech, and knowledge-intensive business services (KIBS). The dependent variable in our empirical model is the binary variable Innovation. We set Innovation = 1 if the firm introduced any new or significantly improved goods or services during the 3 years prior to the late 2010, early 2011 survey, and Innovation = 0 otherwise.[5]

We focus on three independent variables. First, Institute measures how important PRIs were to the firm as a source of knowledge for exploring new business opportunities. In the AEGIS survey, firms were asked to rank the importance of PRI knowledge on a Likert scale from 1 (not important) to 5 (extremely important). From firm responses, we coded Institute equal to 1 if the importance scale was 3 or higher, and Institute = 0 otherwise.[6] Second, because market structure is likely to affect innovative behavior, we created an indicator variable to account for this. Competition equals 1 if the firm indicated it had many business competitors, and

[4] An excellent review of the literature on KIE firms is in Malerba and McKelvey (2019). Audretsch and Link (2018b) offer a synopsis of definitions of KIE firms in the literature.

[5] The AEGIS survey question is: "Did your firm introduce new or significantly improved goods or services during the past three years? (Exclude the simple resale of new products purchased from other enterprises and changes of solely aesthetic nature)." The response categories are yes (= 1) or no (= 0).

[6] The AEGIS survey question is: "Please evaluate the importance of public research institutes as a source of knowledge for exploring new business opportunities on a 5-point scale, where 1 is not important and 5 is extremely important." For the marginal effects from the analysis of Section 4, we also considered including indicator variables for each of the response categories. The results were quantitatively very similar, so we only present estimates using the binary-coded variable in this paper. Estimates using the ordinal scale are available from the authors upon request.

Competition = 0 otherwise.[7] Third, investments in R&D are a technical capital input for the creation of new or significantly improved goods or services, and we define the variable RDtoSales as a measure of the firm's R&D-to-sales ratio or its R&D intensity.[8]

Finally, to account for any behavioral or competitive differences among the three sectors (high-tech, low-tech, and KIBS) as well as similar differences among countries—for example, due to differences in the innovation policy environment (e.g., patenting regulations)—we include sector and country fixed effects in the empirical models as well.

Empirical model

To investigate the association between innovation and the value placed on knowledge obtained from PRIs, we estimate a probit model (e.g., Wooldridge 2010). In this model, the probability that Innovation = 1 is specified as a function of (Institute, Competition, RDtoSales, $RDtoSales^2$) and a full set of sector and country indicators.

Rather than reporting the coefficient estimates—which are only informative with regard to their algebraic sign—we report estimates of the average marginal effect for each independent variable. For the variable Institute in particular, the marginal effect is the change in the probability of introducing new or significantly improved goods or services when Institute changes from 0 ("not important") to 1 ("important"). Calculated marginal effects and robust standard errors are reported.[9]

Analytical findings

Descriptive statistics

Descriptive statistics for our sample of firms are given in Table 1, both for the full sample of firms (column (1)) and the subsamples of firms that did (column (2)) and did not (column (3)) invest in R&D. About 63.6% of the firms had introduced new or significantly improved goods or services during the past 3 years. This percentage is higher among firms that invested in R&D (73.8%), compared with those that did not (45.2%).

The average importance attached to PRIs as a source of knowledge for exploring new business opportunities, measured on a Likert scale from 1 to 5, is overall relatively low at 2.1. The average is higher for firms that invested in R&D (2.27) compared with those that did not (1.77), perhaps suggesting the complementary nature of PRI knowledge and internal investments in R&D. In terms of our binary-coded measure of importance, just over 40% of firms investing in R&D assigned a value of 3 or higher to PRIs as a source of knowledge compared with slightly more than 23% of firms that did not invest in R&D.

[7] The AEGIS survey question is: "Are there other businesses offering the same products and/or services to your potential customers?" The three response categories are the following: (a) yes, many business competitors; (b) only a few business competitors; or (c) no other business competitors.
[8] The AEGIS survey question is: "On average, what percentage of your sales has been spent on R&D during the last three years?"
[9] Specifically, the marginal effect was calculated for each KIE firm. We then calculate the average marginal effect across the entire sample and calculate standard errors from the delta method.

Table 1. Descriptive statistics

	(1) Full sample (*n* = 4004)	(2) RDtoSales > 0 (*n* = 2674)	(3) RDtoSales = 0 (*n* = 1330)
Innovation (0/1)	63.6%	73.8%	45.2%
Importance of PRI knowledge (1–5)	2.10 (1.21)	2.27 (1.23)	1.77 (1.10)
Institute (importance ≥ 3)	34.6%	40.1%	23.4%
Sector			
Low-tech	40.0%	38.3%	43.5%
High-tech	10.5%	12.1%	7.3%
KIBS	49.5%	49.7%	49.2%
Competition (0/1)	58.7%	55.0%	65.9%
RDtoSales (0–100%)	12.5 (19.4)	18.7 (21.1)	--
Country			
France	14.2%	12.9%	17.0%
Italy	14.5%	17.9%	7.6%
Portugal	8.3%	8.3%	8.2%
Croatia	5.0%	6.5%	2.0%
Czech Republic	5.0%	4.7%	5.6%
Denmark	8.2%	7.8%	9.2%
Germany	13.9%	13.1%	15.5%
Greece	8.3%	7.8%	9.2%
Sweden	8.3%	6.6%	11.9%
UK	14.3%	14.4%	13.9%

Sample means are reported for the full sample of AEGIS firms, and the subsamples where R&D spending as a fraction of sales is positive or zero. Standard deviations are reported in parentheses next to selected means

Nearly one-half of all firm in the sample operated in the KIBS sector, followed by firms in the low-tech (40.0%) and high-tech (10.5%) sectors. Firms investing in R&D were more likely to operate in the high-tech sector (12.1%) than firms without R&D (7.3%). While the majority of firms operated in a competitive market structure, firms that invested in R&D were less likely to face a large number of business competitors (55.0%) than firms without R&D (65.9%). Firms that invested in R&D reported an average R&D-to-sales ratio of 18.7%.

The largest concentration of the firms in the AEGIS dataset sample was located in either the UK (14.3%), France (14.2%), Italy (14.5%), and Germany (13.9%), followed by smaller numbers of firms in the remaining six EU countries (Portugal, Croatia, Czech Republic, Denmark, Greece, and Sweden).

Marginal effects

The average marginal effects from our probit models are presented in Table 2. We estimated these in the full sample (column (1)), and separately for the subsamples of firms with a positive R&D-to-sales ratio (column (2)), and firms without R&D investments (column (3)). In the full sample, firms that considered PRIs an important source of knowledge are 5.3 percentage points more likely to innovate. The marginal effect is of similar magnitude among firms with positive investments in R&D (5.1 percentage points) but not statistically significant for firms that did not invest in R&D.

Table 2. Marginal effects on the probability of innovation

	(1) Full sample (*n* = 4004)	**(2) RDtoSales > 0 (*n* = 2674)**	**(3) RDtoSales = 0 (*n* = 1330)**
Institute (importance of PRI knowledge ≥ 3)	0.0529*** (0.0160)	0.0512** (0.0176)	0.0356 (0.0328)
Competition (0/1)	− 0.0616*** (0.0151)	− 0.0464** (0.0173)	− 0.0886** (0.0291)
RDtoSales (0–100%)	0.0112*** (0.0008)	0.0053*** (0.0008)	--
Low-tech	--	--	--
High-tech	0.0400 (0.0250)	0.0506 (0.0270)	−0.0424 (0.0542)
KIBS	− 0.0135 (0.0161)	− 0.0324 (0.0190)	0.0328 (0.0293)
n	4004	2674	1330

All probit models include country fixed effects (estimates not shown here). Marginal effects are partial derivatives $\partial P(\text{Innovate} = 1 | X)/\partial X$ for continuous covariates, and differences $P(\text{Innovate} = 1 | X = 1) - P(\text{Innovate} = 1 | X = 0)$ for binary covariates. Low-tech is the reference category for the sector indicators. Robust standard errors are given in parentheses. Huber-White standard errors were calculated using Stata 15 software

*$p < 0.10$

**$p < 0.05$

***$p < 0.01$

Firms in a competitive industry are on average about 6.2 percentage points less likely to innovate than firms in non-competitive industries. This effect is smaller among firms with positive investments in R&D (4.6 percentage points) than among firms that did not invest in R&D (8.9 percentage points).

The average marginal effect for a firm's R&D-to-sales ratio is 0.0112, and it is statistically significant at the 1 percent level. This result implies that if a firm increased its R&D-to-sales ratio by 10 percentage points, we expect the probability of innovation to increase by roughly 11.2 percentage points (against a mean value of Innovation of 0.636). Among firms with a positive R&D-to-sales ratio, the magnitude of this marginal effect was about one-half as large.

We find no significant between-sector differences in the probability to innovate. For example, in the full sample, the results indicate that firms in the high-tech sector are about 4 percentage points more likely to innovate than firms in the low-tech sector, but this estimate is not statistically significant. Similar conclusions hold for the subsamples of firms with and without investments in R&D.

Discussion

Based on the analytical findings presented in Tables 1 and 2, we conclude, not surprisingly, that firms that reported investing in R&D—as measured by a positive R&D-to-sales ratio—were much more likely to have introduced new or significantly improved goods or services to the market. The former group is also more likely to cite public research institutes as important for exploring new business opportunities.

The marginal effects show that there appears to be a strong relationship among investing in R&D, the value firms place on PRIs as a source of knowledge, and the propensity to innovate.

Among firms with a positive R&D-to-sales ratio, citing PRIs as important is associated with a higher propensity to innovate. For firms without investments in R&D, this relation is absent.

A possible explanation for our findings is that the indicator for the importance of PRIs as a source of knowledge acts as a proxy for actual collaboration between firms and PRIs. Firms that invest in R&D are more likely to collaborate with PRIs, since the collaboration requires firm resources. Such firms are more likely to place a higher value on PRIs as a source of knowledge for exploring new business opportunities. Also, firms that invest in R&D and value PRIs as important are more likely to collaborate with PRIs, which in turn increases the probability that innovations occur. While firms that do not invest in R&D may still value PRIs, it is much less likely that such firms collaborate with PRIs, so that the probability of introducing product or service innovations remains unchanged.

Perhaps the results presented in this paper have important implications for policymakers who decide whether to fund PRIs. Firms that invest in internal R&D and value PRIs as a source of knowledge have a significant increase in their likelihood of innovating—approximately 5 percentage points. This result is an indication of the effectiveness of third sector national R&D and the need to continue funding these institutions.

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