Fostering university-industry R&D collaborations in European Union countries

James A. Cunningham · Albert N. Link

Abstract This paper advances our understanding of university-industry research and development (R&D) collaborations. These strategic relationships are a dimension of entrepreneurial activity, and they are thus important drivers of economic growth and development. Business collaboration with universities increases the efficiency and effectiveness of industrial investments. Previous studies have found that universities are more likely to collaborate with industry if the business is mature and large, is engaged in exploratory internal R&D, and there are not major intellectual property (IP) issues between both parties. Businesses gain from such collaborations through increased commercialisation probabilities and economies of technological scope. Based on publicly available data collected by the Science-to-Business Marketing Research Centre of Germany as part of a European Commission project, our paper focuses on two key questions. First, why are there cross-country differences in the extent to which universities collaborate with business in R&D? Second, are there covariates with these differences that might offer insight into policy prescriptions and policy levers for enhancing the extent to which such collaboration takes place? We find that access is positive and statistically significant in relation to fostering university-business R&D collaborations. Our results, albeit that they are tempered by a small sample of data, have implications how national innovation systems support further harmonization of IP regimes across universities and how universities prioritize their own investments and incentives.

Keywords R&D collaborations · Entrepreneurship · University-industry partnerships · European Union

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Introduction

In 2010 and 2011, the Science-to-Business Marketing Research Centre of Germany (S2BMRC 2011) undertook for the European Commission a systematic study of cooperation among Higher Education Institutions (HEIs) in European Union (EU) countries and public and private organizations in Europe.[1] As part of their study, all registered European HEIs in 33 countries were surveyed about, among other things, their cooperative activities with industrial businesses.[2] Motivating the EU's interest in such a study was the premise that (Davey et al. 2011, p. 8):

> Successful cooperation of HEIs in synergetic relationships with governments and businesses … is considered to be an essential driver of knowledge-based economies and societies.

As such, the EU might have recognized these synergistic relationships as being a form of entrepreneurial activity through which all parties broaden their networks and thus realize an enhanced likelihood of perceiving new opportunities and reacting to them (Leyden and Link 2014).

During 2013, 14 EU country reports were published, each presenting aggregate information about the country's state of university-business collaboration as quantified through the S2BMRC survey.[3] Of particular importance for this paper are the aggregate findings about the extent to which HEIs are involved with businesses in collaboration in research and development (R&D).[4] Figure 1 shows country mean responses by HEIs to the survey question: *Please indicate to what extent your university cooperates with business with respect to collaboration in R&D*. These aggregate country-level data will be analyzed in Section "Analytical model and descriptive findings" below.

Our focus on collaboration in R&D is based on the fact that industrial investments in R&D are an important—arguably the most important—driver of economic growth and development, and business collaboration with universities is an important strategic vehicle—possibly the most important—to increase the efficiency and effectiveness of such investments.[5] Thus, two questions are relevant from both an academic and policy perspective. The first question is: Why are there cross-country differences in the extent to which universities collaborate with business in R&D? And the second question is: Are there covariates with these differences that might offer insight into policy prescriptions and policy levers for enhancing the extent to which such collaboration takes place?

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[1] HEIs refer to all types of formally recognized institutions that provide higher education. Among those recognized by relevant national/regional authorities are: universities, universities of applied sciences, polytechnics /technical universities, and colleges and tertiary schools (Davey et al. 2011, p. 7).

[2] Over 3,000 HEIs participated in the study; it resulted in a sampling population of 6,280 academics and HEI representatives (Davey et al. 2011, p. 7).

[3] Each country study is titled "The State of University-Business Cooperation in [the country], and each report is available at http://www.ub-cooperation.eu/index/[the country].

[4] Other dimensions of collaboration summarized in the report included mobility of academics, mobility of students, commercialization of R&D results, curriculum development and delivery, lifelong learning, entrepreneurship, and governance. It is important to emphasize that responses to this question is from the perspective of the HEI.

[5] We see this fact being in concert with the premise that motivated the S2BMRC study for the European Commission, as quoted above.
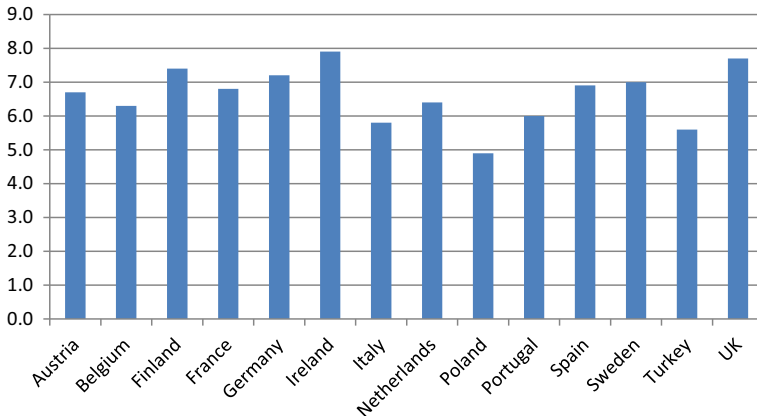
Fig. 1 Extent of Industry-Business Collaboration in R&D, by Country. Note: Shown in the figure are mean responses from HEIs, by country, based on a 10-point Likert. Response scale: 1 = "Not at all" to 10 = "To a large extent"

In Section "The academic literature on university-industry collaborations in R&D" of this paper we briefly review that extant academic literature related to university-industry collaborations in R&D. In this review we emphasize university motivations for collaboration because data available from the S2BMRC surveys are from the perspective of universities. Then, in Section "EU policies to foster university-industry collaboration in R&D", we discuss existing EU public policies to foster such collaborations. In Section "Analytical model and descriptive findings", we present our descriptive findings about covariates with cross-country differences in the extent of university-business collaborations in R&D from Fig. 1; and then in Section "Public policy recommendations and concluding remarks" we posit, based on our descriptive findings, public policy recommendations for universities to foster such collaborations, and we offer concluding remarks.

The academic literature on university-industry collaborations in R&D

As Hall et al. (2003) and Link and Wessner (2011) note, university motivations for partnering with businesses in R&D seem to be financially based. Administration-based financial pressures for faculty to engage in applied commercial research with industry are growing (Siegel et al. 2003). Zeckhauser (1996, p. 12746), for example, referred to the supposed importance of industry-supported research to universities as he describes how such relationships might develop:

> Information gifts [to industry] may be a part of [a university's] commercial courtship ritual.

Cohen et al. (1997, p. 177) similarly argue, primarily from a U.S. perspective, that:

> University administrators appear to be interested chiefly in the revenue generated by relationships with industry.

Cohen et al. (1997, p. 178) are also of the opinion that the faculty at a university, who are fundamental to making such relationships work:

> desire support, *per se*, because it contributes to their personal incomes [and] eminence … primarily through foundation research that provides the building blocks for other research and therefore tends to be widely cited.

Several drawbacks to university involvement with industry have also been identified in the literature (Thursby et al. 2001). These drawbacks include the diversion of faculty time and effort from teaching, the conflict between industrial trade secrecy and traditional academic openness, and the distorting effect of industry funding on the university budget allocation process (in particular, the tension induced when the distribution of resources is vastly unequal across academic units).

The academic literature concludes that universities are more likely to collaborate with industry if: the business is engaged in exploratory internal R&D (Bercovitz and Feldman 2007); the business is mature and large (Stuart et al. 2007, Fontana et al. 2006); there is a lack of intellectual property issues between the business and the university (Hall 2004; Hall et al. 2001); and if receptive university faculty are male, with tenure, and are part of a university research center (Boardman and Corley 2008; Link et al. 2007).

Regarding the R&D benefits to a business from collaboration with a university: the productivity of business R&D increases with university participation in the R&D process (Link and Rees 1990); the probability of an R&D project begin commercialized increases when a university is an R&D partner (Link and Ruhm 2009), and a business's economies of technological scope increase with university involvement (Leyden and Link 2013, 2014). Other benefits include access to university research and discoveries (Lee 2000), leveraging research investments (Graff et al. 2002), and sharing of R&D expenditure (Sheehan and Wyckoff 2003).

EU policies to foster university-industry collaboration in R&D

In response to the productivity slowdowns in most industrialized nations in the early-1970s and then again in the late-1970s and early-1980s, a new innovation paradigm began to be adopted by the European Commission as well as by the OECD and UNCTAD. The focus of economic policies moved from an industry policy perspective to one that embraced the long-term benefits of high technology (Soete 2007). Mytelka and Smith (2002), p. 1473) describe this change:

> In part, this [change in focus] involved such organisations taking a wider perspective on the role of innovation policy, and in part it involved changed conceptualisations of the nature of innovation and of appropriate policy instruments.

This redirection manifested itself in 1984 through the design and implementation of the first Research and Technology Development (RTD) programme. The overall aim of this and subsequent programmes has been to increase the competitiveness of the EU, to

build a strong scientific and technology base, and to support R&D collaborations. The Framework Programmes have evolved around *thematic programmes*, such as life sciences, as well as *horizon programmes* that encouraged researcher mobility and training.

During the 1980s and 1990s, the EU developed and implemented policies that embraced the need for infrastructure support for technology and innovation. As Soete (2007, p. 278) observed:

> A common feature of all such systems—regional, national and trans-national— was the fact that firms rarely if ever innovative alone. … there is a need for a constant interaction and co-operation between the innovating firm and its external environment, which in the optimal case leads to a virtuous learning circle of better exploitation of available knowledge.

Such changes also coincided with a new mindset toward the role of large-scale publicly funded programmes in Europe (Georghiou 2001).

After the Lisbon European Council 2000, the EU began to adopt an open method of coordination of R&D and innovation (Kaiser and Prange 2004). This change resulted in greater emphasis on the need for R&D support as well as on a more comprehensive and multilayered policy approach to innovation as a process. Within the EU at this time there was a diversity of approaches among Member States on the formation and implementation of their innovation policies, the appropriate levels of public and private investment in R&D, and priorities about institutional support for their national innovation systems. Given this diversity, one of the challenges has been to systematically evaluate the European system from a performance perspective (Borras 2004). The establishment of the Innovation Union Scorecard in 2007 provided an overview of innovation performance within Member States. The evaluation of Europe's innovation system reflects the diversity of innovation approaches and policy focus. Table 1 shows the most recent groupings the diversity of innovation performance.

A further evolution of innovation policy has focused on *Europe 2020*, which seeks, through the EU Commission, to promote smart, sustainable, and inclusive growth

Table 1 Innovation Union index 2013

Innovation leaders:

Sweden, Germany, Denmark and Finland, all show performance well above that of the EU average.

Innovation followers:

Netherlands, Luxembourg, Belgium, the UK, Austria, Ireland, France, Slovenia, Cyprus and Estonia all show performance close to that of the EU average.

Moderate innovators:

The performance of Italy, Spain, Portugal, Czech Republic, Greece, Slovakia, Hungary, Malta and Lithuania is below the EU average.

Modest innovators:

The performance of Poland, Latvia, Romania and Bulgaria is farther below that of the EU average.

EU Commission (2013, p.10)

among Member States. Each Member State is expected to tailor the implementation of its innovation policy to its own circumstances. In particular, *Europe 2020* seeks to address the fact that Europe's average growth rate has been structurally lower than that of its trading partners, and this is a result of a widening productivity gap (European Commission 2010, p. 7):

> due to differences in business structures combined with lower levels of invest-ment in R&D innovation, insufficient use of information and communication technologies, reluctance in some parts of our societies to embrace innovation, barriers to market access and a less dynamic business environment.

The purpose of R&D Development under *Europe 2020* is to increase levels of innovation activities across all sectors of the European economy, drive resource efficiency, increase competitiveness, and create new jobs. The goal is to refine and hone the innovation value chain from ideation to the market. The Commission has committed itself to working on completing the European Research Area to improve conditions for business to innovate and to launch the creation of European Innovation Partnerships to hasten the development and deployment of new technologies. At a national level, Member States will need to (European Commission 2010, p. 13):

> reform national (and regional) R&D and innovation systems to foster excellence and smart specialization, *reinforce cooperation between universities, research and business* [emphasis added] … [and] ensure a sufficient supply of science, math and engineering graduates and to focus school curricula on creativity, innovation, and entrepreneurship.

To give tangible support to the ambition outlined in *Europe 2020*, the European Commission launched *Horizon 2020* in December 2013. It is the largest research innovation programme in its history with over €80 billion of funding. Previous programmes such as the European Strategic Programme for Research and Development on Information Technologies (ESPRIT), Community Programme in Education and Training for Technology (COMETT), SPRINT, and other programmes that supported R&D development have resulted in what Mytelka and Smith (2002) described as:

> Every significant institution working in the innovation field in Europe has participated, and virtually every significant researcher. The level of networking and contact between researchers has multiplied dramatically, as have the number of journal and the volume of publication. So these EU-backed project[s] have provided a major dynamics impetus to innovation studies, as well as providing a practical level of support without which some key institutions in the area might not have survived.

Growth in developing relationships between universities and technology-based industrial firms has been due to the technical expertise available within universities, the need to make "research more 'relevant' to the 'needs' of the market place" (Storey

and Tether 1998, p. 1044).[6] This growth of the building of strong relationships between universities and industry has progressed at different rates among EU countries. According to Storey and Tether (1998, p. 1046):

> There is evidence that there has been a major shift in the last 15 years in almost all EU economies towards ensuring stronger links are established between research institutions and the commercial sector. These links tend to be strongest between universities and larger, rather than smaller, firms. Nevertheless, there is considerable interest in most countries in enhancing the links between universities and SMEs.

Lemola (2002, p. 1484) noted, as one example of growing synergies between universities and industry, what occurred in Finland[7]:

> A new organization, the National Technology Agency (Tekes) was established in 1983 as the key planner and executor of the new technology-oriented policy. Tekes was designed after the Swedish Board for Technical Development (Styrelsen för teknisk utveckling). In line with the operations of Japan (and Sweden), in particular, national technology programs were developed to serve as [a] new instrument by which Tekes could control R&D activities. As in several other OECD countries, the first programs were focused on information technology. The programs turned out to be an effective instrument to intensify *cooperation between universities, research institutes and firms* [emphasis added]

Analytical model and descriptive findings

In an effort to understand better potential policy prescriptions and policy levers that might affect university-industry collaborations in R&D among EU countries, as well as to characterize the EU's push toward public sector entrepreneurship, we identified covariates associated with the extent of collaboration in R&D in Fig. 1. Our descriptive model is:

$$RDCollab = \mathrm{f}(\mathbf{X}) \qquad (1)$$

where *RDCollab* represents the mean responses by HEIs to the European Commission survey question about the extent of university cooperates with business with respect to collaboration in R&D. The aggregate data used to estimate *RDCollab* are at the country level ($n=14$). $\mathbf{X}$ is a vector of institutional factors hypothesized to affect the extent of collaboration in R&D. The variables represented by $\mathbf{X}$ are delimited by responses to questions on the S2BMRC survey. The variables in vector $\mathbf{X}$ also come from the European Commission survey and are also aggregated to the country level. However,

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[6] See Cunningham et al. (2014) for a parallel discussion of knowledge transfer from universities and public institutions.
[7] Other country-specific examples are in OECD (2013).

those survey questions are sufficiently rich to allow us to undertake an initial, yet exploratory, examination of potential policy prescriptions and policy levers.

The relevant variables considered for the estimation of Eq. (1) are defined in Table 2, and descriptive statistics on the variables are in Table 3.

We hypothesize, holding constant the availability of business-sector R&D facilities, *Access*, that (1) the more relevant the lack of university funding for cooperation, *UnivFund*, the less the extent that the university cooperates with business with respect to collaborative R&D, (2) the greater the index of the lack of internal and external infrastructure to facilitate university-business cooperation, *Infra*, the lesser the extent that the university cooperatives with business with respect to collaborative R&D,[8] and finally (3) the greater the concern of business about the loss of their intellectual property, *IP*, the lesser the extent that the university cooperates with business with respect to collaborative R&D. Thus, each of these three variables should enter Eq. (1) negatively.

The Tobit estimates from Eq. (1) are in Table 4.[9] Given the paucity of degrees of freedom in the estimation of the model and the aggregate nature of the cross-country data, the findings in Table 4 should be interpreted cautiously and only as initial descriptive evidence of covariates with collaborative R&D efforts. *Ceteris paribus*, the greater the access to business-sector R&D facilities, the greater the extent of collaborative R&D. Thus, the Tobit estimate on *Access* is positive and statistically significant. Each of the three university variables of interest is negative, as hypothesized, and each is statistically significant at least at the .10 level.

Public policy recommendations and concluding remarks

Fostering university-business collaboration in R&D is complex but of significant importance for scientific advancement and for economic growth and societal well-being. These are the economic outcome objectives implicit in the policy directives discussed in Section "EU policies to foster university-industry collaboration in R&D". Even taking into account the small sample of data in Fig. 1, some public policy issues and recommendations merit discussion.

First, national innovation and education policies should enhance the extent and the nature of university-business collaboration in R&D. In practical terms within national innovation systems having system wide harmonization, standard term sheets, intellectual property (IP) agreement protocols, common methodologies to assess IP value, industrial partnership agreement templates to ensure that the interaction between universities and business is simplified, protect both parties and allows for effective exploitation. This also means that system wide harmonization reduces IP issues between universities and businesses (Hall 2004; Hall et al. 2001).

Second, the descriptive findings in Table 4 highlight the need for universities to prioritize investments in human and financial resources when developing effective access to business across the university community. To catalyse this may require

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[8] Bonaccorsi et al. (forthcoming) suggest that the knowledge conditions external to the university may influence university-industry collaborations. Their scholarship not only motivates the inclusion of this variable but also complements our recommendations in Section V below.
[9] A Tobit specification is appropriate because the variable *RDCollab* has a Likert scale upper bound of 10.

Table 2 Definition of variables

Variable	Definition[a]	Measurement
RDCollab	Extent to which the university cooperates with business with respect to collaboration in R&D	1 = "Not at all" to 10 = "To a large extent"
Access	Extent to which access to business-sector R&D facilities facilitates university cooperative with business	1 = "Not at all relevant" to 10 = "Very relevant"
UnivFund	Relevance of lack of university funding for university-business cooperation	1 = "Not at all" to 10 = "To a large extent"
Infra	Index of the lack of internal and external infrastructure to facilitate university-business co-operation. *Infra* equals the sum of two variables: relevance of a lack of contact people with scientific knowledge within business to facilitate university-business cooperation, and no appropriate initial contact person within either the university or business to facilitate university-business cooperation.	1 = "Not at all" to 10 = "To a large extent" for each of the component variables
IP	Relevance of business fear that their knowledge, or intellectual property, will be disclosed through university-business cooperation	1 = "Not at all" to 10 = "To a large extent"

[a] These definitions came from the EU country reports

proactive national and European innovation policy direction setting that affects change at the university level as well as further public-sector investments. Such a prioritization benefits business in terms of increasing their R&D activities and expanding their economies of technological scope (Leyden and Link 2013). Universities can also benefit through enhanced economies of technological scope with existing industrial R&D collaborations and through developing new R&D collaborations. Our findings suggest that universities have to devise more innovative approaches to access that targets businesses that are mature and large (Stuart et al. 2007, Fontana et al. 2006) and that are engaged in exploratory internal R&D (Bercovitz and Feldman 2007).

Third, to improve, enhance, and accelerate university business collaboration, for incentives to be effective they must ensure greater levels of collaboration. For universities to accomplish this it means having internal incentive systems that reward individual scientists/research groups for their levels of industrial collaboration as well as providing internal research supports that makes the interaction and collaboration with industrial partners as easy and as effective as possible. This could mean that such research groups get rewarded for access and infrastructure that facilitates and yields

Table 3 Descriptive statistics on the variables (*n*=14)

Variable	Mean	Standard Deviation	Range
RDCollab	6.614	0.842	4.9–7.9
Access	5.921	0.490	4.9–6.6
UnivFund	6.821	0.843	5.3–8.1
Infra	11.443	1.245	9.8–13.7
IP	5.757	0.459	4.9–6.4

Table 4 Tobit estimates from Eq. (1), $n=14$; dependent variable is *RDCollab*

Variable	Tobit Coefficient (standard error)
Access	0.783 (0.290)***
UnivFund	−0.230 (0.178)*
Infra	−0.214 (0.123)*
IP	−0.602 (0.298)**
Constant	9.931 (2.574)***
Tobin's sigma	0.475 (0.090)***
Log likelihood	−9.453
Pseudo R^2	0.657

*** significant at .01 level, ** significant at .05 level, * significant at .10 level

sustainable R&D collaborations. This could also mean that universities reduce institutional barriers that scientists experience when dealing with industrial partners (Cunningham et al. 2014). The OECD (2013) noted that some universities are experimenting with new IP regimes and vesting IP rights with academics. Consequently, new institutional norms and expectations are beginning to be created to sustain these activities over the long term. Our findings suggest that university management teams need to act entrepreneurially, that is they need to address systematically these issues if they are to sustainably foster business R&D collaborations.[10] Business also benefits as collaboration increases the probabilities of an R&D project being commercialized.

Fourth, with respect to ownership, public universities in Europe within Member States can operate under legal and administrative requirement that can restrict their activities in this area. Our descriptive findings suggest that developing access between university and business is a critical necessary condition for collaborative R&D. For individual universities this may mean putting in place organizational structures and/or experimenting with new models such as regional hub and spoke (OECD 2013).

These policy recommendations should interpret cautiously because of the exploratory nature of our empirical analysis. Yet, our findings are sufficiently strong, given the small sample size, to encourage other researchers and policy analysts to continue to investigate correlates associated with university-industry R&D collaborations in an effort to enhance public sector entrepreneurship.

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[10] This recommendation may be overly optimistic. As Hülsbeck et al. (2013) have discussed from the perspective of Germany, most technology transfer offices at public universities are occupied with individuals with little experience of specific human capital in the natural sciences.

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