Exploring the effectiveness of research and innovation policies among European Union countries

By: James A. Cunningham and Albert N. Link

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Abstract:

In this paper we explore the effectiveness of selected research and innovation policies among EU countries. Using data from the AEGIS database and information from the 2015 Bruegel's Partnership report on research and innovation polices in EU countries, we compare and contrast the response of knowledge intensive firms to a sample of policies. We find that the impact of the policies in our sample varies not only across countries but also across the age of affected firms in those countries. We conclude our analysis with a call for policy makers to begin to investigate the incidence of the impact of their research and innovation policies as measured not only by the age of firms but also by other dimensions.

Keywords: research policy | innovation policy | European Union | R&D | property rights | technology

Article:

Introduction

European Union (EU) member states and their regions have long embraced the economic growth importance of research and innovation policies.[1] EU policies have been designed with the intention of encouraging more intense and sustainable interactions among triple helix actors (i.e., universities, industries, and government) and strengthening the supporting public infrastructures.[2] There have been challenges, however, in assessing the impact of EU-funded programmes across member states (Luukkonen 1998).

[1] See, in particular, Caiazza (2015) and Van Looy et al. (2003).

[2] The triple helix is a conceptual and analytical model of university, industry, and government relationships, policies and dynamic interactions (see Link and Tassey 1989; Etzkowitz and Leydesdorff 1999). Within the triple helix, universities play a critical role in these dynamic relationships and interactions (see Cunningham 2015; Cunningham and Harney 2006). More recently, scientists in the principal investigator role are seen as key actors at the micro level in forging these dynamic interactions within the triple helix (see Mangematin et al. 2014)

In recent years the EU, through the Innovation Union Scoreboard, has reported and compared the innovation and research performance of each member state. Using 25 indicators that are categorized around enablers, firm activities, and outputs the innovation and research performance of each member state has been quantified. Specifically, the Innovation Union Scoreboard categories the innovation performance of each member state into one of four categories—leading innovators, strong innovators, moderate innovators and modest innovators—in an effort to highlight the strengths and weaknesses of national research and the attendant innovation systems. These efforts, while important, are broader and less focused than an assessment of policy effectiveness.

In a recent report issued by the Bruegel's Partnership (Veugelers 2015), a cross-country taxonomy of 28 broadly-defined research and innovation polices across 27 EU countries was presented and discussed. Veugelers (2015, p.22) found:

> Our analysis found the mix of innovation policies deployed in EU member states to be pretty standard across EU countries. Most member states appear to deploy similar combinations of instruments, irrespective of their innovation position and the challenges they face. All member states spend most of their programmed innovation budget on a six-pack of instruments that makes up 70 % of the reported budget outlays. This six-pack includes competitive public research funding, collaborative RDI programmes, direct business support for R&D, direct support for innovation, loans for firms and tax incentives.

A summary statement like the one above raises the question: Why is there such innovation policy deployment homogeneity across EU countries given the clear variations in member states' national innovation systems and economies? Some of the homogeneity is focused on what Veugelers (2015) termed the "six pack of instruments."[3]

In our view, the Bruegel Partnership report is an important and potentially influential collection of information; its compilation is one that will not only encourage scholars to compare and contrast research and innovation policies across EU countries at the individual policy level, but also it has the potential to engender cross-country studies on the effectiveness of such policies.

In fact, there have been empirical studies of the so-called "six pack of instruments" prior to the publication of the report. For example, Becker (2015) found that direct support for R&D across EU countries has some positive impacts on labour productivity for innovating firms, and others (e.g., Akçomak and Ter Weel 2007; Barrios et al. 2004; Guimón 2011) have found that selected EU country policies focused on corporate R&D have had positive spillover impacts. As another example, Hewitt-Dundas and Roper's (2010) study of Irish manufacturing found positive impacts for public support for private R&D, and the Heydebreck et al. (2002) study highlighted the importance of innovation support services meeting the needs of new technology based firms in Sweden.

[3] This group of policies may have its antecedents in the replication of innovation policies between the United States and Europe (Gulbrandsen and Etzkowitz 1999).

Studies focusing on the European regions and regional innovation systems have also found some positive effects resulting from innovation policies. Bilbao-Osorio and Rodríguez-Pose (2004) found in their study of peripheral regions of Europe that R&D investment are positively associated with innovation, but other scholars (e.g., Cappelen et al. 2003) showed that the effectiveness of such investments is contingent on region-specific economic characteristics and structural reforms focused on regional policies. Relatedly, Romero-Martínez et al. (2010) showed that EU public programme funding is important for innovation among SMEs.

The economic crisis in Europe during this decade had an impact on the ability of national governments to support public R&D development. In the case of Spain, for example, the economic crisis initiated public sector budget cuts that meant research organisations had limited ability to respond to the crisis thereby creating uncertainties and lower levels of trust among triple helix actors (Cruz-Castro and Sanz-Menendez 2015).

Some questions have appropriately been raised about how the reduction in EU R&D funding would impact the rate and direction of technological change among EU countries. With respect to the funding cuts to EU framework programmes, Luukkonen (2000), for example, has suggested that a medium- to long-run view is needed for evaluation purposes. This perspective could possibly support the identification of new emerging technologies that have benefited from public research programmes.

Against this background, we take a first step, albeit an exploratory one, in this paper to investigate the effectiveness of a small portion of innovation policies across selected EU countries. Our descriptive analysis is however limited in several dimensions. As shown in Table 1, our analysis focuses on only 5 broadly-defined research and innovation policies across 9 selected countries. The reason for this delimitation is a pragmatic one. Our approach to exploring the effectiveness of any policy depends our being able to identify relevant information about firm responses to the policy. We rely on information from the AEGIS database—a unique and relatively unexamined database about knowledge intensive entrepreneurial firms in selected EU countries—to obtain measures of firm responses. However, only a few research and innovation measures are available therein to map into the policy areas defined in the Bruegel Partnership report, and only a few EU countries are represented in the AEGIS database. Thus, although our analysis is juxtaposed to the Bruegel Partnership report, it is still exploratory and limited in its nature.

The remainder of this paper is outlined as follows. In “The AEGIS Database” section, we briefly discuss the AEGIS database and we discuss the cross-walk between the research and innovation policies in Table 1 and the available data. We also discuss our methodology for measuring effectiveness in this section. In “Descriptive Statistics and Empirical Findings” section, we present descriptive statistics related to the measures discussed in “The AEGIS Database” section, and we present our empirical analysis of the probability of the effectiveness of research and innovation policies across countries. Finally, in Section “Concluding Remarks” section we discuss the limitations of our analysis, and we offer a suggestion about how our findings could be interpreted from a policy perspective.

Table 1. Research and innovation policies implemented by EU countries from 1990 to 2013

	Research and innovation policy variables				
Country	**Collaborative R&D programmes**	**Support to venture capital**	**Direct business R&D support**	**Intellectual property rights measures**	**Innovation networks and platforms**
Czech Republic	x		x		
Denmark	x				x
France	x	x	x	x	
Germany	x	x	x	x	x
Greece	x				
Italy	x		x		x
Portugal	x		x		
Sweden	x		x		
United Kingdom	x	x	x		x

Source: Based on Veugelers (2015)

The AEGIS database

The AEGIS project was funded by the European Commission under Theme 8 "Socio-Economic Sciences and Humanities" of the 7th Framework Programme for Research and Technological Development.[4] The focus of the project was on knowledge intensive entrepreneurship (KIE) under the assumption that KIE is one potential means through which to obtain economic growth and societal well-being.[5]

The AEGIS database contains information on 4004 businesses established between 2002 and 2007 across 10 European countries. These countries are (alphabetically): Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Portugal, Sweden, and the United Kingdom (UK).[6] High-tech, low-tech, and knowledge-intensive business services sectors are represented across these countries.[7]

There are data in the AEGIS database that approximate firm behaviour that parallels the research and innovation policies in Table 1. More specifically, we have listed in Table 2 the AEGIS survey questions that might be viewed as approximating the policy response of firms.

[4] We have written about the AEGIS database numerous times. Duplication of background informational text is inevitable.

[5] According to AEGIS (2012, p. 4): "Knowledge-intensive entrepreneurship is [the] core interface between two interdependent systems: the knowledge generation and diffusion system, on the one hand, and the productive system, on the other."

[6] For an institutional overview of innovation policies in Germany, for example, see Audretsch and Lehmann (2016).

[7] The firms in the AEGIS database are not a random sample of European firms. In order to have a large enough sample to study firms in all countries, firms in smaller countries (e.g., Croatia and the Czech Republic) were sampled at a higher rate than firms in larger countries (e.g., France and Germany). To account for this non-random sampling, unless otherwise noted, sample weights are used in the analyses. As described in Caloghirou et al. (2011), the sampling process was challenging due to the desire to have adequate representation of smaller countries and across industries. The final sampling frame consisted of 202,286 firms, and the database includes survey information on 4004 firms. See Link and Swann (2016).

Table 2. Research and innovation policies mapped to AEGIS survey questions

Policies	AEGIS survey questions
Collaborative R&D Programmes	Please indicate to what extent your company has participated in R&D agreements. (1 = not at all to 5 = very often)
Support to Venture Capital	Please indicate the importance of the availability of finance as a factor for the formation of the company. (1 = not important to 5 = extremely important)
Direct Business R&D Support	Please evaluate the importance of R&D in creating and sustaining the competitive advantage of this company. (1 = no impact to 5 = huge)
Intellectual Property Rights Measures	Please indicate if patents were used by your firm to protect its intellectual property during the last 3 years. (1 = used; 0 = not used)
Innovation Networks and Platforms	Please indicate the importance of networking with scientific research organizations as a factor in creating and sustaining the competitive advantage of this company. (1 = no impact to 5 = huge impact)

Source: Compiled by the authors

Of course, the data that correspond to the 5 survey questions are not intended to represent all of the dimensions of response by a firm. We contend that the responses measured through these survey questions capture a reasonable set of behaviours and merit an initial analysis in an effort to explore the effectiveness of the policies.[8] It goes without saying that the 5 research and innovation polices in Tables 1 and 2 taken from an exhaustive list of 28 policies in the Bruegel Partnership report only scratch the surface of target variables.[9,10] Similarly, the 9 EU countries listed in Table 1 are not intended to be viewed as a representative sample of the 27 EU countries in the same report. These 9 EU countries are the only countries in the AEGIS database that map into the Bruegel Partnership report's data. We discuss these caveats again in "Concluding Remarks" section as we emphasize that caution must be exercised in interpreting our findings.

Descriptive statistics and empirical findings

Our analysis is based on the 110 survey responses from firms in high-tech industries as defined in the in AEGIS database: aerospace; computers and office machinery; radio-television and communication equipment; manufacture of medical, precision and optical instruments; and pharmaceuticals.

We quantify the relative importance of each policy using the mean survey responses. See Table 3.[11] Looking across the mean responses, by country, it appears that firms are relatively more responsive to policies related to *Support to Venture Capital* and to *Direct Business R&D Support* than to *Collaborative R&D Programmes* and to the existence of *Innovation Networks and Platforms*.

[8] Examples of other efforts to explore firm performance associated with EU technology-related policies are Fairweather et al. (2010), Allen and Link (2015), Cunningham and Link (2015), and Veugelers and Schweiger (2015).

[9] Many of the policies in the Bruegel Partnership report relate to the creation of technology-related infrastructure, such as the existence of centers of excellence or cluster formations. Information on the use of such infrastructures is not captured by the knowledge intensive entrepreneurial firms in the AEGIS database.

[10] Leyden and Link (2015) refer to such technology and innovation polices as examples of public sector entrepreneurship.

[11] See Table 2 for response codes and note that responses to *Intellectual Property Rights Measures* are dichotomous rather than in terms of a 5-point Likert scale.

Table 3. Descriptive statistics on research and innovation policies, by country, $n = 110$ [mean, (standard deviation), {range}]

	Research and innovation policy variables				
Country	**Collaborative R&D programmes**	**Support to venture capital**	**Direct business R&D support**	**Intellectual property rights measures**	**Innovation networks and platforms**
Czech Republic	1.62	2.88	3.75	0.125	1.75
($n = 8$)	(0.744)	(1.25)	(0.707)	(0.354)	(1.04)
	{1–3}	{1–5}	{3–5}	{0/1}	{1–4}
Denmark	1.50	3.00	2.83	0.167	1.50
($n = 6$)	(0.837)	(1.41)	(1.47)	(0.408)	(0.837)
	{1–3}	{1–5}	{1–5}	{0/1}	{1–3}
France	1.94	3.35	3.82	0.294	2.41
($n = 17$)	(1.34)	(1.27)	(1.47)	(0.470)	(1.18)
	{1–5}	{1–5}	{1–5}	{0/1}	{1–4}
Germany	1.89	3.89	3.00	0.149	2.37
($n = 27$)	(1.28)	(1.12)	(1.36)	(0.362)	(1.39)
	{1–5}	{1–5}	{1–5}	{0/1}	{1–5}
Greece	2.71	4.14	3.29	0.286	3.71
($n = 7$)	(1.60)	(0.690)	(1.38)	(0.488)	(1.60)
	{1–4}	{3–5}	{1–5}	{0/1}	{1–5}
Italy	2.46	3.69	4.08	0.231	3.38
($n = 13$)	(1.51)	(1.38)	(0.862)	(0.439)	(1.26)
	{1–5}	{1–5}	{3–5}	{0/1}	{1–5}
Portugal	2.29	3.42	3.00	0.143	2.43
($n = 7$)	(1.70)	(1.51)	(1.15)	(0.378)	(1.13)
	{1–5}	{1–5}	{1–4}	{0/1}	{1–4}
Sweden	2.25	2.67	3.17	0.250	2.92
($n = 12$)	(1.22)	(1.30)	(1.34)	(0.452)	(1.31)
	{1–4}	{1–5}	{1–5}	{0/1}	{1–5}
United Kingdom	2.69	4.31	4.15	0.615	3.69
($n = 13$)	(1.44)	(0.751)	(0.801)	(0.506)	(1.18)
	{1–5}	{3–5}	{3–5}	{0/1}	{1–5}

Source: Compiled by the authors

See Table 2 for response codes and note that responses to intellectual property rights measures are dichotomous rather than in terms of a 5-point Likert scale

Table 4. Mean survey responses of relative importance of research and innovation policies, by countries with and without policies, $n = 110$ (standard deviation)

	Research and innovation policy				
Countries	**Collaborative R&D programmes**	**Support to venture capital**	**Direct business R&D support**	**Intellectual property rights measures**	**Innovation networks and platforms**
Countries with policies	*na*	3.77	3.81***	0.294	3.16**
		(1.17)	(1.15)	(0.470)	(1.39)
Countries without policies	*na*	3.49	3.02***	0.247	2.53**
		(1.29)	(1.31)	(0.434)	(1.35)

na implies that all of the countries listed in Table 1 have adopted collaborative R&D policies

Source: Compiled by the authors

** denotes significant differences in means at .05-level with unequal variances

*** denotes significant differences in means at .01-level with unequal variances

As shown in Table 1, policies related to *Collaborative R&D Programmes* are in each of the 9 countries.[12] But, there is considerable cross-country variation visible in Table 1 with respect to the other 4 policies. Table 4 reports mean survey responses for these 4 other policies between those countries with the policy and those without. Based only on means, firms in countries with the policies have numerically greater relative importance values than in countries without the policies.

A focal variable in the analysis below is the age of the firm. Firm age, *Age*, is a first-order proxy for the maturing of the firm and thus for its resource base and ability to respond to policy incentives. Descriptive statistics on the variable *Age* are in Table 5, by country.

Table 5. Descriptive statistics on *Age*, by country, $n = 110$

Country	Mean	Standard deviation	Range
Czech Republic ($n = 8$)	7.88	2.23	5–10
Denmark ($n = 6$)	7.17	1.72	5–10
France ($n = 17$)	7.76	2.17	5–10
Germany ($n = 27$)	6.41	2.02	4–10
Greece ($n = 7$)	6.29	1.80	4–9
Italy ($n = 13$)	8.46	1.56	5–10
Portugal ($n = 7$)	7.29	2.43	4–10
Sweden ($n = 12$)	7.00	2.13	4–10
United Kingdom ($n = 13$)	7.92	1.98	4–10

Source: Compiled by the authors

We estimated a probit model of the relative importance of a policy as a function of the age of the responding firm. To quantify relative importance, we assume that a firm viewed a policy as important if it responded to the survey question with Likert responses of "4" or a "5;" a response of "3," "2," or "1" was interpreted to mean the policy is not important. Of course, firm responses regarding *Intellectual Property Rights Measures* are already dichotomous.

The probit results are reported in Table 6. We interpret an insignificant probit coefficient to mean that the effect of a policy on firms is not specific to the age of the firm. In other words, younger firms respond similarly to older firms. Note, however, that the firms in the AEGIS database are relatively young (see Table 5). Looking at the probit coefficients that are statistically significant at a .10-level or better, we observe that in France, for example, younger firms respond that *Collaborative R&D Programmes* is more important than do older firms, but older firms in France response that *Direct Business R&D Support* is more important than do younger firms.

[12] For a more in-depth discussion of EU collaborative policies see Matt et al. (2012) and Protogerou et al. (2013).

Table 6. Probit coefficients from Equation (1), $n = 110$ (robust standard errors)

Independent variable	Dependent variable				
	Collaborative R&D programmes	**Support to venture capital**	**Direct business R&D support**	**Intellectual property rights measures**	**Innovation networks and platforms**
Age (Czech Republic)	−1.35 (0.000)	−0.092 (0.070)	0.130* (0.075)	−0.019 (0.078)	−0.013 (0.076)
Age (Denmark)	−1.37 (0.000)	−0.061 (0.083)	−0.013 (0.089)	−0.019 (0.098)	−1.33 (0.000)
Age (France)	−0.113* (0.067)	−0.015 (0.056)	0.179*** (0.067)	0.044 (0.060)	−0.050 (0.058)
Age (Germany)	−0.107 (0.072)	0.038 (0.063)	0.021 (0.062)	−0.021 (0.068)	−0.081 (0.063)
Age (Italy)	−0.058 (0.062)	0.002 (0.057)	0.124** (0.060)	0.007 (0.063)	0.001 (0.057)
Age (Portugal)	−0.010 (0.077)	0.015 (0.078)	0.058 (0.076)	−0.080 (0.113)	−0.127 (0.094)
Age (Sweden)	−0.042 (0.071)	−0.159** (0.080)	0.037 (0.068)	0.017 (0.074)	−0.020 (0.068)
Age (United Kingdom)	−0.041 (0.064)	0.125* (0.077)	0.160** (0.066)	0.156** (0.066)	0.036 (0.060)
Intercept	−0.243 (0.367)	0.261 (0.349)	−0.493 (0.351)	−0.830** (0.377)	−0.120 (0.346)
Pseudo R^2	0.190	0.245	0.256	0.203	0.190
Likelihood Ratio	11.67	18.07	20.19	13.33	13.08

Age of Greek firms ($n = 7$) is captured in the intercept term
Source: Compiled by the authors
* significant at .10-level
** significant at .05-level
*** significant at .01-level

Looking at the table as a whole, *Support to Venture Capital* affects younger firms in Sweden but older firms in the UK. Older firms in the Czech Republic, in France, in Italy, and in the UK view *Direct Business R&D Support* as more important than do younger firms. But, in the other countries, the importance of that policy is age-neutral. Regarding *Intellectual Property Rights Measures*, that policy is generally age-neural except in the UK it is more important to older firms. Lastly, *Innovation Networks and Platforms* is an age-neutral policy.

Concluding remarks

Our empirical findings in this paper should be interpreted cautiously for all of the reasons previously mentioned. Not only have we explored the effectiveness of a small sample of research and innovation policies, but also we have done so with a limited number of quantifiable measures across an equally limited number of EU countries. That said, our findings consistently support two conclusions. The first conclusion is that firms in countries with specific research and innovation policies responded to the related AEGIS survey questions as being of greater importance than did firms in countries without the specific policies (see Table 4). This, however, is not that unexpected of a conclusion.

The second conclusion is perhaps more unexpected and of greater importance. The Bruegel Partnership report concluded that (Veugelers 2015, p.22):

> Our analysis found the mix of innovation policies deployed in EU member states to be pretty standard across EU countries. Most member states appear to deploy similar combinations of instruments, irrespective of their innovation position and the challenges they face

It is this point with which we take some issue not because the point is inaccurate when all 27 countries are considered but because the conclusion does not go far enough; it does not consider cross-country cross-policy difference in the relative importance of each policy.[13] Albeit that we only considered 5 polices and 9 countries, our findings in Table 6 speak to the importance of policy makers not only considering the existence of policies across countries, but also taking a step further and considering as well the incidence of the impact of those policies. Herein we explored the differential impact across firm ages, but there are many other dimensions of impact that have yet to be considered and should be considered in future research.

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