

***IPTS WORKING PAPER on
CORPORATE R&D AND INNOVATION - No. 09/2009***

Is Corporate R&D Investment in High-Tech Sectors More Effective? Some Guidelines for European Research Policy

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Abstract

This paper discusses the link between R&D and productivity across the European industrial and service sectors. The empirical analysis is based on both the European sectoral OECD data over the period 1987-2002 and on a unique micro longitudinal database consisting of 532 top European R&D investors over the six-year period 2000-2005. The main conclusions are as follows. First, the R&D stock has a significant positive impact on labour productivity; this general result is largely consistent with previous literature in terms of the sign, the significance and the magnitude of the estimated coefficients. More interestingly – both at sectoral and firm levels - the R&D coefficient increases monotonically (both in significance and magnitude) when we move from the low-tech to the medium and high-tech sectors. This outcome means that corporate R&D investment is more effective in the high-tech sectors and this may need to be taken into account when designing policy instruments (subsidies, fiscal incentives, etc.) in support of private R&D. However, R&D investment is not the sole source of productivity gains; technological change embodied in gross investment is of comparable importance on aggregate and it is the main determinant of the productivity increase in the low-tech sectors. Hence, an economic policy aiming to increase productivity in the low-tech sectors should support the overall capital formation.

Keywords: R&D, productivity, high-tech sectors, innovation and industrial policy

JEL classification: O33

1. Introduction

From a macroeconomic viewpoint, starting from the '90s, the US and the EU show a persistent divide both in terms of economic growth (see Fig. A1 in the Appendix) and in terms of labour productivity growth (see Fig. A2 in the Appendix). In particular, what seems obvious is that the EU15's historical process of catching-up to the higher levels of labour productivity of the US economy stops around the mid '90s (see O'Mahony and Van Ark, 2003; Blanchard, 2004; Turner and Boughol, 2008).

Most of scholars agree that to explain the transatlantic productivity gap and the differences within Europe, one has to seriously take into account the R&D and innovation divides which emerged with the spread of the ICT technologies (see Daveri, 2002; Crespi and Pianta 2008). Indeed, R&D expenditures in general and ICT technologies in particular have been demonstrated to play an important role in explaining this persistent and somehow broadening productivity gap within the industrialised countries (see Oliner and Sichel, 2000; Stiroh, 2002;).

Within this interpretation of recent economic trends and divides, the role of private R&D investment by corporate firms (Business Enterprise Research and Development: BERD) has been recognised as a fundamental engine for productivity growth both at the macro and microeconomic level (see Baumol, 2002; Jones, 2002).

The EU15 lags considerably and persistently behind the US in this respect (see Fig. 1). Hence the private R&D gap might be considered the main culprit of the growth and productivity transatlantic gaps discussed above. Indeed, increasing R&D investment is an issue of major concern for the European long term policy strategy. This is the rationale of the "Lisbon agenda 2000" to make Europe the most dynamic knowledge economy in the world by 2010 and of the more specific "Barcelona target" which - two years later - committed the EU to reach the objective of an R&D/GDP level of 3%, two thirds of which accounted for the private sector (European Council, 2002; European Commission 2002)².

If increasing R&D is envisaged as the main strategy to fill the productivity gap between the US and the EU, a strong case in favour of the R&D intensive sectors may arise. In fact, one can argue that the European delay in terms of private R&D investment is mainly due to a sectoral

² In particular, the 7th Framework Programme for Research, Technological Development and Demonstration activities, the 7th Euratom Framework Programme for Nuclear Research and Training Activities, the Competitiveness and Innovation Framework Programme (CIP), and the Structural Funds are the four EU funding sources for supporting research, development and innovation.

The EU FP7 with a total budget of over € 50 billion for the period 2007-2013 is the EU instrument specifically targeted at supporting research and development. It provides funding to co-finance research, technological development and demonstration projects based on competitive calls and independent peer review of project proposals. Support is available for collaborative and individual research projects as well as for the development of research skills and capacity. Since the 1980s, the successive Research Framework Programmes have played a lead role in multidisciplinary research and cooperative trans-national R&D activities in Europe and beyond.

The Euratom FP7 (2007-2011) has a dedicated budget of € 2.75 billion for applied research and training activities in fusion energy and nuclear fission and radiation protection.

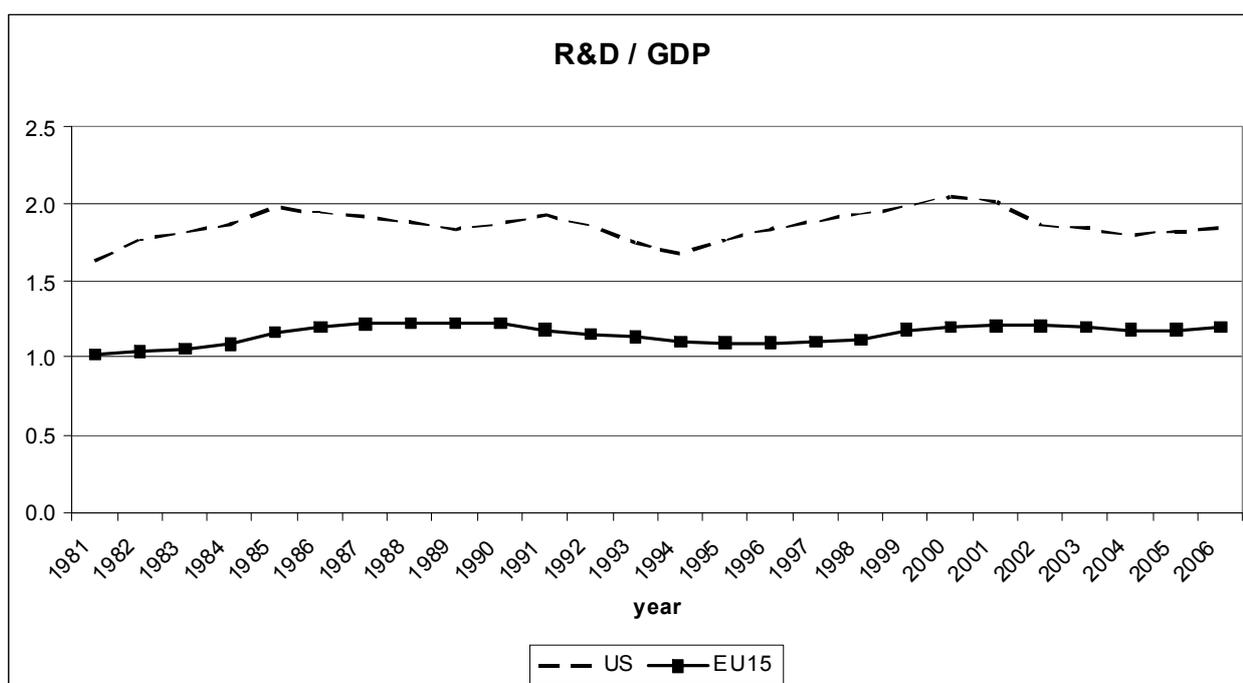
The CIP aims to foster the competitiveness of European enterprises and has a total budget of over € 3.6 billion for the period 2007-2013. Specific CIP programmes promote innovation (including eco-innovation); foster business support services in the regions and better access to finance, with small and medium-sized enterprises (SMEs) as the main target; encourage a better take-up and use of information and communications technologies (ICT); help to develop the information society and promote the increased use of renewable energies and energy efficiency.

Finally, the Structural Funds support many thematic areas, including research, innovation and enterprise for which EU funding in the period 2007-2013 will be above €86 billion. Each region or Member State has developed, in discussion with the Commission and in partnership with all relevant private and public stakeholders, operational programmes that cover the entire programming period.

composition effect, since the R&D-intensive, high-tech sectors are under-represented in the European economy in comparison with the American one (European Commission, 2008).

However, this interpretation appears controversial at the light of the very recent theoretical and empirical debate. For instance, Mathieu and Van Pottelsberghe de la Potterie (2008), running a panel analysis of the R&D intensity of 21 economic sectors in 10 European countries over the period 1991-2002, conclude that BERD intensity is mainly driven by the degree of specialization in R&D intensive industries. At any rate, this evidence in favour of the role of the sectoral composition effect is limited to an analysis within European countries and to a sectoral breakdown where manufacturing is singled out into 20 sectors while services are treated as a single aggregate.

Fig. 1: Private R&D/GDP in EU15 and the US: 1981-2006



Source: OECD – Main Science and Technology Indicators (2008 edition)

Erken and Van Es (2007) put forward a more convincing exercise based on OECD-STAN and OECD-ANBERD data concerning 14 European countries and the US and 36 industries (with a proper disaggregation of services) over the period 1987-2003. Their striking result is that the EU/US gap in private R&D intensity is mainly due to an intrinsic effect (European firms do less R&D within each sector) rather than to the sector composition effect.

If the sectoral composition of the European economy provides only a marginal explanation for the R&D divergence between the EU and the US, the argument for targeting high-tech sectors is partially weakened; although it remains true – by definition – that a way to increase the European effort in private R&D is to insist on the high-tech sectors, the sectoral composition of the European economy does not emerge as the main shortcoming to catch-up the US upper trend in the private R&D/GDP ratio.

However, the overall European productivity delay can be explained not only by a lower level of private R&D investment, but also by a lower capacity to translate R&D investment into productivity gains, in turn fostering competitiveness and economic growth. With regard to the latter explanation, the European economies may be still affected by a sort of Solow's (1987) paradox, *i.e.* by a difficulty to translate their own investments in technology into increases in productivity³.

Differently from other studies, in this paper we gather available evidence and analyses with the aim to put forward an original perspective, where high-tech sectors may be crucial not because they invest more in R&D but because within high-tech sectors corporate R&D investment may be more fruitful in terms of achieving productivity gains.

If the private R&D/labour productivity link is stronger in the high-tech sectors, we would find out an additional argument in favour of industrial and innovation policies targeted to reinforce high-tech sectors in Europe. These policies should be advisable not only because high-tech sectors invest more in R&D, but also because in those sectors private R&D investment is more effective in getting those productivity gains which are in turn necessary to fill the transatlantic gap in terms of competitiveness and economic growth.

The rest of the paper is organised as follows. In the next section a review of the previous literature will be provided. In the following Section 3, the analysis – using OECD data - will be disentangled at the sectoral level, indeed showing that the highest productivity gains can be achieved in European high-tech sectors. This outcome will be further supported by the microeconomic evidence put forward in Section 4. The conclusive Section 5 will be devoted to the possible implications of these empirical outcomes for the design of public instruments to support R&D and for targeted European industrial and innovation policies.

2. Previous evidence

Starting from the seminal contributions of Zvi Griliches (1979, 1995 and 2000), the R&D-productivity relationship has been studied at the national, sectoral and firm's level, using different proxy for productivity according to data availability (labour productivity measured as the ratio between value added and employment; labour productivity as the ratio between value added and hours worked; total factor productivity; Solow's residual; etc.).

In general, previous literature has found robust evidence of a positive and significant impact of R&D on productivity (see, for instance, Klette and Kortum, 2004; Janz, Lööf and Peters, 2004; Rogers, 2006; Lööf and Heshmati, 2006). In this literature, the estimated overall elasticity of productivity in respect to R&D is positive, generally statistically significant and with a magnitude depending on the level of analysis (country, sector or firm), on the adopted econometric methodology and on the data used.

However, in this literature, the estimated overall average elasticity of productivity in respect to R&D is ranging from 0.05 to 0.25 (see Mairesse and Sassenou, 1991 for a survey; Griliches 1995 and 2000; Mairesse and Mohnen, 2001).

Although previous empirical evidence from the microeconomic literature including sectoral breakdowns is scarce, it seems to suggest a greater impact of R&D investment on productivity in the high-tech sectors rather than in the low-tech ones.

³ This paper uses firm labour productivity, as a proxy of firm performance, however the authors are conscious that other firm performance variables can be used to explain the economic growth.

For instance, Griliches and Mairesse (1982) and Cuneo and Mairesse (1983) performed two comparable studies using micro-level data and making a distinction between firms belonging to science-related sectors and firms belonging to other sectors. They found that the impact of R&D on productivity for scientific firms (elasticity equal to 0.20) was significantly greater than for other firms (0.10).

In a more recent paper, Verspagen (1995) used OECD sectoral-level data on value added, employment, capital expenditures and R&D investment in a standard production function framework. His major finding was that the influence of R&D on output was significant and positive only in high-tech sectors, while for medium and low-tech sectors no significant effects could be found.

Wakelin (2001) applied a Cobb–Douglas production function where productivity was regressed on R&D expenditures, capital and labour using data on 170 UK quoted firms during the period 1988-1992. She found R&D expenditure had a positive and significant role in influencing productivity growth; however, firms belonging to sectors defined as "net users of innovations" turned out to have a higher rate of return on R&D.

Finally, Tsai and Wang (2004) also applied a Cobb-Douglas production function to a stratified sample of 156 large firms quoted on the Taiwan Stock Exchange over the period 1994 -2000. They found that R&D investment had a significant and positive impact on the growth of firm's productivity (with an elasticity equal to 0.18). When a distinction was made between high-tech and other firms, this impact was much greater for high-tech firms (0.3) than for other firms (0.07).

3. Sectoral evidence

3.1 The framework and the data

We will test the hypothesis that R&D expenditures are more effective in the high-tech sectors using comprehensive and recent databases both at the sectoral (this section) and at the firm level (next section). In this and the following section, we will use the same specification, based on an augmented production function:

$$\ln(VA / E) = \alpha + \beta \ln(K / E) + \gamma \ln(C / E) + \lambda \ln(E) + \varepsilon \quad (1)$$

Our proxy for productivity is labour productivity (Value Added, VA , over total employment, E); our pivotal impact variables are the R&D stock (K) per employee, and physical capital expenditures (C) per employee⁴. Taking per capita values permits both standardisation of our data and elimination of possible size effects (see, for example, Crépon, Duguet and Mairesse, 1998, p.123). In this framework, total employment (E) is a control variable: if λ turns out to be greater than zero, it indicates increasing returns. All the variables are taken in natural logarithms and deflated according to the different national GDP deflators.

⁴ Other explanatory variables like organizational innovation and skills (although not of the scope of this contribution) are surely important in explaining firm productivity growth (see Piva, Santarelli and Vivarelli, 2005). Unfortunately, given to data limitations, there was no possibility to control for the important role of human capital. As far as spillovers are concerned, in a previous more analytical version of the paper (see Potters, Ortega-Argilés, Vivarelli, 2008) sectoral spillovers have been controlled for and the main results turned out virtually unchanged.

While K/E (R&D stock per employee) is capturing that portion of technological change which is related to the cumulated R&D investment, C/E (physical capital per employee) is the result of extensive (using the same technology) and intensive investment, implementing new technologies. This latter component of C represents the so-called *embodied technological change* with its great potential to positively affect productivity growth. The embodied nature of technological progress and the effects related to its spread in the economy were originally discussed by Salter (1960); in particular, vintage capital models describe an endogenous process of innovation in which the replacement of old equipment and machinery is the main way through which firms update their own technologies (see Freeman, Clark and Soete, 1982; Freeman and Soete, 1987).

As is common in this type of literature (see Hulten, 1990; Jorgenson, 1990), stock indicators - rather than flows - are considered as impact variables; indeed, productivity is affected by the cumulated stocks of capital and R&D expenditures and not only by current or lagged flows. In this framework, R&D and physical capital stocks have been computed using the *perpetual inventory method*, according to the following formulas:

$$K_{t0} = \frac{R \& D_{t0}}{(g + \delta)} \quad \text{and} \quad K_t = K_{t-1} \cdot (1 - \delta) + R \& D_t \quad \text{where R\&D} = \text{R\&D expenditures} \quad (2)$$

$$C_{t0} = \frac{I_{t0}}{(g + \delta)} \quad \text{and} \quad C_t = C_{t-1} \cdot (1 - \delta) + I_t \quad \text{where } I = \text{gross investment} \quad (3)$$

Moreover, the use of cumulated stock permits to avoid the arbitrary choice of a particular structure of lags in measuring the impact of current and previous R&D investments. Finally, in using the perpetual inventory method and computing both g and δ , sectoral and country peculiarities in the available data have been taken into account.

In this section the data sources are the OECD-STAN and the OECD-ANBERD databases. Given the aims of this study, separate estimates for the high, medium and low-tech European sectors will be put forward, using the standard OECD sectoral splitting (Hatzichronoglou, 1997)⁵.

Given the limitations in the availability of comparable OECD sectoral data, regressions have been run over the period 1987-2002 and compounded average growth rates (g) have been computed over at least the three years period before the reference period.

Depreciation rates (δ) have been differentiated, taking into account what commonly assumed in the reference literature (see Nadiri and Prucha, 1996 for physical capital; Hall and Mairesse, 1995 and Hall, 2007 for the R&D stock): namely, on the one hand, depreciation rates for the R&D stocks have been assumed larger than the corresponding rates for physical capital (assuming technological obsolescence being more rapid than scrapping of physical capital); on the other hand, depreciation rates for the high-tech sectors have been assumed larger than the corresponding rates for medium and low-tech sectors (under the assumption that the technological pace is more accelerated in the high-tech sectors). In detail, depreciation has been assumed equal to 4%, 6% and 8% with regard to physical capital depreciation

⁵ In this section, the analysis is limited to the sole manufacturing sector and to the period 1987-2002 because of data limitations in terms of availability, reliability and homogeneity. In the next section, the analysis will include the service sectors.

respectively in the low, medium and high-tech sectors, while the corresponding δ for R&D stocks has been assumed equal to 12%, 15% and 20% respectively⁶.

3.2 Empirical findings at the sectoral level

Taking into account the limitations in the OECD STAN and ANBERD sectoral databases, the EU overall estimation accounts for (on average, with some missing values) 15 manufacturing sectors in 9 European countries over 12 years, resulting in a total number of observations equal to 1,591.⁷ Pooling estimates (POLS) have been controlled for national and annual fixed effects through country and yearly dummies (both highly significant) and computed using heteroskedasticity robust standard errors.

In addition to POLS estimates, we also run random effect specifications in order to control for possible idiosyncratic sectoral effects such as particular evolutions in the sectoral cost structure and in the sectoral demand. We chose a random rather than a fixed effects specification because the within-sector component of the variability of the dependent variable turned out to be overwhelmed by the between-sectors one (0.18 vs 0.46). Moreover, the Hausman test comparing the random and fixed effects models for the whole sample clearly supported the former ($\chi^2=17.23$, p -value=0.24). Heteroskedasticity problems were checked and corrected accordingly by the Eicker/Huber/White sandwich estimator.

Table 1. Sectoral estimates; Dependent variable: log(Labour Productivity) – 9 European countries, 1987-2002 (column (1) Total; column (2) High-tech sectors (ISIC 2423, 30, 32, 33); column (3) Medium-tech sectors (ISIC 23, 24-2423, 25, 26, 27+28, 29, 31, 34, 35); column (4) Low-tech sectors (ISIC 15+16, 17+18+19, 20+21+22, 36+37))

Model Specification	Whole Sample		High-tech		Medium-tech		Low-tech	
	POLS	RE	POLS	RE	POLS	RE	POLS	RE
Log (R&D stock per employee)	0.096 (0.007)	0.085 (0.021)	0.130 (0.034)	0.234 (0.055)	0.039 (0.009)	<u>0.010</u> (0.031)	<u>0.017</u> (0.017)	-0.120 (0.017)
Log (physical capital stock per employee)	0.266 (0.012)	0.086 (0.019)	0.283 (0.046)	<u>0.073</u> (0.066)	0.244 (0.022)	0.072 (0.023)	0.249 (0.025)	0.127 (0.029)
Log (Employment)	-0.072 (0.016)	0.031 (0.062)	0.212 (0.056)	0.372 (0.114)	-0.171 (0.020)	-0.279 (0.061)	0.162 (0.015)	<u>0.001</u> (0.039)
Constant	2.924 (0.085)	3.429 (0.223)	1.979 (0.255)	2.463 (0.401)	3.428 (0.116)	4.399 (0.275)	2.083 (0.120)	3.379 (0.249)
Wald time-dummies (p-value)	2.37 (0.007)	197.33 (0.000)	0.93 (0.514)	20.74 (0.036)	2.17 (0.014)	180.84 (0.000)	1.17 (0.307)	147.30 (0.000)
Wald- country-dummies (p-value)	15.98 (0.000)	11.61 (0.169)	28.49 (0.000)	53.72 (0.000)	13.60 (0.000)	22.76 (0.003)	46.84 (0.000)	28.09 (0.000)
R-squared (overall)	0.518	0.396	0.550	0.357	0.555	0.488	0.623	0.280
observations	1591		308		863		420	
sectors	133		26		72		35	

Note: robust standard errors in brackets; all coefficients are significant at the 99% level of confidence apart from those underlined (not significant).

⁶ It is the authors' intention to run a sensitivity analysis to see how sensitive the model is to the choice of different depreciation rates. Some preliminary robustness checks have been performed and the results did not change.

⁷ See Table A1 for the covered countries and periods; the sectors involved are indicated in the headings of Table 1.

Looking at the evidence presented in Table 1, it is obvious that both the cumulated physical capital and the cumulated technological capital (the R&D stock) have a positive and significant impact on labour productivity on aggregate⁸; however, the role of R&D is particularly strong in the high-tech sectors with an elasticity (highly statistically significant) ranging from 13% to 23%. The impact of the cumulated R&D stock in the medium-tech sectors goes down to 4% according to POLS and becomes even not significant according to the RE estimates. Finally, if we turn our attention to the low-tech sectors, the R&D stock has a non-significant or even a counter-productive impact on productivity⁹. Hence, high-tech sectors emerge as the only ones where the R&D/productivity link is significant and robust to the different specifications.

The physical capital stock is also positively and significantly affecting productivity in aggregate and this effect is homogeneously significant across sectors (with the only exception of the RE model in the high-tech sectors). Hence, embodied technological change emerges as important source of productivity gains in all sectors of the European economy; since R&D seems to be ineffective in the low-tech sectors, it turns out to be the sole driver of increases in productivity in the low-tech ones.

4 Microeconometric evidence

4.1 The framework and the data

In order to further investigate whether the revealed relationship between R&D and productivity is more obvious in firms belonging to certain sectors than to other ones, we built up an unbalanced longitudinal database consisting of 532 top European R&D investors over the six-year period 2000-2005¹⁰. This unique database was constructed by merging the UK-DTI R&D Scoreboard data and the UK-DTI Value Added Scoreboard data¹¹. By merging the two databases we obtained the necessary information to compute our dependent variable (labour productivity, VA/E), our main impact variable (K/E) and our additional variables (C/E and E)¹².

⁸ Both these results are expected and consistent with the previous literature discussed above.

⁹ However, the negative and significant R&D coefficient in the RE model concerning the low-tech sectors (last column in Table 1) should be taken cautiously since – differently from the whole sample, high-tech and low-tech cases – the RE estimates dramatically depart from the POLS ones, revealing both instabilities in the single coefficients and a disappointing fitness of the overall regression (see the low R-squared).

¹⁰ The shortness of the panel, only six years in terms of its time series dimensions and where the dominant component of the data variability has a purely cross-section nature, does not allow us to take into account the dynamic properties of the model, the stationarity of the time series and the opportunity to run a specification in terms of growth rates. This suggestion of further analyses will be taken into account in the following extensions of the work done in this working paper. The COMPUSTAT data (comprising about twenty years) will allow investigating the dynamic properties of the model.

¹¹ The UK Department of Trade and Industry (DTI) collects detailed and tracked data on the larger European firms – both in manufacturing and services - in terms of their R&D investment and value added (VA); the two separate DTI datasets contain information at the firm level, distinguishing by country and sector. Although including data from 14 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Norway, Spain, Sweden, Switzerland, the Netherlands and the UK), British firms are over-represented in the DTI databases.

¹² Out of the original 577 firms, 27 firms belonging to marginal sectors with fewer than five firms were dropped, 6 outliers were excluded according to the results of Grubbs' tests centred on the sectoral average growth rates of firms' R&D stock intensity (K/VA) over the investigated period, and 12 additional firms were dropped for reasons related to the computation of the R&D and capital initial stocks in the year 2000. Finally, M&A were treated in a way that does not compromise the comparability of longitudinal data; specifically, when an M&A occurs, a new entry appears in the database, while the merged firms exit.

An important caveat about the following analysis concerns the nature of the sample, which is made by the top European performers with regard to R&D investments. In other words, while the previous sectoral analysis based on OECD BERD data can be considered fully representative of the European economy, here only the European "champions" are considered. However – notwithstanding this source of sample selection – we can still provide interesting insights on the possible differences in the R&D/productivity relationship across top R&D investors belonging to different industrial sectors¹³.

In particular, we split our panel into three subgroups of comparable size: high-tech, medium-tech and low-tech sectors¹⁴. *Ex ante*, we endogenously grouped the sectors according to their overall R&D intensity (R&D/VA), assuming the thresholds of 5% and 15%¹⁵. *Ex post*, we compared the outcome of our taxonomy with the OECD classification, and we registered a high degree of consistency at least as far as the comparable manufacturing sectors are concerned¹⁶. The service sectors were allocated accordingly (see Tables A2 and A3 in the Appendix)¹⁷.

As in the previous section and accordingly with the related microeconomic literature (see Hall and Mairesse, 1995; Bönte, 2003; Parisi, Schiantarelli and Sembenelli, 2006), stock indicators (rather than flows) were inserted as impact variables; indeed, a firm's productivity is affected by the cumulated stocks of capital and R&D expenditures and not only by current or lagged flows¹⁸.

In this framework, R&D and physical capital stocks were computed again using the perpetual inventory method. As far as the growth rates for the physical capital and R&D are concerned, we used the OECD STAN and the OECD ANBERD databases respectively. In particular, we computed the compounded average rates of change in real R&D expenditures and fixed capital expenditures in the relevant sectors and countries over the period 1990-1999 (the ten-year period preceding the period investigated in this section).

As far as the depreciation rates for K and C are concerned we chose to apply different rates to each of our three sectoral groups. Like in the previous section, we applied sectoral depreciation rates of 20%, 15% and 12% to the R&D stock and 8%, 6% and 4% to the physical capital stock (respectively for the high tech, medium-high-tech and medium-low/low-tech sectors). The resulting weighted averages were 15.6% for the R&D stock and 6.0% for the capital stock respectively; these values are very close or identical to the 15% and 6% commonly used in the literature¹⁹.

¹³ The context of organization changes, financial constraints and financial systems are some aspects that are interested to be considered, however due to limitations of the data in this version of the working papers are not taken into account. Financial indicators will be addressed in the next versions of the analysis using COMPUSTAT dataset.

¹⁴ Compared with the OECD classification, we grouped low-tech and middle-low-tech sectors together, in order to have enough observations in each of the sectoral groups.

¹⁵ Note that these thresholds are significantly higher than those adopted by the OECD for the manufacturing sectors only (2% and 5%, see Hatzichronoglou 1997); this is the obvious consequence of dealing with the top European R&D investors.

¹⁶ Only two sectors (automobile and food) turned out to be up-graded; this is also a consequence of dealing with top R&D investors.

¹⁷ Given the data limitations, we have grouped the sector based on the R&D intensity, it is our intention to replicate the same analysis with COMPUSTAT data and put forward a sectoral classification based on multiple innovative variables.

¹⁸ Using cumulated R&D and capital stocks – as in the previous relevant literature – overcomes a potential endogeneity problem which can arise if flows are used.

¹⁹ It is the authors' intention to run a sensitivity analysis to see how sensitive the model is to the choice of different depreciation rates. Some preliminary robustness checks have been performed and the results did not change.

4.2 Empirical findings at the firm level

The results from the microeconomic estimates are reported in Table 2. Specification (1) was tested through two econometric methodologies: pooled ordinary least squares (POLS) and random effects (RE).

We chose a random rather than a fixed effects specification for various reasons. Firstly, the nature of our unbalanced short panel (six years with an average of 3.4 observations available per firm) severely affects the within-firm variability component of our data. Secondly, and consistently with the previous observation, the within-firm component of the variability of the dependent variable turns out to be overwhelmed by the between-firms component (the standard deviations being 0.15 and 0.58 respectively). Thirdly, the Hausman test comparing the random and fixed effects models for the whole sample clearly supports the former ($\chi^2=4.65$, p -value=0.79). Fourthly, in the fixed effects model the estimation of the coefficient of any time-invariant regressor – such as an indicator of sectoral belonging – is not possible as it is absorbed into the individual-specific effect; this is particularly unfortunate in our case, where the two-digit sectoral dummies always turn out to be both jointly significant (see the corresponding Wald tests in Table 2) and individually significant in the vast majority of cases (for instance, in 25 cases out of 27 sectoral dummies for the whole sample).

As was the case in the sectoral estimates, we used the Eicker/Huber/White sandwich estimator; diagnosis tests reveal the satisfactory fitness of the chosen models and the usefulness of including country, time and sectoral dummies.

As can be seen, the R&D stock has a significant positive impact on a firm's productivity with an overall elasticity of about 10%; this general result is largely consistent with the previous literature both in terms of the sign, the significance and the estimated magnitude of the relevant coefficient (see Section 2)²⁰.

More interestingly, the coefficient increases monotonically when we move from the low-tech to the medium-high and the high-tech sectors, ranging from a minimum of 3-5% in the low-tech industries (and turning barely significant in both the models) to 11-13% in the medium-tech sectors (achieving 99% significance) and to a maximum of 14-17% in the high-tech ones (also fully significant). These outcomes are consistent with the previous empirical results at the sectoral level (see Section 3): on the whole, high-tech sectors not only invest more in R&D²¹, but are also getting more - in terms of productivity gains – from their own research activities. On the other side of the spectrum, a clear link between private R&D and productivity does not come out as far as the low-tech industries are concerned.

The physical capital stock also increases a firm's productivity, with an overall elasticity which turns out to be around 12/13%; however, this effect is stronger in the low-tech sectors, lower but still significant in the medium tech sectors, while it turns out to be not significant in the high-tech sectors²². Consistently with what emerged in the previous section, this evidence

²⁰ The results are far from being expected: giving the law of decreasing returns, ex-ante expectations are exactly the opposite. One would have expected lower marginal coefficients in the high-tech sectors, characterized by largely higher level of the knowledge stock. Results show that, at least in Europe, high-tech sectors have still a lot to gain from R&D investment, both in terms of average and marginal productivity returns.

²¹ See Table A2 in the Appendix for some descriptive statistics, where it clearly emerges the higher average R&D intensity (K/E) characterising the firms belonging to the high-tech sectors.

²² At the micro level, it may well be the case that a high-tech firm is always "on the frontier" as far as the installed capital is concerned (for instance, using the latest vintages of machineries incorporating the most recent process innovations). In this context, marginal productivity gains only come from the R&D activities and the correlated product innovations. In the low-tech sectors, the opposite can happen, with productivity gains mainly associated with the process innovations associated with a gradual renewal of the installed capital (embodied technological change).

seems to suggest that the embodied technological change is crucial in the low-tech sectors²³, while in the high-tech sectors technological progress is mainly introduced through R&D investments.

Table 2. Firm level estimates; Dependent variable: log(Labour Productivity)

Model Specification	Whole Sample		High-tech		Medium-tech		Low-tech	
	POLS	RE	POLS	RE	POLS	RE	POLS	RE
log(R&D stock per employee)	0.104 (0.009)	0.104 (0.017)	0.169 (0.019)	0.138 (0.030)	0.115 (0.014)	0.126 (0.031)	<i>0.029</i> (0.015)	<i>0.048</i> (0.026)
log(physical capital per employee)	0.132 (0.013)	0.123 (0.018)	<u>0.002</u> (0.019)	<u>0.017</u> (0.024)	0.154 (0.019)	0.147 (0.031)	0.245 (0.021)	0.223 (0.032)
log(Employment)	-0.078 (0.009)	-0.115 (0.017)	-0.059 (0.014)	-0.118 (0.028)	-0.086 (0.014)	-0.089 (0.027)	-0.092 (0.018)	-0.127 (0.028)
Constant	<u>0.088</u> (0.195)	0.809 (0.293)	-1.533 (0.196)	-0.532 (0.263)	-0.977 (0.167)	-0.919 (0.299)	-0.497 (0.195)	1.130 (0.297)
Wald time-dummies (p-value)	7.67 (0.000)	95.68 (0.000)	2.97 (0.012)	29.93 (0.000)	3.87 (0.002)	32.37 (0.000)	6.46 (0.000)	54.63 (0.000)
Wald sector-dummies (p-value)	46.04 (0.000)	382.93 (0.000)	28.16 (0.000)	43.91 (0.000)	14.05 (0.000)	19.98 (0.003)	36.35 (0.000)	161.23 (0.000)
Wald country-dummies (p-value)	8.11 (0.000)	32.70 (0.002)	21.28 (0.000)	85.55 (0.000)	30.11 (0.000)	79.34 (0.000)	6.38 (0.000)	<u>19.06</u> (0.087)
R-squared (overall)	0.663	0.651	0.581	0.556	0.515	0.507	0.802	0.789
observations	1787		600		671		516	
firms	532		170		196		166	

Note: robust standard errors in brackets; all coefficients are significant at the 99% level of confidence apart from those either underlined (not significant) or in *italics* (barely significant at the 90% level).

5 Conclusions and policy implications

Consistently with the evidence from previous literature, this study further confirms that the relationship between R&D stock and productivity is positive and statistically significant, with an overall elasticity around 0.10. Moreover, this report provides the following further original findings.

1. The positive and significant impact of R&D on productivity is confirmed at both sectoral and firm levels.
2. R&D is clearly and significantly linked to productivity in the high-tech sectors and – to a lesser extent – in the medium-tech industries; differently, a significant impact seems not to be found within the low-tech sectors. Hence, firms in high-tech sectors not only invest more in R&D, but also achieve more in terms of the productivity gains connected with research activities.

²³ On the crucial role played by embodied technological change in traditional sectors, see Santarelli and Sterlacchini (1990); Conte and Vivarelli (2005).

3. Investment in physical capital is significantly linked to productivity gains, confirming that the "embodied technological change" is a crucial driver of productivity evolution. This relationship is particularly strong in the low-tech sectors, where investment activities are the sole significant sources of productivity gains.

The implications in terms of European research and innovation policy are straightforward.

1. Considering that higher productivity gains can be achieved in the high-tech sectors, the allocation of the R&D efforts is as important as its increase; hence, high-tech sectors should be targeted by the R&D policy.
2. Considering that the relationship between R&D and productivity is stronger in the high-tech sectors, another way to increase the European productivity performance consists in an industrial policy based on incentives in favour of the expansion of the presence of the high-tech sectors in the European economies. In other words, the European industrial structure – although given in the short-term – should be addressed in the long-run, to favour the relative growth of the high-tech sectors.
3. Considering that productivity gains within low-tech sectors are better achieved through the implementation of embodied technological change, a proper policy aiming to increase productivity in those sectors should foster investment in physical capital.

On the whole, the findings of this report support a targeted research policy rather than an "*erga omnes*" type of public intervention. This consideration applies both to the distribution of subsidies and to the design of fiscal incentives targeting corporate R&D investment.

As far as fiscal policy is concerned, most of European governments (Germany being a notable exception) have adopted tax incentives to foster R&D expenditure, leaving the private sector to decide which is the most productive way to invest the fiscal gain (see CREST, 2004 and 2006). However, most of the adopted fiscal measures are "*erga omnes*" and related to general R&D costs and investment. Exceptions can be found in particular fiscal schemes addressed either to innovative SMEs (such as, for instance, the EUROSTARS scheme²⁴), start-ups or research cooperation. However, sectoral discrimination in fiscal measures does not seem on the agenda of European governments, apart from specific measures to support the so-called new technology based firms (NTBFs; see Nill, 2006). As it will be now obvious to the reader, the picture that emerges from this report favours targeted fiscal measures to foster R&D in the high-tech sectors, far away from increasing the adoption of fiscal incentives on a general basis.

To summarise, it is nowadays necessary to go a step ahead of the current conventional wisdom, stating that increasing R&D is crucial to foster European productivity and competitiveness. While this is the common background of the Lisbon-Barcelona targets, the evidence provided in this study not only confirms the need to increase corporate R&D investment, but supports the view that this effort should be concentrated in the high-tech sectors. Overall, the allocation of the R&D effort is as important as its increase.

²⁴ The EUROSTARS programme will offer funding to those European SMEs with less than 250 employees who invest at least 10% of their annual turnover in R&D activities.

6 References

- Arellano, M. 1987. Computing robust standard errors for within-groups estimators, *Oxford Bulletin of Economics and Statistics*, 49, 431-434.
- Baumol, W.J. (2002), *The free market innovation machine: Analyzing the growth miracle of capitalism*, Princeton: Princeton University Press.
- Blanchard, O. 2004. The economic future of Europe, *Journal of Economic Perspectives*, 8, 3-26.
- Bönte, W. 2003. R&D and productivity: internal vs. external R&D – Evidence from West German manufacturing industries, *Economics of Innovation and New Technology*, 12, 343-360.
- Conte A. and M. Vivarelli. 2005. One or many knowledge production functions? Mapping innovative activity using microdata, *IZA Discussion Paper*, n. 1878, Bonn: IZA.
- Crépon, B., E. Duguet and J. Mairesse. 1998. Research, innovation, and productivity: an econometric analysis at firm level, *Economics of Innovation and New Technology*, 7, 115–158.
- Crespi, F. and M. Pianta. 2008. Diversity in innovation and productivity in Europe, *Journal of Evolutionary Economics*, 18, 529-545.
- CREST Expert Group on Fiscal Measures for Research (2004), Report submitted to CREST in the context of the Open Method of Co-ordination, The Hague, June 15th, 2004
- CREST Working Group (2006), Evaluation and design of R&D tax incentives. OMC Crest Working Group report submitted to meeting in CREST 17th March 2006,
- Cuneo, P. and J. Mairesse. 1983. Productivity and R&D at the firm level in French manufacturing, *NBER Working Paper* 1068.
- Daveri, F. 2002. The new economy in Europe, 1992-2001, *Oxford Review of Economic Policy*, 18, 345- 362.
- Erken, H. and F. Van Es. 2007. Disentangling the R&D shortfall of the EU vis-à-vis the US, *Jena Economic Research Paper*, n. 2007-107, Jena: Max Planck Institute of Economics.
- European Council. 2002. *Presidency conclusions. Barcelona European Council. 15 and 16 March 2002*, Brussels.
- European Commission. 2002. *More research for Europe. Towards 3% of GDP*, COM(2002) 499 final, Brussels.
- European Commission. 2008. *Analysis of the 2007 EU Industrial R&D Investment Scoreboard*, Luxembourg.
- Freeman, C. and L. Soete. 1987. *Technical Change and Full Employment*, Oxford: Basil Blackwell.
- Freeman, C., Clark, J. and L. Soete. 1982. *Unemployment and Technical Innovation*, London: Pinter.
- Griliches, Z. 1979. Issues in assessing the contribution of Research and Development to productivity growth, *Bell Journal of Economics*, 10, 92-116.
- Griliches, Z. 1995. R&D and productivity: econometric results and measurement issues, in P. Stoneman (Ed.), *Handbook of the Economics of Innovation and Technological Change*, Oxford: Blackwell Publishers, 52-89.
- Griliches, Z. 2000. *R&D, Education, and Productivity*, Cambridge, MA: Harvard University Press.
- Griliches, Z. and J. Mairesse. 1982. Comparing productivity growth: an exploration of French and US industrial and firm data, *NBER Working Paper* 961.

- Hall, B.H. 2007. Measuring the returns to R&D: the depreciation problem, *NBER Working Paper* 13473.
- Hall, B.H. and J. Mairesse. 1995. Exploring the relationship between R&D and productivity in French manufacturing firms, *Journal of Econometrics*, 65, 263-293.
- Hatzichronoglou, T. 1997. *Revision of the High-technology Sector and Product Classification*, Paris: OECD.
- Hulten, C.R. 1990. The measurement of capital, in E.R. Berndt and J.E. Triplett (eds.), *Fifty Years of Economic Management*, Chicago: University of Chicago Press, 119-152.
- Janz, N., H. Lööf, and B. Peters. 2004. Firm level innovation and productivity – Is there a common story across countries?, *Problems and Perspectives in Management*, 2, 1-22.
- Jones, C. I. 2002, Sources of U.S. economic growth in a world of ideas, *American Economic Review*, 92, 220-39.
- Jorgenson, D.W. 1990. Productivity and economic growth, in E.R. Berndt and J.E. Triplett (eds.), *Fifty Years of Economic Growth*, Chicago: Chicago University Press, 19-118.
- Klette, J. and S. Kortum. 2004. Innovating firms and aggregate innovation, *Journal of Political Economy*, 112, 986-1018.
- Lööf, H. and A. Heshmati. 2006. On the relation between innovation and performance: a sensitivity analysis, *Economics of Innovation and New Technology*, 15, 317-344.
- Mairesse, J. and P. Mohnen. 2001. To be or not to be innovative: an exercise in measurement, *NBER Working Paper* 8644.
- Mairesse, J. and M. Sassenou. 1991. R&D and productivity: a survey of econometric studies at the firm level, *NBER Working Paper*, n. 3666.
- Mathieu, A. and B. Van Pottelsberghe de la Potterie. 2008. A note on the drivers of R&D intensity, *CEPR discussion paper*, n. DP6684.
- Nadiri, M.I. and I.R. Prucha. 1996. Estimation of the depreciation rate of physical and R&D capital in the U.S. total manufacturing sector, *Economic Inquiry*, 34, 43-56.
- Nill, J. 2006. Design and use of fiscal incentives to promote business RDI in CREST countries - an overview. Contribution for the CREST OMC 3% 2nd cycle expert group on fiscal measures, JRC-IPTS, Seville.
- Oliner, S. and D. Sichel. 2000. The resurgence of growth in the late 1990s: is information technology the story?, *Journal of Economic Perspectives*, 14, 3-22.
- O'Mahony, M. and B. Van Ark (eds.) 2003. *EU Productivity and Competitiveness: An Industry Perspective. Can Europe Resume the Catching-up Process?*, Luxembourg: European Commission.
- Parisi, M., F. Schiantarelli and A. Sembenelli. 2006. Productivity, innovation creation and absorption, and R&D. Microevidence for Italy, *European Economic Review*, 8, 733-751.
- Piva, M., E. Santarelli and M. Vivarelli 2005. The Skill Bias Effect of Technological and Organisational Change: Evidence and Policy Implications, *Research Policy*, 34, 141-157.
- Potters, L., R. Ortega-Argilés and M. Vivarelli 2008. R&D and Productivity: Testing Sectoral Peculiarities with Micro Level Data", *IZA Working Paper Series*, n. 3338, Bonn, Germany.
- Rogers, M. 2006. *R&D and productivity in the UK: evidence from firm-level data in the 1990s*, *Economics Series Working Papers* 255, University of Oxford.
- Salter, W.E.G. 1960. *Productivity and Technical Change*, Cambridge: Cambridge University Press.

Santarelli, E. and A. Sterlacchini. 1990. Innovation, formal vs. informal R&D, and firm size: some evidence from Italian manufacturing firms, *Small Business Economics*, 2, 223-228.

Solow, R.M., 1987. We'd better watch out, *New York Times*, book review, July 12.

Stiroh, K.J., 2002. Information technology and the US productivity revival: what do the industry data say?, *American Economic Review*, 92, 1559-1576.

Tsai, K.H. and J.C. Wang. 2004. R&D productivity and the spillover effects of High-tech industry on the traditional manufacturing sector: The case of Taiwan, *World Economy*, 27, 1555-1570.

Turner, L. and H. Boulhol. 2008. Recent trends and structural breaks in US and EU15 Labour Productivity Growth, *OECD Economics Department Working Papers*, n. 628, Paris: OECD.

Verspagen, B. 1995. R&D and productivity: A broad cross-section cross-country look, *Journal of Productivity Analysis*, 6, 117-135.

Wakelin, K. 2001. Productivity growth and R&D expenditure in UK manufacturing Firms, *Research Policy*, 30, 1079-1090.

White, H. 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity, *Econometrica*, 48, 817-838.

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press.

Appendix

Fig. A1: Real GDP growth in the US and the EU15: 1980-2007 (Source: OECD)

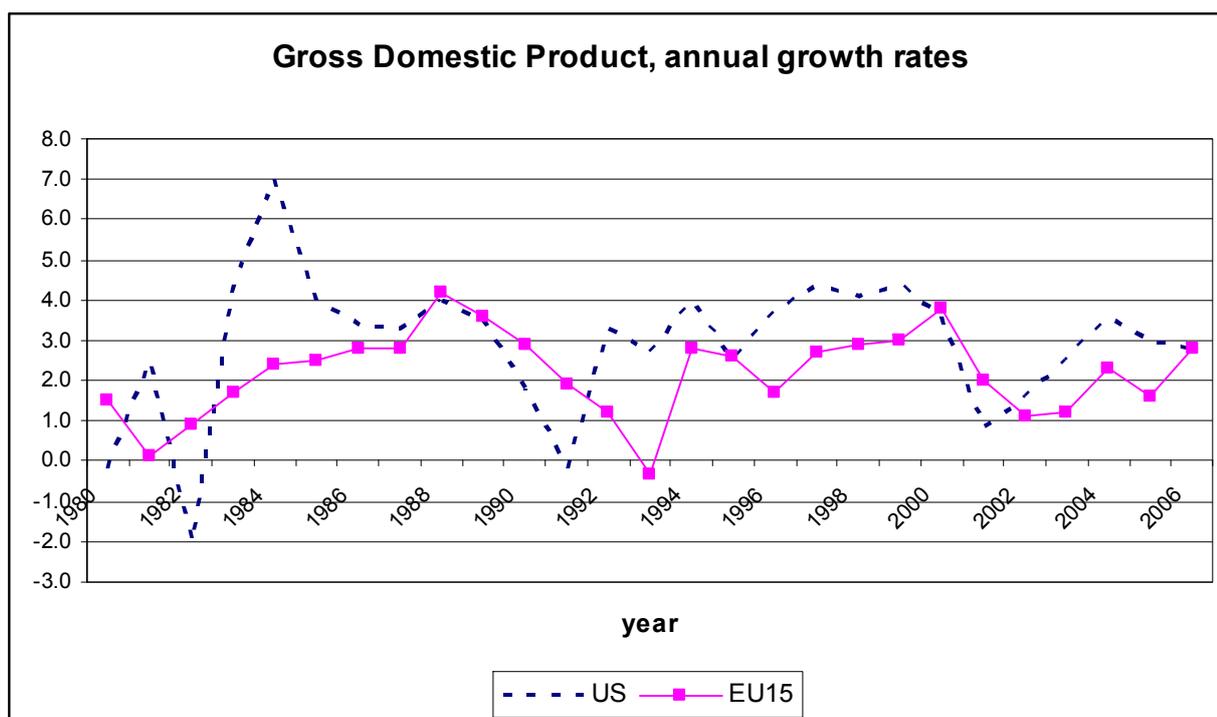


Fig. A2: Labour productivity growth in the US and the EU15: 1996-2006 (Source: OECD)

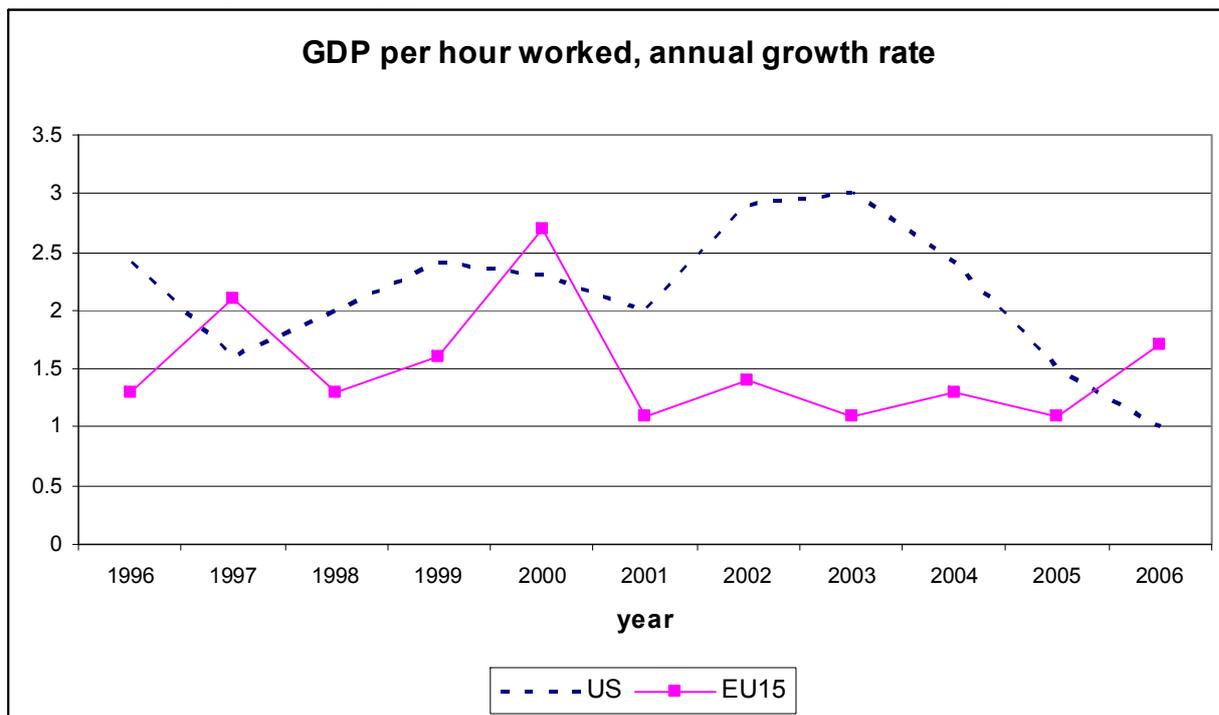


Table A1: The OECD sectoral dataset

Country	N° of manufacturing sectors	Period
Finland	17	1987-2002
France	13	1987-2002
Germany	17	1991-2002
Ireland	14	1991-2002
Italy	17	1991-2002
Netherlands	12	1987-2002
Spain	9	1987-2002
Sweden	17	1987-2002
United Kingdom	17	1987-2002

Table A2: Descriptive statistics (532 UK Scoreboard firms)

<i>Variable</i>	<i>All firms</i>		<i>High-tech</i>		<i>Medium-high</i>		<i>Low-tech</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
VA/E	0.068	0.062	0.063	0.037	0.053	0.024	0.095	0.100
K/E	0.032	0.049	0.062	0.069	0.021	0.026	0.012	0.013
C/E	0.473	1.756	0.158	0.400	0.135	0.176	1.280	3.091
E	36120	62434	40626	73890	22736	38350	48258	69635

Table A3: Sectoral classification and composition of the UK Scoreboard sample

	<i>R&D intensity</i>	<i>firms</i>	<i>observations</i>
High-tech	0.21	170	600
Technology hardware & equipment	0.41	22	77
Pharmaceuticals & biotechnology	0.28	30	120
Leisure goods	0.25	7	25
Aerospace & defence	0.20	21	82
Automobiles & parts	0.16	37	140
Software & computer services	0.16	21	56
Electronic & electrical equipment	0.15	32	100
Medium-tech	0.08	196	671
Chemicals	0.12	42	154
Industrial engineering	0.08	58	209
Health care equipment & services	0.08	14	43
Household goods	0.06	18	51
General industrials	0.05	20	69
Food producers	0.05	31	105
Media	0.05	13	40
Low-tech	0.02	166	516
Fixed line telecommunications	0.03	14	43
Industrial metals	0.02	14	39
Electricity	0.02	13	43
Oil equipment, services & distribution	0.02	7	22
General retailers	0.02	9	29
Support services	0.02	22	67
Construction & materials	0.02	15	65
Banks	0.02	6	6
Gas, water & multiutilities	0.01	23	75
Oil & gas producers	0.01	13	48
Mobile telecommunications	0.01	6	17
Industrial transportation	0.01	11	23
Beverages	0.01	8	20
Mining	0.00	5	19
Total	0.09	532	1787

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Title: Is Corporate R&D Investment in High-tech Sectors more Efficient? Some Guidelines for European Research Policy

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Technical Note

Abstract

This paper discusses the link between R&D and productivity across the European industrial and service sectors. The empirical analysis is based on both the European sectoral OECD data over the period 1987-2002 and on a unique micro longitudinal database consisting of 532 top European R&D investors over the six-year period 2000-2005. The main conclusions are as follows. First, the R&D stock has a significant positive impact on labour productivity; this general result is largely consistent with previous literature in terms of the sign, the significance and the magnitude of the estimated coefficients. More interestingly – both at sectoral and firm levels - the R&D coefficient increases monotonically (both in significance and magnitude) when we move from the low-tech to the medium and high-tech sectors. This outcome means that corporate R&D investment is more effective in the high-tech sectors and this may need to be taken into account when designing policy instruments (subsidies, fiscal incentives, etc.) in support of private R&D. However, R&D investment is not the sole source of productivity gains; technological change embodied in gross investment is of comparable importance on aggregate and it is the main determinant of the productivity increase in the low-tech sectors. Hence, an economic policy aiming to increase productivity in the low-tech sectors should support the overall capital formation.

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IS CORPORATE R&D INVESTMENT IN HIGH-TECH SECTORS MORE EFFECTIVE?

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