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Study on the impact of the internal market and the diffusion of knowledge on preocutivity change and economic growth

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STUDY ON THE IMPACT OF THE INTERNAL MARKET AND THE DIFFUSION OF KNOWLEDGE ON PREOCUTIVITY CHANGE AND ECONOMIC GROWTH

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Abstract

The idea in this paper is to provide an empirical verification of the relationship between innovation adoption and productivity growth. Initially, we are going to provide evidence of the above-mentioned relationship through means of descriptive statistics and subsequently, we will study the real impact that innovation adoption may have on productivity growth through a regression analysis. The analysis is made with the statistical information provided by the Community Innovation Survey in its third and fourth waves.

1. Introduction

Technological progress is a priority for all those countries which aspire to support economic development since innovation is widely regarded as an essential force for starting and fuelling the engine of growth (Romer, 1986). Such force crucially depends on the process of creation, accumulation and diffusion/adoption of knowledge which is often strongly localized into clusters of innovative firms, sometimes in close cooperation with public institutions such as research centres and universities.

This implies that local growth depends on the amount of technological activity which is carried out locally and on the ability to exploit external technological achievements through the diffusion/adoption of such technologies (Martin and Ottaviano, 2001, Grossman and Helpman, 1994, Coe and Helpman, 1995).

The idea in this paper is therefore to **provide an empirical verification of the relationship between innovation adoption and productivity growth.** Initially, we are going to provide evidence of the above-mentioned relationship through means of descriptive statistics and subsequently, we will study the real impact that innovation adoption may have on productivity growth through a regression analysis. The analysis is made with the statistical information provided by the Community Innovation Survey in its third and fourth waves, which concern the innovative activities carried out between 1998 and 2000 and between 2002 and 2004 respectively. The countries covered are all 25 EU Member States plus Iceland and Norway as well as Turkey and Romania, as in WP4/??.

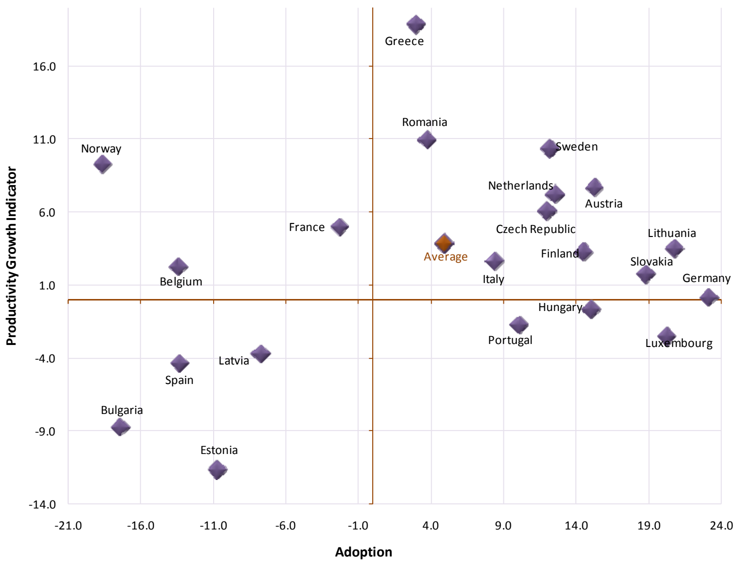
2. Empirical verification of the relationship between innovation adoption and productivity growth through descriptive analysis

The expected relationship between innovation diffusion/adoption and productivity growth is positive as highlighted in previous empirical and theoretical literature. For instance, the Nelson-Phelps (1996) model of technology diffusion/adoption is based on the idea that changes in productivity and in total factor productivity depend, among other variables, on the rate of technology diffusion from the leader country to each of the countries under consideration. We follow the same idea, whereas instead of considering the diffusion from the leader country to the rest of countries we will consider a measure gathering the extent of the change in the adoption of innovation in each country, change computed between the data in CIS3 and that of CIS4. In the next figures we will try to get evidence on this relationship in the case of the European countries using data for productivity growth in the period between 2000 and 2005 from EUROSTAT. For the information on adoption of innovation, reader should go to the description given in WP4/?? of this SEARCH project. We start by providing some scatterplots plotting the average productivity growth in the Y-axis versus different indicators of the growth of adoption of innovation.

Figure 1 plots the average productivity growth in the Y-axis versus the change in the global indicator of the adoption of innovation with information at the national level. Therefore, with the information for the average of the different sectors in each country, Figure IV.1 offers a non-significant coefficient of correlation with a value of 0.246 (p-value: 0.28). In case a weighted correlation was computed, a non-significant but negative value would be obtained, in contrast with the theoretical assumptions. However, if the extreme cases of Greece (with very high productivity growth rates) and Norway (with high growth rates and the lowest rates of innovation adoption), the weighted correlation becomes positive (coefficient of correlation of value 0.0975; p-value: 0.69) and even significant if it is not weighted by the size of the GDP in each country (coefficient of correlation of value 0.488; p-value: 0.03).

If looking at the countries, it can be observed how this positive relationship is mostly due to the positive relationship among both variables for the countries with productivity decreases, that seem to benefit more from the adoption of innovation (lower decreases of productivity as innovation adoption grows). This would be the case of Estonia, Bulgaria, Latvia, Spain, Portugal, Luxembourg and Hungary (coefficient of correlation of value 0.815; p-value: 0.02). On the contrary we do not observe such a clear relationship for the countries with high levels of productivity, since there are very different patterns of behaviour: some countries present very low increases of adoption of innovation (such as France, Norway and Belgium) and some others important increases in innovation adoption (Italy, Finland, Sweden, Netherlands, Austria, Czech Republic, Lithuania and Slovakia). It seems therefore that the adoption of innovation is positively related with productivity in those countries that experience lower increases of productivity, which can take more advantage of such intangible asset.

Figure 1. Scatterplot of the change in innovation adoption and productivity growth



In the next figures we analyse the relationship between productivity growth and innovation adoption in the case of product and process innovations separately. As depicted in Figure 2, we obtain a **significantly positive relationship** at a 10% level, with a value of 41.4% **when considering product adoption if Greece and Norway are not considered** (with them, the coefficient of correlation presents a value of 0.075; p-value of 0.75). So, for product innovation adoption, the relationship seems more clearly positive than in the general case. Again, we observe that the relationship is clearer for the countries with decreases in productivity.[1]

The picture does not change much when one studies **the relationship between productivity growth and changes in the adoption of process innovations.** Although it is not significant with a correlation coefficient of 33.7% (p-value: 0.13) (Figure 3), once we delete Greece and Norway, the correlation becomes clearly significant (coefficient of correlation of 0.426; p-

[1] The values of productivity changes may vary along the different plots. This is due to the fact that each national value is obtained as an average of the growth rates of productivity in the different sectors for which we have data on the variable of adoption considered in the plot. Since the observations presenting missing values for innovation adoption are different in the diverse categories of adoption, the national averages of productivity growth rates do not lead to the same value in all the plots.

value: 0.06). In general terms it can be concluded that there is a positive relationship between changes in adoption rates and in productivity growth no matter the type of innovation, although it is more straightforward in the case of the adoption of process innovations. This could be due to the fact that introducing a new production process makes the firms to be more efficient, reducing costs and therefore each worker being more productive.

Figure 2. Scatterplot of changes in product adoption and productivity growth

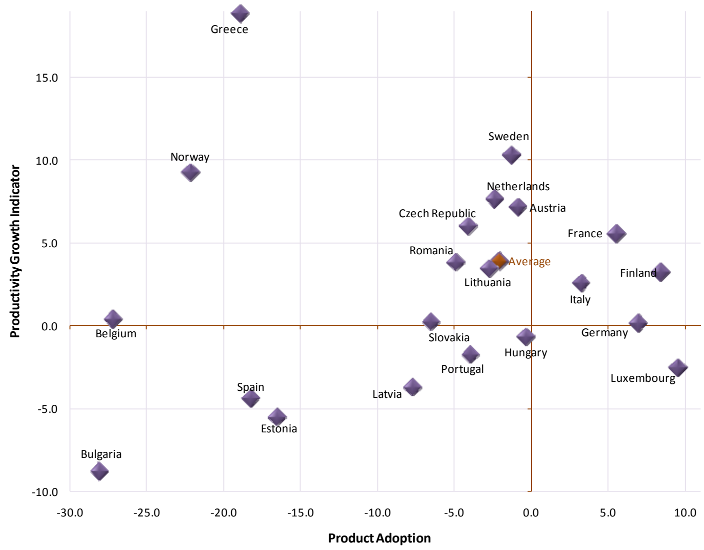
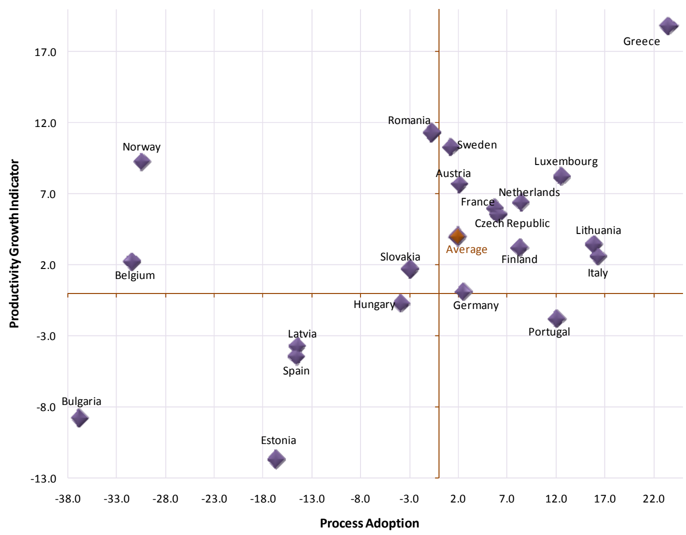


Figure 3. Scatterplot of changes in process adoption and productivity growth



Similar conclusions are obtained when plotting the relationship between productivity and adoption of product/process innovations **in case of cooperating** with other firms or institutions (Figures IV.4 and IV.5). Again **the relationship is positive** for product adoption

(18.6% that becomes significant once Norway is dropped, with a higher value of correlation, 37%), but even more significantly positive for the case of process adoption (45.7%, significant at a 5% level, with all the countries considered). Therefore, as in the general case, the correlation is **higher for process than for product innovation also when focusing on the cooperation link.** Using cooperation-based adoption, however, tends to slightly increase the effect of product adoption on productivity.

Fig 4. Plot of changes in product innovation coopearation-based and productivity growth

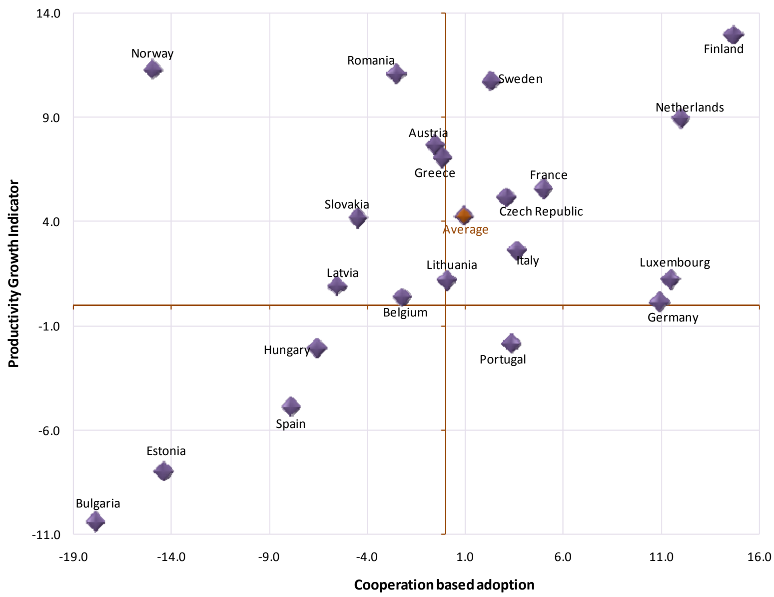
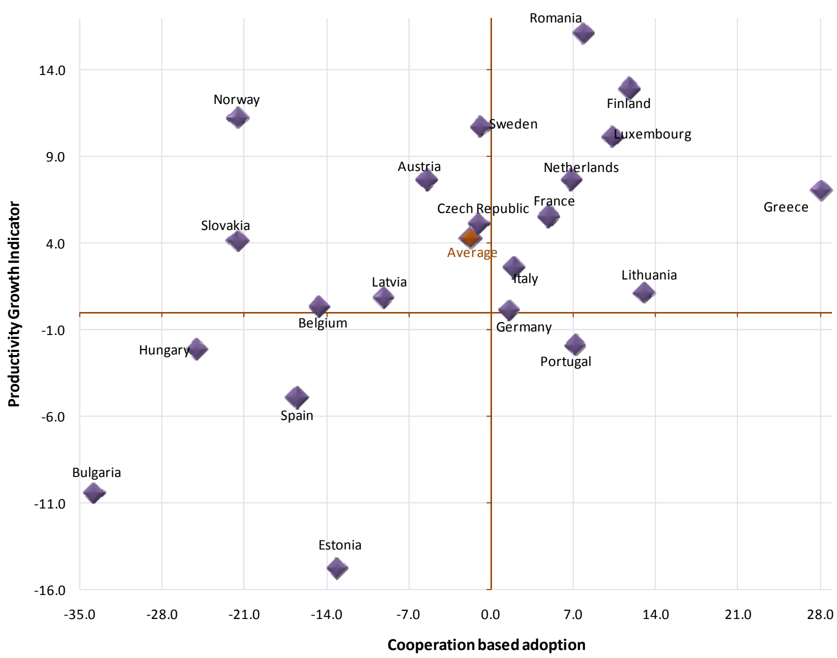


Fig 5. Plot of changes in process innovation coopearation-based and productivity growth



The conclusions are not maintained when plotting the relationship between the evolution of productivity and adoption of product/process innovations **in the case of purchasing the innovation from** other firms or institutions (Figures 6 and 7). Again **the relationship is positive** for product adoption (46%, being significant at a 3% level), but it is no longer significant for the case of process adoption and even presenting a negative although small value (-11%, although positive without Hungary). Therefore, contrary to the general case and to the case of innovation adoption made in cooperation, **the correlation is not significant for process innovations when they are acquired from an external enterprise or organisation.**

Fig 6. Plot of changes in product innovation other organisation-based and productivity growth

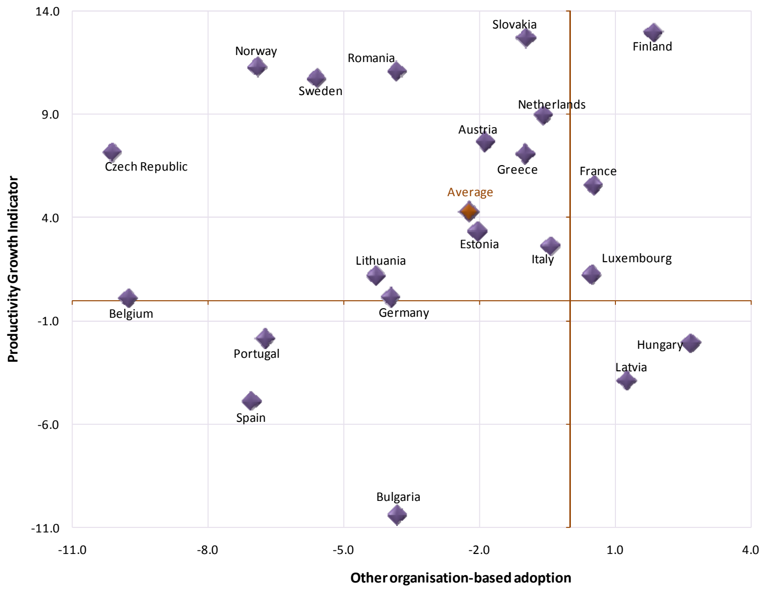
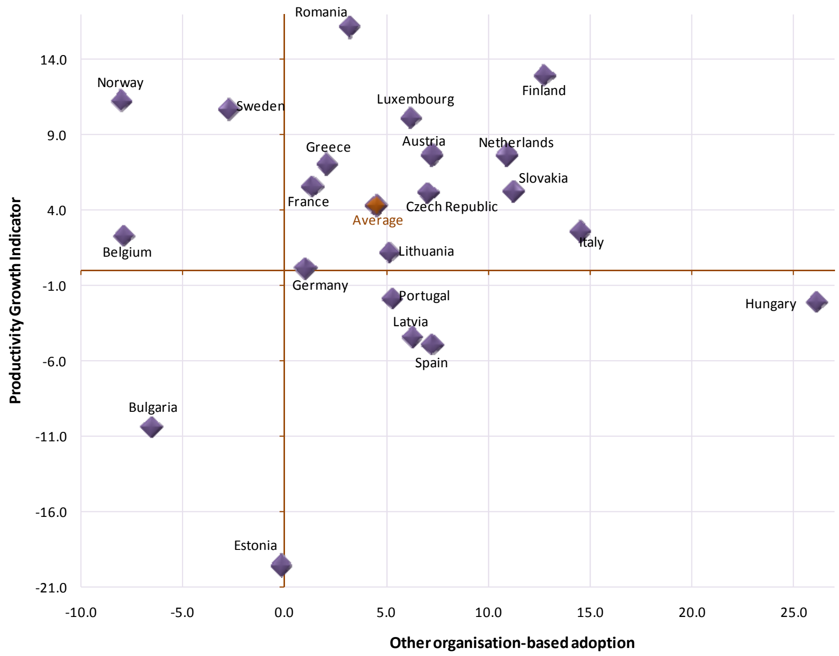


Fig 7. Plot of changes in process innovation other organisation-based and productivity growth



In Table 1 we summarise the weighted coefficients of correlations obtained between productivity growth and the changes in the different categories of innovation adoption with the information at the national level.

Table 1. Coefficients of correlations between productivity growth and changes in innovation adoption. National level

	Correlation	**Correlation without some countries**
Adoption	-0.0285 (0.9023)	0.0975 (Norway and Greece dropped) (0.691)
Product adoption	0.0754 (0.7453)	0.4145 (Norway and Greece dropped) (0.077)*
Process adoption	0.3367 (0.1356)	0.4258 (Norway and Greece dropped) (0.069)*
Product adoption in cooperation	0.1866 (0.418)	0.3700 (Norway dropped) (0.100)*
Process adoption in cooperation	0.4569** (0.0373)	
Product adoption other organisation-based	0.46 (0.0359)**	
Process adoption other organisation-based	-0.11 (0.6351)	

P-values are given in parenthesis

3. Empirical verification of the relationship between innovation adoption and productivity growth. Regression analysis

In the figures in the section above, although not conclusive for all types of innovation adoption, in general terms we have obtained that there exists a positive relationship between innovation adoption and productivity growth which is significant in some cases. However, we can not deduce a real impact of innovation adoption on productivity unless it is analysed through regressions. Therefore, the descriptive analysis on the time evolution of the relevant indicators of both items need to be complemented by regression results shedding some lights on the possible role played by innovation and specially innovation diffusion as emerged by CIS data. This is done in this section through the estimation of a growth equation.

Growth theories have been classified either in a neoclassical or endogenous growth group. In what is related to predictions for convergence, the neoclassical model (Solow, 1956; Swan, 1956) supports a convergence process based on the existence of decreasing returns in capital accumulation. Increases in capital lead to increases less than proportional in product. This circumstance explains the existence of a steady state level for the main magnitudes, such as product per unit of employment, to which the economy will tend after any transitory shock. These being the case, poor economies will growth at higher rates than rich ones, guaranteeing convergence across all of them.

On the other hand, endogenous growth models are characterized by giving mechanisms that determine the absence of convergence. In a first step, the fact of not imposing decreasing returns to capital (Romer, 1986; Lucas, 1988) and some ulterior mechanisms in which technological growth is a non-decreasing function of some factors (among others, the resources devoted to innovation), lead to models in which there is not a steady state or long run equilibrium. In other words, these models would not impose any limits to growth. Both mechanisms, although through different ways, allow economies which are initially rich to keep this condition the same as poor economies. In fact, an important part of the efforts in endogenous models have been motivated on the notable persistence observed in the differences in the levels of income and welfare across economies.

However, the implications in terms of convergence derived from both types of models are not straightforward. As can be easily deduced from the assumptions of neoclassical models, the convergence predicted can not be directly translated to the disappearance (of a great part) of the differences across economies. This will also be true when all the economies share the same steady state. Also, in the scope of the endogenous growth models it is possible to design mechanisms that will allow approaching the development levels across economies through, for instance, technological diffusion processes.

A simple growth equation can be expressed as (Barro and Sala-i-Martin, 1995):

(1) $$\log(GDPpw_{c,i,t} / GDPpw_{c,i,t-l}) = a - (1 - e^{-\beta T}) \log(GDPpw_{c,i,t-l}) + u_{c,i,t}$$

that includes a random error term which proxies the transitory shocks. The subscripts c and i denote the country and sector respectively, t is the year under consideration and l refers to a time lag. This way, the intercept would reflect all the factors influencing the steady state.

With respect to the steady state, if we can just consider it to be proxied by the intercept, we would be imposing the existence of the same steady state in all the economies under consideration, which is known as absolute convergence. However, we can think of some specific factors that have a real influence in it and consider them explicitly. These factors can be introduced ad-hoc through the consideration of additional explanatory variables, in a way that has been called growth equations à la Barro. Specifically, we are interested in considering the impact of innovation creation as well as innovation adoption. These factors are introduced ad-hoc in the way à la Barro as follows:

(2) $$\begin{aligned}\log(GDPpw_{c,i,t} / GDPpw_{c,i,t-l}) &= \delta_0 + \delta_1 \log(GDPpw_{c,i,t-l}) + \delta_2 \widehat{InnoAdopt}_{c,i,t} \\ &+ \delta_3 \, InnoCrea_{c,i,t} + DUM_c\delta_4 + DUM_i\delta_5 + DUM_t\delta_6 + u_{c,i,t}\end{aligned}$$

where the variable InnovAdopt is the fitted value of the innovation adoption rate obtained in the second-stage of the regression analysis carried out in WP4/?? of this SEARCH project, but this time with a panel structure thanks to the availability of data from CIS3 and CIS4. InnoCrea is a variable for innovation creation proxied by R&D expenditure in different categories as obtained from CIS. In our case, we estimate a growth equation for the sample of 26 countries of the EU for which we have information on labour productivity obtained from EUROSTAT (value added per worker) for two time periods: 2000-2002 and 2003-2005. This way, the explanatory variables coming from CIS are referred to the time periods 1998-2000 and 2002-2004, so that there is a time lag in the impact of these explanatory variables on the endogenous. We estimate by fixed effects with the use of weighted regressions, according to the economic size of the countries measured with GDP.

Therefore, the econometric specification we will exploit is detailed in eq. (2) where the fitted value of the dependent variable in eq. (12) in WP4/?? is inserted as a regressor in eq. (2). This amounts to run a two-stage least square estimation (2SLS). In fact, by using this kind of estimation we are solving at once also the likely problem of endogeneity that may affect productivity growth and innovation adoption. In fact, either innovation adoption may have a direct effect explaining productivity growth but, at the same time, productivity growth may cause innovation adoption rates to increase or decrease. By estimating in two stages we solve the endogeneity problem and get consistent estimates of the partial effects of innovation adoption. This way, through the consideration of these 2SLS estimation we are also inferring the effect of the IM on productivity growth.

The results for the estimation are depicted in table 3. As it can be observed in column (i) there is not an absolute convergence in the period considered, given the positive value of the coefficient of the level of value added in the initial year. This would point to the fact that departing from low values of value added does not imply growing a higher rate than those starting with higher values of value added.

In column (ii) we condition this regression model including a proxy for innovation adoption (the fitted value of the innovation adoption rate obtained in the preferred specification in Part III) and a proxy for innovation creation (Total R&D expenditures). Additionally, we consider the variable that considers the percentage of EU regulations in Internal Market implemented by each member state in the two years of our panel, proxied by the Transposition Deficit Indicator for Internal Market (TDI Internal Market). Although some IM measures have already been taken into account in the first and second stage of the estimation procedure followed in Part III, we are also interested in controlling for the most general measure which is the extent to which the regulations in the Internal Market have been undertaken by the countries. As observed, in this second column the lack of convergence is maintained with a significant and positive sign of the level of value added in the initial year. Additionally, the TDI of the Internal Market presents a positive although not significant coefficient, meaning that the adoption of more EU regulations by each member state does not lead to higher increases, once the impact on trade, competition and cooperation is taken into account.

Table 3. Growth Equation (endogenous variable: labour productivity growth)								
Productivity	3.272	14.515	8.436	8.904	8.716	8.954	9.038	10.462
	(3.04)***	(4.65)***	(2.90)***	(3.19)***	(3.03)***	(3.17)***	(3.12)***	(3.69)***
Adoption		23.702	29.562	37.737	31.609	36.571	23.126	35.396
		(1.67)*	(2.38)**	(3.04)***	(2.37)**	(2.83)***	(1.81)*	(2.23)*
R&D Expend.		0.017						
		-0.06						
Intra R&D			1.199					1.489
			-1.05					(-0.71)
Extra R&D				3.037				4.477
				(2.64)***				(2.44)**
Acq Machin					1.215			-4.425
					-0.97			(-1.71)
Training						2.702		6.758
						(1.97)**		(2.18)**
Market innov							-0.524	-5.267
							(-0.49)	(-3.01)**
TDI IM		0.329	0.384	0.313	0.376	0.291	0.402	0.402
		-1.22	-1.36	-1.13	-1.33	-1.03	-1.41	-1.41
Constant	-15.703	-107.382	-97.501	-106.418	-98.806	-105.438	-85.697	-85.697
	(-3.22)***	(-3.53)***	(-2.99)***	(-3.37)***	(-2.98)***	(-3.26)***	(-2.67)***	(-2.67)***
# Obs	364	134	141	141	141	141	139	139
# Countries	26	16	16	16	16	16	16	16
R-squared	0.2	0.38	0.33	0.36	0.33	0.35	0.33	0.33

Absolute value of t statistics in parentheses. *, **, *** significant at 10%, 5% and 1%, respectively. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4), except in the case of the endogenous variable in which the growth rate is computed between 2000 and 2002 for the first time span and between 2003 and 2005 in the second one.

More interesting for our purpose are the signs and significance of the parameters on innovation. The innovation adoption rate is positive and significant at a 10% level in all the specifications estimated, indicating that those countries that increase their rates of innovation adoption tend to present higher productivity growth rates. This result would be in line with the conclusions drawn on the descriptive analysis. On the contrary, although positive, we do not obtain a significant coefficient for the total R&D expenses as a proxy for innovation creation. This would be in contrast to what has been obtained in previous literature and in light of the surveyed empirical and theoretical literature on innovation and innovation diffusion. It is somehow surprising the little role played by innovative investments as a determinant of productivity. Two reasons could be behind this result. First, R&D expenditures is an indicator for innovation on the input side, and it has been criticised in some papers since it does not really encompasses the results of the innovation efforts made by the enterprises. Second, this measure for R&D expenditure is very general and encompasses very different types of innovation. Given that the CIS data contains detailed information on different innovative items, we are going to split total R&D expenditure into its different categories.

The results on the impact of the different categories of R&D expenditures are shown in colums (iii) to (viii). First of all, it is worth pointing out that all the conclusions obtained from the rest of parameters are maintained: lack of convergence, positive and significant impact of innovation adoption and positive although not significant impact of the TDI Internal Market. With respect to the different categories of innovation, we can observe that only those of Extramural R&D as well as the one on Training have a significant and positive impact on productivity growth.[2] This is the case both introducing the R&D expenditures one by one and also if all the types of R&D are included together in the same regression, as in the last column.

[2] Whereas the variable on Total R&D expenditures refers to the expenditure itself, the variables for the different categories refer to the number of firms engaged in the corresponding category of R&D activities. This is due to the the non-availability of the variables on innovation expenditure for some of the categories in the CIS. On the contrary, the number of firms engaged is provided. Therefore, one can not compare directly the coefficient for Total R&D expenditures and those of the different categories or innovation, since in the latter it is referring not to expenditures but to the number of firms.

4. Concluding remarks

As a concluding of this paper, it seems that an effort in line of making enterprises increasing innovation adoption, either in the form of cooperating with other enterprises or incorporating innovations made by other enterprises has a positive and clear impact on productivity growth. However, the impact of increasing R&D expenditures is not as clear, but depends on the type of innovation carried out. In this sense, we have obtained that the countries making efforts to increase the number of their firms engaged in extramural R&D or the number of firms engaged in training tend to have higher increases in productivity. On the contrary, the result is not as clear if the type of innovation that is encouraged is R&D intramural, in acquisition of machinery or market introduction of innovation.

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