A Note on the Drivers of R&D Intensity (Note 1)

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Abstract

This research note evaluates the extent to which national industrial structure affects country rankings based on aggregate R&D intensity. The econometric analysis performed on a cross-country cross-industry panel dataset (21 industrial sectors, 18 countries, and 5 years) suggests that accounting for industrial structure substantially affects the traditional country rankings. Sweden, the USA, France and Japan have an 'above-than-average' R&D intensity in most industries, whereas the high level of aggregate R&D intensity in South Korea and Finland, for instance, is essentially due to the importance of R&D-intensive industries in their economy (telecom and computers), and not to a macroeconomic environment particularly favourable to R&D. The US, Japanese and Swedish 'exceptions' might result from higher 'expected' returns to R&D in these countries.

Keywords: R&D intensity, S&T policies, high-tech industries.

1. Introduction: the R&D component of the Lisbon Agenda

According to its 2006 *Innovation Scoreboard*, the European Union (EU) suffers from a worrying large innovation gap as compared to the USA and Japan (Note 2). This is worrying because innovation is increasingly perceived as being at the root of sustainable economic growth and employment creation (Griliches, 1979). It is even more worrying in the context of the *Lisbon Agenda*, endorsed in 2000, as the key reaction of European policy makers to relatively poor economic performances. The Lisbon objective stated that the EU had to become by 2010 "*the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment*". Amongst the areas covered by this agenda, the realisation of a knowledge society included: "*increasing Europe's attractiveness for researchers and scientists, making research and development (R&D) a top priority...*" (Note 3).

Two years after its creation, the Barcelona' European Council reviewed progress towards the Lisbon agenda. It was then agreed that, at the EU-wide level, R&D expenses should reach 3% of GDP by 2010. This agenda was set at a time where relative R&D expenses were much higher in the USA and Japan (respectively 2.7% and 3% of GDP in 2000) than in the EU (about 1.9% for the EU15).

Yet, few studies acknowledge that the industrial composition of a country could substantially affect its observed R&D intensity. For instance, country A might have two industries with higher R&D intensities than in country B, but display a lower aggregate R&D intensity because of a strong specialization in the low R&D intensity industry. One would wrongly conclude that country B is more R&D intensive than country A. The objective of this research note is precisely to evaluate the extent to which the industrial composition of a country affects its observed aggregate R&D intensity. The methodology consists in a panel data analysis of the R&D intensity of 21 industrial sectors in 18 countries over the period 2001-2004. It is worth noticing that the present research note is not an attempt to grasp all R&D determinants (cf. for instance Guellec & Van Pottelsberghe, 2003) for the factors influencing business R&D outlays, or Furman and Hayes (2004) for cross country variations in innovation output).

The paper is structured as follows. The next section briefly reviews the literature on R&D determinants. Section 2 presents the data and illustrates the 'Lisbon failure'. Section 4 presents the quantitative analysis aiming at explaining cross-industry and cross-country variations in R&D intensity as well as the results. Section 5 concludes.

The empirical results confirm that industrial structure is strongly linked to R&D intensity, and hence affects the observed rankings based on aggregate relative efforts in research activities. Countries with an above-than-average business R&D intensity in most industries are the USA, Japan, France and Sweden. Contrary to their usual 'reputation', Finland or South Korea actually perform like (or even worse) the average country for most of their manufacturing industries. We suggest that the American, Japanese or Swedish 'exceptions' might be due to particularly high expected return to R&D in these countries, which in turn is driven by market size and government funding of research activities, like academic research.

2. Literature review

Improving national innovative capacity is important to insure lung-run economic growth (Pavitt, 1980). Such national innovative capacity may be improved by fostering industrial R&D, by funding sufficiently academic research and by supporting effectively university-industry interactions to strengthen the linkage between R&D and product development. For what relates to government support to business R&D, this would be justified by the existence of market failures associated with R&D activities (Arrow, 1962). The major policy tools used by government to support business R&D include grants, procurement, tax incentives and direct performance of research (in public laboratories or universities). The effectiveness of this support has also been long lastly debated in the literature. Some observe a substitution impact (e.g. Carmichael, 1981), some observe no impact (e.g. Lichtenberg, 1984) and others observe positive impacts (e.g. Goldberg, 1979; Levin & Reiss, 1984; Guellec & Van Pottelsberghe, 2003).

For what relates to academic research, there is extensive evidence that it is a very important driver of economic growth (see for instance Adams, 1990; Mansfield, 1991; Klevorick et al., 1995; Zucker et al., 1998; Cohen et al., 2002; Arundel & Geuna, 2004; Guellec & Van Pottelsberghe de la Potterie, 2004). However, the socio-economic benefits of publicly funded basic research remain difficult to measure. Indeed they vary with scientific field, technology and industrial sector, as stated by Salter and Martin (2001) in their critical review of the literature. Low level of academic research may slow down further economic development. For instance, Faulkner and Senker (1994), observe that, in the "ceramic engineering" field, the low level of public science research-industry linkages and inputs did not imply a lack of interest in the research frontier but instead, that the interviewed firms lamented the paucity of available public knowledge.

As regards the linkage between R&D and product development, government may stimulate knowledge transfer from universities to firms by supporting the process itself. For instance, the encouragement of multi-firm/university collaborations enables smaller firms to overcome resource barriers to involvement in large-scale formal links with universities (Faulkner & Senker, 1994).

All these studies aim to identify factors explaining and enhancing R&D volume. This paper aims to contribute to this existing knowledge by investigating in which measure national R&D intensities, aside of these traditional studied determinants, are affected by the structure of manufacturing industries, and by the relative importance of R&D-intensive sectors. Complementarily to studies like Furman and Hayes (2004), that explain cross country variation in innovation output by examining national policies and innovation infrastructure as well as investments in physical and human capital, this paper looks at the issue from an industry-level perspective.

3. Data

Figure 1 clearly shows two striking differences between the EU on the one hand and Japan and the US on the other hand. First, the R&D intensity has always been significantly lower in the EU than in Japan or the US. Second, over the past 10 years (starting in the mid 90s), the gap between the EU 15 and Japan or the US has substantially increased. In 2007, Japan and the USA, with R&D intensities of 3.4% and 2.7% respectively, are far ahead from the EU-15' R&D intensity of 1.9%.

<Figure 1 about here>

There is however a strong heterogeneity within the EU-15 area (cf. Figure 2). While three Scandinavian countries pull the European average upwards, Mediterranean countries like Italy, Spain and Greece have a rather low performance. For the majority of countries the R&D intensity only slightly increased over time.

<Figure 2 about here>

The objective here is to investigate empirically whether business R&D intensity is associated more to country-specific or to sector-specific factors. The idea is to test whether the variation in national R&D intensities (total R&D expenditures/GDP) across the OECD countries is more due to national differences – i.e., national innovation system, national science and technology policies -, and/or to different industrial structures across countries – i.e., is the specialisation of Finland in mobile communication linked with its good macro-economic R&D intensity? Or is the high R&D intensity of Finland more linked to efficient science and technology policies and particularly good 'national' framework conditions (such as education, entrepreneurial culture, the corporate income tax rate, labour mobility…)?

4. Quantitative evidence: the method and results

In order to test which of the two hypotheses prevails - the 'national factor' or the 'industrial structure factor' – we rely on a panel database composed of 21 industrial sectors (Note 4) in 18 countries for the years 2000 to 2004. Descriptive statistics (median, minimum, maximum and standard deviation values of R&D intensity by country and by sector) are shown in Figure 5. The control variables are time dummies, country dummies and/or industry- dummies. The former takes into account the 'national factor' whereas the latter accounts for the 'specialization factor'. The 21 industries are indexed by i (= 1,…,21); the 18 countries are indexed by j (= 1,…,18), and the 5 years by t (=1,..., 5), which makes 5,735 observations. RI, J, I and T are respectively the business R&D intensity (Note 5), or total R&D expenses divided by value added country- industry- and time-specific vectors of dummy variables. R&D outlays are from the OECD ANBERD database and from OECD (2006a, b, c, d), and the information on value added comes from the OECD STAN database. βi and βj are the vectors of parameters to be estimated. Equations are estimated by the OLS method. The results are presented in Figure 3.

$$RIi,jt = \beta jJ + \varphi tT \quad (1)$$

$$RIi,jt = \beta jJ + \alpha iI + \varphi tT \quad (2)$$

Equation 1 investigates the extent to which country specificities are linked to the variance in R&D intensity (cf. column 1). All the country dummies are significantly associated with R&D intensity. The adjusted R-squared suggests that national differences account for about 32% of the variation in R&D intensity across the studied countries and sectors. The countries that are associated with the highest impact are Sweden (0.11) and the USA (0.11), France (0.11), Norway (0.09) and Japan (0.09). Interestingly, Finland is in an intermediate position, with a 0.08 impact, whereas it is the second highest level of R&D intensity in Figure 2. This difference may be explained by the fact that the Finish industrial sectors are on average less intensive in R&D than other countries' sectors in the panel. A substantial focus in a few high-tech (R&D intensive) industries is probably the major factor underlying the high macroeconomic level of R&D intensity in Finland.

The second regression measures the simultaneous effects of national and industry-specific factors, which account for 69% of the variance in R&D intensity, more than twice higher than the variance explained by country dummies alone (Figure 3, column 2). Taking into account the industry effect reduces the estimated impact of most country dummies, but the relative ranking remains broadly similar to the one presented in column 1. Sweden, France and the USA have the highest 'median' R&D intensity across industries. Similar results have been found by Meliciani (2001, pp. 73-77) with patent data. The author finds that the industry-effects are stronger than the country-effects in more recent years (1980-1990). Interestingly, he also found that this phenomenon was new. Earlier in history (1965-1973), the country effects used to be stronger than the industry-effects.

It could be argued that the US and Japanese economies should be compared with a large geographical area, like Europe, instead of a multitude of smaller European countries. This approach is presented in column 3 of Figure 3. The median R&D intensity of European manufacturing sectors is about twice smaller than in Japan or the USA.

Industrial structure being accounted for, one could logically wonder whether cross country differences are significant or not. A simple way to test the relative differences across countries is to include an intercept amongst the independent variables and drop one of the country dummies. The parameters associated with the country dummies (normalized for years and industries) represent the median R&D intensity (over 21 industrial sectors) of countries (and *vice versa* for the industry dummies). Dropping one country dummy (e.g., Germany), the other countries' parameters would then measure the extent to which each country's industries are more (or less) R&D intensive than in the «reference" country. The results – relative to Germany -, are presented in Figure 4. The countries that seem to invest in R&D "above than the average" in a majority of industries are Sweden, France, the USA and, to a lesser extent, Japan. Several other countries have R&D intensities across industries that are similar to the German ones, including Belgium, the United Kingdom and the Netherlands. The Finish and South Korean industries are also in this group, which was unexpected, as these two economies have a very high aggregate R&D intensity.

<Figure 3 about here>

It seems therefore that the observed R&D intensity performance of South Korea and Finland is essentially due to a strong specialization in an R&D intensive sector (ICT), and not to a particularly high propensity to invest in R&D. South

Korean industries are even significantly less R&D intensive than German ones. This is also the case for Irish, Spanish or Australian industries. Sweden deserves a particular attention, as most of its manufacturing sectors have an R&D intensity which outperforms all other countries in most manufacturing sectors.

The international differences in total R&D intensity observed in Figure 2 should therefore be taken with caution. Aggregate R&D intensity is actually strongly affected by a country's industrial structure (in particular by a specialization in R&D intensive industries) and not by a country-specific environment particularly favourable to R&D expenses, except for a few countries.

<Figure 4 about here>

One could logically wonder why Sweden, the USA, Japan and France have succeeded in achieving an above-than-average R&D intensity in a majority of their industrial sectors. One explanation is that the "expected" return to R&D is higher in these countries and hence translates into a higher propensity to invest in R&D. Two broad factors might affect the return to research activities: the market size would logically increase the potential market associated with an invention, and science and technology policies would rather reduce the cost of doing R&D.

-A larger homogeneous market for new technologies or product: Japan and the USA

This driver implicitly assumes a positive relationship between the size of a country and its R&D intensity (see Guellec (1999) for conceptual support and anecdotic evidence and Desmet and Parente (2006) for theoretical and empirical evidence). The size of a country is indeed an indicator that helps to predict, at least partly, the relative effort in R&D. The USA and Japan are by far the largest homogenous market amongst the OECD countries, and both have relatively high R&D expenses (Note 6).

As far as market size is concerned, one could wonder why Europe, by far a larger market than the USA or Japan, is not associated with a higher R&D intensity. The main reason is probably related to the fact that the European market is still far from being integrated, or at least not sufficiently integrated. Several clues witness an insufficient level of integration of the European market for goods and services. The market for good or for services is not yet homogeneous, there is a lack of harmonised tax scheme, there is a lack of labour mobility (especially across borders) and there is a lack of a European market for technology, mainly due to the fact that once granted, a European patent must be validated, translated and managed at the country level, inducing high levels of complexity, not to mention heavy costs (cf. Van Pottelsberghe &François, 2009). Within Europe, some small countries also have a very high R&D intensity, like Sweden, for which other factors enter into play.

-Lower costs of performing R&D: Swedish academic research

Science and technology policies essentially aim at reducing the cost of performing R&D. They include for instance direct subsidies (or government-funded business R&D), fiscal incentives, and public research. The two former reduce the cost of R&D for the business sector (Note 7), whereas the latter consists in performing basic or applied research projects that might eventually be used by the business sector (cf. Adams, 1990 or Guellec & Van Pottelsberghe, 2004). In this respect, Sweden is the country with the highest intensity of R&D performed by the higher education sector within the whole OECD area. This strong orientation towards academic research generates new knowledge available for the business sector, which invests further in business R&D to make it profitable.

5. Concluding remarks

The objective of this research note was to test the extent to which the industrial structure of a country affects its observed R&D intensity at the macroeconomic level, and hence the country rankings that are highly fashionable nowadays. The motivations were essentially driven by the idea that some countries may wrongly be considered as particularly intensive (or non-intensive) in research activities. Indeed, Sweden, Finland and Japan are strongly specialized in high-tech industries, and have a high R&D intensity. One could therefore wonder whether they systematically invest more than other countries in most manufacturing sectors.

The econometric results clearly confirm that business R&D intensity is strongly linked to industrial structure. When it is accounted for, the countries which keep a particular high (significantly above than average) R&D intensity are Sweden, the USA, France and, to a lower extent, Japan. Finland and South Korea, on the other hand, have actually a relatively low R&D intensity when their industrial structure is accounted for. Specialisation matters under certain conditions, as shown by Dalum et al. (1999): if countries specialize in R&D intensive industries with slow growth rates, the end result could end up with a small aggregate performance.

The well-known international 'rankings' of R&D intensity should therefore be taken with a degree of caution. The business component of R&D intensity is actually mainly associated to the industrial structure of a country and less to a country-specific environment particularly favourable to R&D efforts, except for Sweden, France, the USA and Japan. Market size (for the US and Japan) and a strong orientation towards academic research (for Sweden) are factors that might explain the higher expected return to R&D in these countries.

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Notes

Note 1. The views expressed in this paper are purely those of the authors and may not in any circumstances be regarded as stating an official position of the Institutions where the authors work.

Note 2. See The Financial Times, 13th of January 2006, "EU is 50 years behind the US for innovation".

Note 3. See "Facing the Challenge: The Lisbon Strategy for Growth and Employment", Report from the High Level Group chaired by Wim Kok, November 2004.

Note 4. The 21 industrial sectors have been selected according to the availability of data; they all are defined according to the United Nations International Standard Classification (ISIC rev. 3) – For full details, see Statistical Office of the United Nations (1990). The corresponding 2-digit codes of the divisions, and in one case, the 3-digit code of the group – "divisions" and "groups" are called in this context "industries" for the simplicity of interpretation - are put in brackets after the denomination of the industry, the number before shows our own classification: (S1) Food products, Beverages and Tobacco (15-16), (S2) Textiles, Textile products, Leather and Footwear (17-19), (S3) Wood and Products of Wood and Cork (20), (S4) Pulp, Paper, Paper products, Printing and Publishing (21-22), (S5) Coke, Refined Petroleum products and Nuclear fuel (23), (S6) Chemicals excluding pharmaceuticals (24 ex 2423), (S7) Pharmaceuticals (2423), (S8) Rubber and Plastic products (25), (S9) Other non-metallic mineral products (26), (S10) Basic metals (27), (S11) Fabricated metal products, except machinery and equipment (28), (S12) Machinery and equipment, NEC (29), (S13) Office, accounting and computing machinery (30), (S14) Electrical machinery and apparatus, NEC (31), (S15) Radio, television and communication equipment (32), (S16) Medical, precision and optical instruments (33), (S17) Motor vehicles, trailers and semi-trailers (34), (S18) Other transport equipment (35), (S19) Electricity, Gas and Water supply (40-41), (S20) Construction (45), (S21) Total services (50-99).

Note 5. Business R&D intensity comes from the STAN Indicators Database 2005. It is a measure of the R&D intensity using the value added. The formula is: $RDIVt_{i,j}$ = ANBERD $t_{i,j}$ / VALU $t_{i,j}$ where ANBERD and VALU are the business enterprise Research and Development and value added at current prices, respectively. The 21 industries are indexed by i (= 1,…,21); the 18 countries are indexed by j (= 1,…,18), and the 5 years by t (=1,..., 5). The R&D intensity is the ratio of R&D expenditures to some measure of output. For a country, the used output is the GDP, for an industry, as it is the case in this paper, a measure of the output is the total production or the value added. The value added was chosen due to (i) the availability of data; (ii) the fact that it is a stronger measure of the real generated output because it is a "net" measure of any expenses in, for instance, goods and services or human resources.

Note 6. In order to take into account the market size of countries, a regression was ran with the logarithmic value of the population amongst the right-hand side variables. The variable turned out to be positive and highly significant. Taking it into account jointly with the parameters associated with country dummies lead to the same ranking of countries (cf. regression 4 in Figure 4).

Note 7. The two types of financial support stimulate business funded R&D (see for instance, Reinthaler and Wolff (2002, 2004); Falk (2004) and Guellec and van Pottelsberghe (2003) who provide empirical evidence on the effectiveness of government financial support to business R&D).

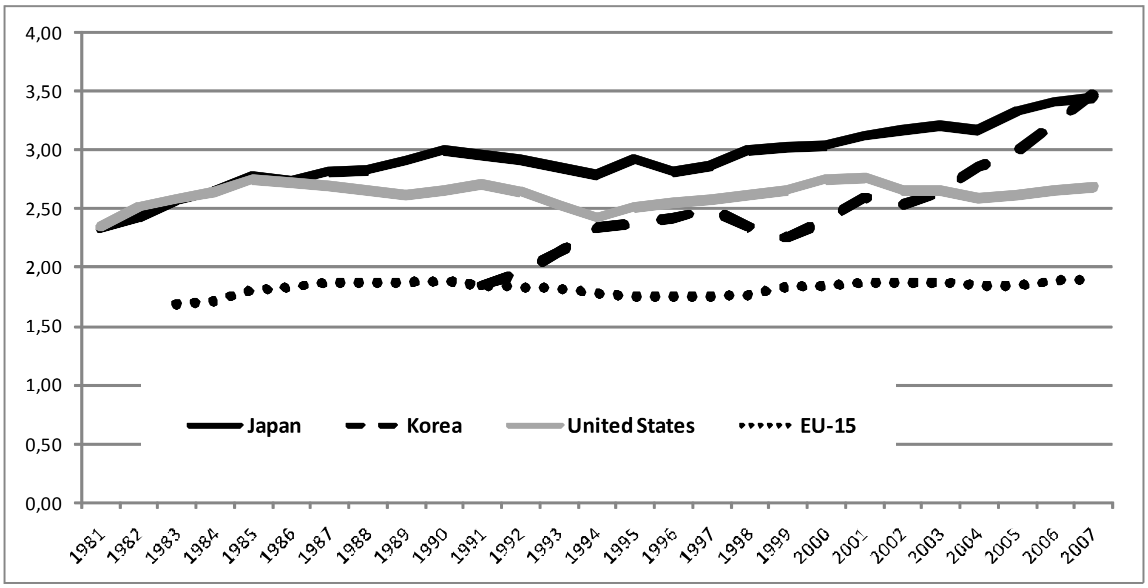

Figure 1. Evolution of the R&D intensity (DIRD/GDP) in Japan, South Korea, the USA and Europe, 1981-2007

Source: OECD, MSTI (2009)

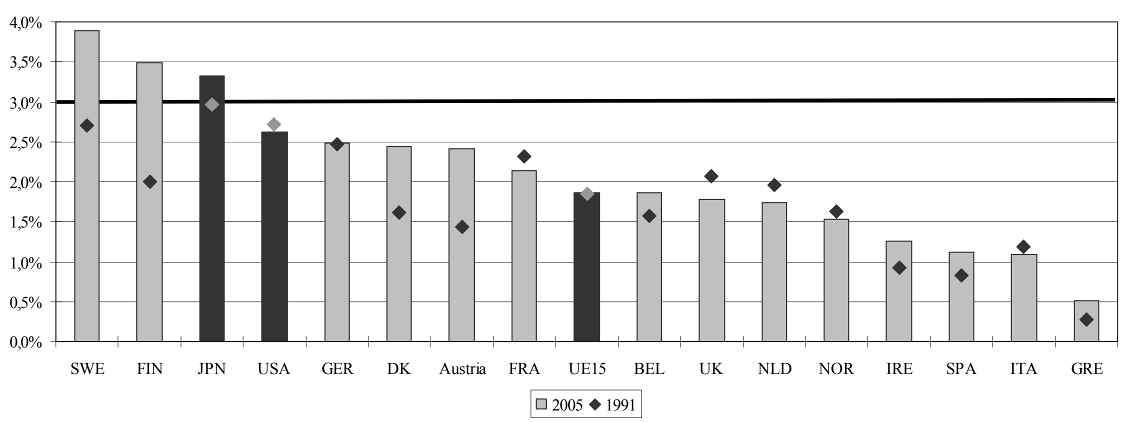

Figure 1. R&D Intensity (DIRD/GDP) across the EU countries, the USA and Japan, 1991 and 2005

Source: OECD, MSTI (2007)

Dependent variable is RIt										
Regression #			*1*			*2*				*3*
Japan	0.094	***	(16.14)	0.075	***	(13.24)	*Japan*	0.061	***	(6.04)
Korea	0.040	***	(5.26)	0.022	***	(3.38)	*USA*	0.070	***	(6.96)
Finland	0.079	***	(13.65)	0.058	***	(10.21)	*Europe*	0.032	***	(2.97)
Norway	0.090	***	(14.80)	0.067	***	(11.52)				
Sweden	0.111	***	(18.96)	0.091	***	(15.99)				
Denmark	0.062	***	(10.50)	0.042	***	(7.32)				
Italy	0.042	***	(6.62)	0.024	***	(4.08)				
Spain	0.029	***	(5.18)	0.011	**	(1.95)				
USA	0.108	***	(18.13)	0.086	***	(14.94)				
Germany	0.081	***	(12.55)	0.062	***	(10.46)				
France	0.105	***	(18.20)	0.087	***	(15.34)				
Australia	0.025	***	(3.55)	0.035	***	(5.64)				
Belgium	0.061	***	(9.55)	0.053	***	(8.99)				
Czech Republic	0.022	***	(2.99)	0.008		(1.30)				
Ireland	0.031	***	(5.11)	0.005		(0.94)				
Nederlands	0.064	***	(10.91)	0.052	***	(9.16)				
United Kingdom	0.075	***	(12.21)	0.053	***	(9.14)				
Canada	0.071	***	(12.24)	0.056	***	(9.85)				
Sector dummies			No			Yes				Yes
Reference sector				*Machinery & Equipment, NEC*				*Machinery & Equipment, NEC*		
Food products, Beverages and Tobacco				-0.038	***	(-6.37)		-0.045	***	(-3.34)
Textiles, Textile products, Leather and Footwear				-0.041	***	(-6.77)		-0.048	***	(-3.55)
Wood and Products of Wood and Cork				-0.043	***	(-6.74)		-0.048	***	(-2.84)
Pulp, Paper, Paper products, Printing and Publishing				-0.043	***	(-7.00)		-0.057	***	(-3.89)
Coke, Refined Petroleum products and Nuclear fuel				-0.014	**	(-2.24)		-0.020		(-1.46)
Chemicals excluding pharmaceuticals				0.018	***	(2.89)		0.047	***	(3.44)
Pharmaceuticals				0.176	***	(28.77)		0.167	***	(12.30)
Rubber and Plastic products				-0.018	***	(-3.01)		0.027	**	(1.96)
Other non-metallic mineral products				-0.036	***	(-5.94)		-0.031	**	(-2.28)
Basic metals				-0.028	***	(-4.54)		-0.031	**	(-2.29)
Fabricated metal products, except machinery and equipment				-0.040	***	(-6.50)		-0.045	***	(-3.33)
Office, accounting and computing machinery				0.173	***	(27.82)		0.328	***	(23.81)
Electrical machinery and apparatus, NEC				0.035	***	(5.79)		0.051	***	(3.70)
Radio, television and communication equipment				0.223	***	(36.40)		0.165	***	(11.94)
Medical, precision and optical instruments				0.091	***	(14.32)		0.190	***	(13.79)
Motor vehicles, trailers and semi-trailers				0.042	***	(6.96)		0.075	***	(5.41)
Other transport equipment				0.083	***	(13.80)		0.137	***	(9.92)
Electricity, Gas and Water supply				-0.048	***	(-7.78)		-0.063	***	(-4.33)
Construction				-0.050	***	(-8.07)		-0.063	***	(-3.88)
Total services				-0.048	***	(-8.04)		-0.056	***	(-4.12)
2001	0.005		(0.90)	0.003		(0.74)	*1998*	0.001		(0.01)
2002	0.007		(1.21)	0.005		(1.25)	*1999*	0.001		(0.09)
2003	0.007		(1.22)	0.005		(1.15)	*2000*	0.002		(0.23)
2004	0.003		(0.50)	0.001		(0.29)	*2001*	0.010		(1.15)
							2002	0.016	*	(1.81)
Constant			No			No				No
Number of obs			5726			5726				863
F(22, 5704)			124.77	*F(42, 5684)*		314.29	*F(28, 835)*			153.52
Prob > F			0.000			0.000				0.000
Adj R-squared			0.322			0.697				0.832
Root MSE			0.109			0.073				0.064

Figure 3. Results of the three OLS regressions of R&D intensity on country- and industry-specific effects

Dependent variable is RIt							
Regression #	4				5		
Sweden	0.029	***	(4.98)	*USA*	0.038	***	(6.18)
France	0.025	***	(4.28)	*Japan*	0.029	***	(4.65)
USA	0.023	***	(4.03)				
Japan	0.013	**	(2.21)				
Norway	0.004		(0.73)				
Finland	-0.005		(-0.81)				
Canada	-0.007		(-1.14)				
Belgium	-0.009		(-1.55)				
United Kingdom	-0.009		(-1.60)				
Nederlands	-0.010	*	(-1.80)				
Denmark	-0.021	***	(-3.53)				
Australia	-0.027	***	(-4.32)				
Italy	-0.038	***	(-6.35)				
Korea	-0.040	***	(-6.11)				
Spain	-0.052	***	(-9.10)				
Czech Republic	-0.054	***	(-8.45)				
Ireland	-0.057	***	(-9.63)				
Reference country	*Germany*				*Europe*		
Reference sector	*Machinery & Equipment, N.E.C.*				*Machinery & Equipment, N.E.C.*		
Radio, television and communication equipment	0.223	***	(36.40)	*Office, accounting and computing machinery*	0.328	***	(23.81)
Pharmaceuticals	0.176	***	(28.77)	*Medical, precision and optical instruments*	0.190	***	(13.79)
Office, accounting and computing machinery	0.173	***	(27.82)	*Pharmaceuticals*	0.167	***	(12.30)
Medical, precision and optical instruments	0.091	***	(14.32)	*Radio, television and communication equipment*	0.165	***	(11.94)
Other transport equipment	0.083	***	(13.80)	*Other transport equipment*	0.137	***	(9.92)
Motor vehicles, trailers and semi-trailers	0.042	***	(6.96)	*Motor vehicles, trailers and semi-trailers*	0.075	***	(5.41)
Electrical machinery and apparatus, NEC	0.035	***	(5.79)	*Electrical machinery and apparatus, NEC*	0.051	***	(3.70)
Chemicals excluding pharmaceuticals	0.018	***	(2.89)	*Chemicals excluding pharmaceuticals*	0.046	***	(3.44)
Coke, Refined Petroleum products and Nuclear fuel	-0.014	**	(-2.24)	*Rubber and Plastic products*	0.027	**	(1.96)
Rubber and Plastic products	-0.018	***	(-3.01)	*Coke, Refined Petroleum products and Nuclear fuel*	-0.020		(-1.46)
Basic metals	-0.028	***	(-4.54)	*Other non-metallic mineral products*	-0.031	**	(-2.28)
Other non-metallic mineral products	-0.036	***	(-5.94)	*Basic metals*	-0.031	**	(-2.29)
Food products, Beverages and Tobacco	-0.038	***	(-6.37)	*Fabricated metal products, except machinery and equipment*	-0.045	***	(-3.33)
Fabricated metal products, except machinery and equipment	-0.040	***	(-6.50)	*Food products, Beverages and Tobacco*	-0.045	***	(-3.34)
Textiles, Textile products, Leather and Footwear	-0.041	***	(-6.77)	*Wood and Products of Wood and Cork*	-0.048	***	(-2.84)
Wood and Products of Wood and Cork	-0.043	***	(-6.74)	*Textiles, Textile products, Leather and Footwear*	-0.048	***	(-3.55)
Pulp, Paper, Paper products, Printing and Publishing	-0.043	***	(-7.00)	*Total services*	-0.056	***	(-4.12)
Electricity, Gas and Water supply	-0.048	***	(-7.78)	*Pulp, Paper, Paper products, Printing and Publishing*	-0.057	***	(-3.89)
Total services	-0.048	***	(-8.04)	*Construction*	-0.063	***	(-3.88)
Construction	-0.050	***	(-8.07)	*Electricity, Gas and Water supply*	-0.063	***	(-4.33)
2001	0.003		(0.74)	*1998*	0.001		(0.01)
2002	0.005		(1.25)	*1999*	0.001		(0.09)
2003	0.005		(1.15)	*2000*	0.002		(0.23)
2004	0.001		(0.29)	*2001*	0.011		(1.15)
				2002	0.016		(1.81)
Constant	0.062	***	(10.46)		0.032	***	(2.97)
Number of obs			5726				863
F(41, 5684)			193.05	*F(27, 835)*			86.33
Prob > F			0.000				0.000
Adj R-squared			0.579				0.728
Root MSE			0.073				0.064

Figure 4. Empirical results, testing for differences across countries (OLS method)

Descriptive statistics: R&D intensity by country, 2000-2004

Country	mean(rdiv)	med(rdiv)	min(rdiv)	max(rdiv)	sd(rdiv)
AUS	0,051	0,019	0,001	0,289	0,071
BEL	0,078	0,034	0,002	0,572	0,108
CAN	0,088	0,016	0,001	0,758	0,170
CZE	0,022	0,008	0,000	0,116	0,030
DNK	0,075	0,023	0,000	0,399	0,103
FIN	0,090	0,036	0,005	0,653	0,133
FRA	0,099	0,049	0,001	0,478	0,119
GBR	0,085	0,025	0,001	0,531	0,127
GER	0,078	0,024	0,000	0,435	0,100
IRL	0,024	0,014	0,000	0,123	0,025
ITA	0,035	0,007	0,000	0,192	0,049
JPN	0,124	0,045	0,001	0,984	0,178
KOR	0,044	0,019	0,001	0,234	0,054
NLD	0,045	0,020	0,001	0,346	0,067
NOR	0,080	0,031	0,004	0,515	0,110
SPA	0,035	0,012	0,001	0,177	0,046
SWE	0,125	0,037	0,002	1,077	0,199
USA	0,101	0,026	0,000	0,556	0,144

Descriptive statistics: R&D intensity by sector, 2000-2004

	Sector	mean(rdiv)	med(rdiv)	min(rdiv)	max(rdiv)	sd(rdiv)
S1	FOOD PRODUCTS, BEVERAGES AND TOBACCO	0,015	0,013	0,001	0,050	0,009
S2	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR	0,014	0,012	0,001	0,060	0,009
S3	WOOD AND PRODUCTS OF WOOD AND CORK	0,008	0,004	0,000	0,031	0,008
S4	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING	0,008	0,006	0,000	0,023	0,006
S5	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	0,028	0,021	0,001	0,117	0,027
S6	CHEMICALS EXCLUDING PHARMACEUTICALS	0,068	0,060	0,001	0,167	0,045
S7	PHARMACEUTICALS	0,233	0,235	0,030	0,600	0,143
S8	RUBBER AND PLASTICS PRODUCTS	0,036	0,023	0,006	0,253	0,045
S9	OTHER NON-METALLIC MINERAL PRODUCTS	0,015	0,013	0,003	0,046	0,009
S10	BASIC METALS	0,023	0,019	0,004	0,059	0,015
S11	FABRICATED METAL PRODUCTS, except machinery and equipment	0,013	0,010	0,002	0,041	0,009
S12	MACHINERY AND EQUIPMENT, N.E.C.	0,058	0,059	0,016	0,109	0,025
S13	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	0,216	0,149	0,001	0,984	0,217
S14	ELECTRICAL MACHINERY AND APPARATUS, NEC	0,071	0,069	0,008	0,218	0,048
S15	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	0,275	0,237	0,003	1,077	0,197
S16	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	0,161	0,146	0,019	0,556	0,116
S17	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	0,096	0,096	0,007	0,270	0,067
S18	OTHER TRANSPORT EQUIPMENT	0,115	0,101	0,005	0,294	0,082
S19	ELECTRICITY, GAS AND WATER SUPPLY	0,006	0,004	0,000	0,020	0,005
S20	CONSTRUCTION	0,003	0,001	0,000	0,011	0,003
S21	TOTAL SERVICES	0,005	0,004	0,001	0,011	0,002

Figure 5. Descriptive statistics