WP4/16 SEARCH WORKING PAPER

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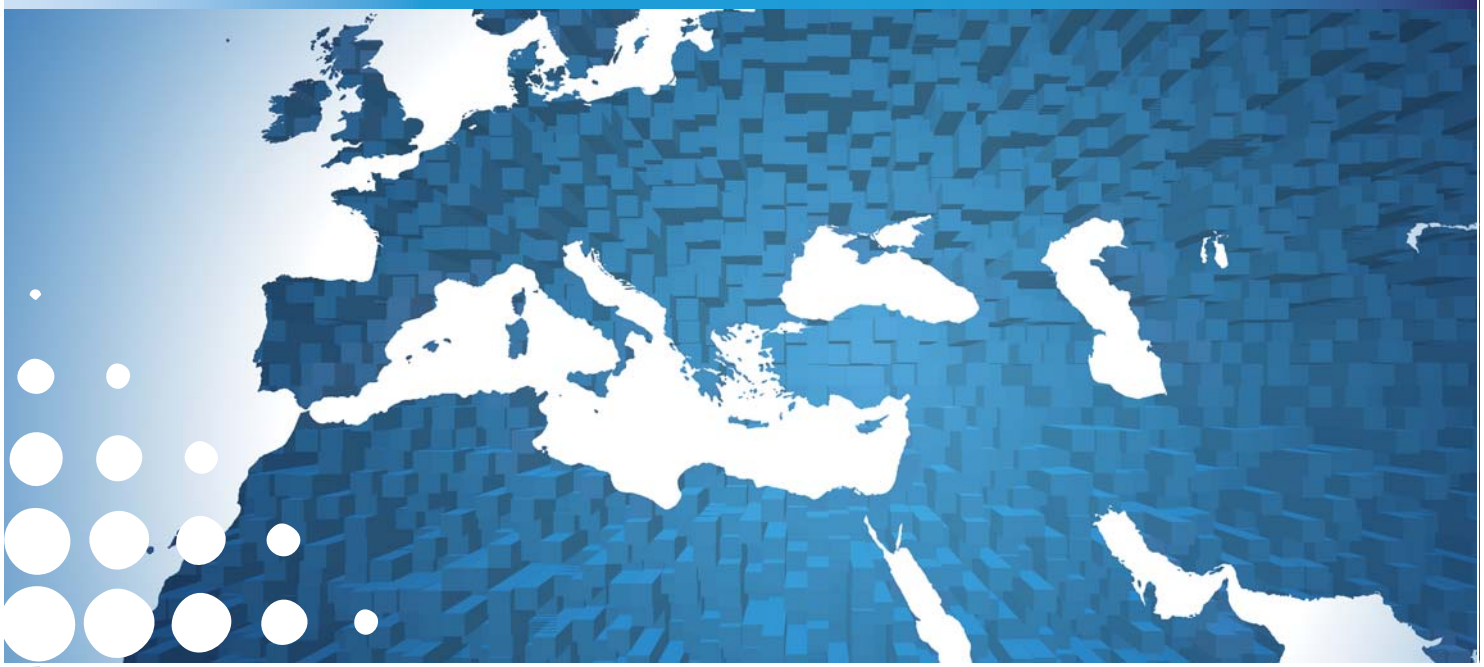
September 2013



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The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2010-2.2-1) under grant agreement n° 266834

The role of the EU Internal Market on the adoption of innovation

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Abstract:

This paper aims at analysing the impact of the regulation of the EU Internal Market on the adoption of innovation. After constructing an indicator of innovation adoption based on the information provided by the Community Innovation Survey, in a first stage we define the impact of some major Internal Market regulations on cooperation, competition and trade across EU countries. The results of this first stage show how different IM regulations are important determinants of these three macroeconomic variables that we consider afterwards having an impact on innovation adoption. Hence, in a second stage we address whether innovation adoption rates significantly depend on the degree of cooperation, trade and competition as well as some control variables such as national legal structures and IPR regulations. Estimations have been computed using an econometric model whose dependent variable is total innovation adoption as well as its possible disaggregation into sub-categories. Results show that cooperation and its main IM determinants impact positively innovation adoption, leaving trade and competition as apparently minor channels of innovation adoption (and especially depending on the type of innovation adoption under examination).

Acknowledgements

The authors would like to acknowledge the support of DG ECFIN/E/2007/020, CICYTs ECO2008-05314 and ECO2009-12678. Additionally, we are indebted to the comments by Corinne Autand-Bernard, Nadine Massard and Jacques Mairesse. The Third Community Innovation Survey, microdata, have been provided by the Eurostat, European Commission. Eurostat has not responsibility for the results and conclusions obtained in this paper. The views expressed in this paper are the authors' only and do not represent the official position of any of the affiliated institutions.

1. Introduction

The Single Market constituted a very ambitious supply-side programme with the aim of removing physical, technical and fiscal non-tariff barriers to the movement of goods, services, capital and persons inside the European Community. The elimination of these barriers by 1st January 1993 undoubtedly represented one of the most relevant changes in the EU institutional structure since its beginnings. To put it in a slightly different way, the aim of the Internal Market (IM) has been explicitly that of increasing the "openness" of the national member states both in terms of economic transactions (trade openness) and in terms of movement of workers (easier cooperation at the EU level). Along with these two fundamental goals, another one was that of increasing the competition level and the productivity of European firms. Indeed, as a result of the progress made from 1992 to 2006 in achieving an enlarged IM of 25 Member States, the GDP increased 2.2% and the gain in total employment was estimated of around a 1.4%, which amounts to 2.75 million jobs (Ilzkovitz *et al*, 2007).

In this paper we analyse the impact that the IM may also have had on the diffusion of innovation at the European level thanks to the adoption of (i) less restrictive trade policies, (ii) increase in cooperation in science and technology and (iii) increased competition. The idea is simple. By pursuing some general goals such as increasing trade integration, cooperation and competition, the IM reforms have also likely reshaped the incentives for innovation creation and its adoption across European member states. As an important "side effect", the IM reforms may have indirectly led to an increase in the rate by which innovation has been adopted in the EU member states due to the better institutional framework provided by these reforms.

Theoretical and empirical literature has already (at least partly) analyzed the links between institutional reforms (like the ones brought about by the new IM regulations at the EU level) and innovative activities (leading to economic growth) finding a positive correlation between them. The seminal contribution by Hall and Jones (1999) or the extensive work by Acemoglu et al. (2001) have already robustly showed the importance of cross-country institutional quality differences on economic growth and productivity differentials. Hall and Jones (1999), for example, point out that, "*in addition to its direct effects on production, a good social infrastructure [institutions] may have important indirect effects by encouraging the adoption of new ideas and new technologies as they are invented throughout the world* ". Also, Manca (2010) empirically shows how good institutions facilitate both productive flexibility lowering the costs of technology adoption and its transmission on a wide sample of countries.

Our specifying assumption is in fact that a considerable (indirect) effect is played by the IM on the adoption of innovation through the (direct) effect that the EU directives have on some “institutional transmission channels” which the literature has identified in trade, competition and cooperation, among the main ones. This assumption allows us to analyze the effect of IM reforms on their "natural" policy targets (trade, cooperation and competition) while also to check the side effect played on the incentives to innovation and innovation adoption in particular. It should be clear then that we understand the impact of the IM on innovation adoption as an indirect one working through the effect that IM reforms had on the institutional framework of each member state.

With this paper, our aim is to try to give an answer to the following questions: “Did (and which among) the EU IM policies lead to a change in the institutional quality of

EU member states through changes in trade openness, cooperation and competition? Did this change foster the adoption of innovation across EU member states? What kind of IM regulations, if any, affected the spread of innovation across EU firms and countries?". Despite the above mentioned theoretical assumptions, there is little cross-country empirical evidence on the effect of the IM on innovation adoption (while much of the empirical research focused on the channels and policies driving to innovation creation).

In contrast to most empirical studies on innovation adoption in which the determinants of technology adoption are analysed through the use of indirect measures such as TFP data, in this study we analyse the determinants of the general innovation adoption process across countries and sectors in the European Union by exploiting survey data which, once representative of the unobserved population, give us a more robust picture of the dynamics ruling innovation adoption at the EU level. Crucially, in fact, another important contribution of our paper is the definition and design of the variable(s) proxying such innovation adoption process. Our analysis relies on the exploitation of the 3rd Community Innovation Survey micro data (CIS3)[1] from which we can compute and obtain data on the number of firms adopting an innovation. We aggregated this data at the country and sectoral level so as to be able to disentangle the specific effect that the different implementation of the IM directives had on the extent of innovation adoption across EU countries. To the best of our knowledge, the present contribution is the first trying to fully exploit the whole statistical information of the CIS (both at the micro and macro level of aggregation) in a comparable and comprehensive way for the

[1] In some cases, it has been necessary to homogenize the information available from both micro and macro databases provided by the CIS.

largest sample of EU member states available. Other recent contributions limit the geographical scope of their analysis to a smaller sample of EU countries.

The remainder of the paper is the following. The second section briefly presents the methodology as well as the econometric approach. Section 3 offers information on the data whereas sections 4 and 5 give the main results. Finally, the last section concludes.

2. Theoretical framework and econometric issues

2.1. Theoretical framework

This section aims at providing a simple theoretical framework able to plausibly sketch the dynamics which link the European IM reforms to the increase in national trade openness, cooperation and competition and to, eventually, their effect on the rate of adoption of innovation across member states. The model is deliberately kept as simple as possible with the aim of highlighting the flow of causality which goes from the implementation of IM reforms to their effect on innovation adoption mediated by the intermediate effect on trade, cooperation and competition levels across member states. The same flow of causality will be then applied to the econometric analysis for which estimation will be carried out in two different steps by means of a two-stage least square estimation consistently with the steps in the theoretical framework.

We assume that countries produce output by standard Cobb-Douglas production function as follows:

$$Y_i = K_i^{\alpha}\left[A_i L_{y,i}^{1-\alpha}\right] \qquad (1)$$

where, as in the endogenous growth model of Romer (1990), $L_{y,i}$ represents the fraction of labour used in the production of good Y in country i and A_i represents the stock of technology (innovations) which are known in each country in the initial year.

Similarly to Romer (1990) the stock of technology evolves over time as follows:

$$\dot{A}_i = \delta A_i^{\phi} L_{r,i}^{\lambda(IQ_i)} \qquad (2)$$

As in standard growth models, the change in the stock of technology (innovations which are already known) is a positive function of the initial stock (A_i) and of the fraction of the population employed in the innovation sector, this being proxied by ($L_{r,i}$). Also, the parameter ϕ captures the returns from previously accumulated technology stocks on the change of *A*. For the sake of simplicity we assume that this is the same across countries[2].

We depart from the model by Romer (1990) by assuming that the productivity of the innovative sector is a function of the institutional framework in each country through the parameter $\lambda(IQ_i)$. Our assumption is consistent with previous empirical evidence (see Hall and Jones (1999), Acemoglu et al. (2001)) for which better institutions provide better incentives to technology change and productivity growth. Also, differences in IQ across countries determine the differences in the returns of the innovative sector and, eventually on the change in the technology stock, $\dot{A}$.

Similarly to previous empirical studies[3], also in our theoretical framework we define IQ as a composite indicator which encompasses different institutional dimensions. Due to the scope of our analysis we focus on the three main targets of the Internal Market (IM) reforms: (i) Trade openness, (ii) Cooperation, (iii) Competition. Hence, we restate the following:

$$IQ_i = F(\mathrm{X}_i, \Phi_i, \Delta_i) \qquad (3)$$

where X, Φ, Δ are Trade, Cooperation and Competition levels respectively.

As we already pointed out in the introduction, the IM reforms are explicitly aimed at affecting the macro-dimensions in eq. (3). The drop in non-tariff barriers has been implemented, for example, with the aim of increasing the openness to trade of the EU member states. Similarly, the envisaged reduction in the value of the transfers and subsidies from national governments to firms, which had been brought about by the IM

[2] That is, given the same amount of accumulated stock of technology in two different countries, the intensity of the returns stemming from it will be the same across countries. On this see the discussion of Jones (2002) p.99.

[3] See for example the Institutional indexes proposed by Hall and Jones (1999), which are computed as an average of different sub-indicators referring to the degree of trade openness and the quality of the government. Also, see the widely used Economic Freedom of the World index (EFW) or the Global Competitiveness index which are all composite indicators.

reforms, had the explicit goal of increasing the degree of competition across European firms. Finally, IM reforms had the goal of allowing workers (and their embedded knowledge) to move freely across European countries and to cooperate on innovation activities which are likely to have led to knowledge spillovers under the form of innovation adoption. Hence, we assume that different sets of IM reforms are going to impact these three dimensions in eq.(3) as follows:

$$\mathrm{X} = f(IM_1) \tag{4}$$

$$\Phi = f(IM_2) \tag{5}$$

$$\Delta = f(IM_3) \tag{6}$$

where IM_1, IM_2 and IM_3 refer to the IM reforms affecting trade, cooperation and competition, respectively. Now, solving as in Romer (1990) for the balanced growth path of each economy we can show the following:

$$\gamma_{A,i} = \frac{\lambda(IQ_i)n}{1-\phi} \tag{7}$$

where $\gamma_{A,i}$ represents the growth in the technology stock given by the adoption of new innovation into the productive process in each country. The variable *n* is the growth rate of population which we normalize to 1. Due to the previously made assumption on ϕ we can re-write eq. (7). This reads as follows:

$$\gamma_{A,i} = \lambda(IQ) = \psi(\mathrm{X}, \Phi, \Delta) \tag{8}$$

Hence, this simple model linking IM reforms to the adoption of innovations predicts that the rate at which the technology base (the degree of innovation adopted) changes is a positive function of *IQ* through the specific IM reforms which lead to increased openness to trade, cooperation and competition levels.

2.2 A brief note on the methodology and econometric approach

As we have already argued the impact that IM regulations may have on the adoption of innovation is likely to be channelled through the impact that the IM regulations have on some macroeconomic dimensions that have already been highlighted in previous theoretical and empirical literature as important drivers of technology spillovers: (i) Trade, (ii) Cooperation and (iii) Competition. Also, at the same time, these same macro dimensions are the natural target of Internal Market reforms. Logically, then, we expect

the IM to affect these 3 institutional macro-dimensions and then, indirectly, to impact also the rate by which innovation is adopted by member states.

From now on, and for the sake of simplicity, we will refer to Trade, Cooperation and Competition as "*transmission channels*" since these are the dimensions through which the IM reforms are going to be "transmitted" (in form of change in economic and institutional incentives) to the innovation activities of EU member states (as technology spillovers). To give an example, IM reforms like the "reduction in the number of days required to open a new business" will affect the Competition level of a specific country, but also, through this institutional improvement, it will also transmit to the incentives perceived by economic agents for the adoption of innovation. Stronger competition will push firms to innovate and to adopt more innovation in order not to be pushed out of business.[4]

Hence, in order to capture the effect of the IM regulation on the adoption of innovation at the EU level we have to carefully analyze the two-stages by which these regulations firstly affect the transmission channels and, secondly, how these channels affect innovation adoption rates. From an econometric point of view a two-stage estimation (which makes use of Instrumental Variables techniques) seems to be the best option to be pursued. In what follows, therefore we are going to estimate a set of first stage regressions which put in relation various IM regulation proxies with the detected transmission channels. Then, once we find a correct specification for the first stage we will use the fitted values of the channels (which will not be endogenous to the error process in the second stage) in order to estimate the indirect impact of the IM regulation

[4] Recent empirical and theoretical literature argues how more competition and neck-and-neck markets may incentivize innovation and therefore affect also positively the possibility of adoption of new innovations and technology across countries (Griffith et al, 2006).

on the share of innovation adoption across countries in the second stage estimation. This second stage is estimated at the global level using robust 2SLS.

Here below we sketch the first stage system of equations which defines the impact that IM directives have on the three transmission channels. These are captured in our theoretical framework by eq. (4) to (6).

(9) $$\text{Trade}_{c,i} = \alpha_0 + \text{IM}_C\alpha_1 + \text{ZTrade}_{c,i}\alpha_2 + \text{DUM}_i\alpha_3 + \nu_{c,i}$$

(10) $$\text{Coop}_{c,i} = \beta_0 + \text{IM}_C\beta_1 + \text{ZCoop}_{c,i}\beta_2 + \text{DUM}_i\beta_3 + \varepsilon_{c,i}$$

(11) $$\text{Comp}_{c,i} = \gamma_0 + \text{IM}_C\lambda_1 + \text{ZComp}_{c,i}\gamma_2 + \text{DUM}_i\gamma_3 + \xi_{c,i}$$

In the system above, *IM* are the Internal Market proxies; *Z_* are the control variables necessary to explain each dependent variable and *DUM* are the sectoral dummy variables. Subscripts c and i refer to country and sector, respectively.[5]

In order to complete the model, we depict the second stage equation which will disentangle the indirect effect of IM through the transmission channels taken as dependent variables in eq. (9), (10) and (11). Hence, we are going to estimate the following specification:

(12) $$\text{InnoAdopt}_{c,i} = \lambda_0 + \lambda_1\hat{\text{T}}\text{rade}_{c,i} + \lambda_2\hat{\text{C}}\text{oop}_{c,i} + \lambda_3\hat{\text{C}}\text{omp}_{c,i} + \text{Z\_IA}_{c,i}\lambda_4 + \text{DUM}_i\lambda_5 + \text{DUM}_C\lambda_6 + \xi_{c,i}$$

where *InnoAdopt* is the innovation adoption rate; $\hat{\text{T}}\text{rade}$, $\hat{\text{C}}\text{oop}$ and $\hat{\text{C}}\text{omp}$ are the fitted values of trade, cooperation and competition, respectively, obtained from the first stage; *ZIA* are the different control variables of innovation adoption and *DUM* refer to either

[5] Since the IM variables we use in this paper are given at the national level, without sectoral variation, we avoid the sub-index *i* in them.

sectoral and country dummies, depending on the subscript. It is clear how this second stage specification is the empirical counterpart of eq. (8) in the theoretical model.

As already pointed out, since we are interested in the specific partial effect of each of the channels on the adoption of innovation, our empirical strategy is to estimate the equations in the first stage and then use their fitted values in the 2nd stage as instruments once cleaned from the possible correlation that they may experience with their correspondent error terms. It is interesting to notice that following this strategy not only allows us to deal with the indirect effect that IM may play on innovation adoption, but it also expunges the regression results from the possibility of being inconsistent if estimated by simple OLS due to the likely endogeneity between the transmission channels and the innovation adoption rates. In fact, it is straightforward to understand that trade, competition and cooperation may cause innovation adoption but, at the same time, being affected in a simultaneous relation, by innovation adoption through the effect on economic activity. This is to say that we are not able to consistently define whether it is trade (for instance) to generate more innovation adoption or if it a rise in the adoption of innovation to ignite economic growth and eventually also further trade.

To solve the endogeneity problem, therefore, we make use of the variables that we believe to be truly orthogonal to the innovation adoption. In this case it is easy to understand that for the measure of IM we do not observe reverse causality. That is, our identifying assumption is that IM Structural Reforms do cause innovation adoption (through their effect on the above mentioned channels, trade, competition and cooperation) but that innovation adoption does not cause IM Structural Reforms since these are exogenous to the model and defined directly by political reasons. This simple

assumption ensures that the 2-stages estimates are consistent w.r.t. the simple OLS estimation and that the effect of the IM is sketched as an indirect one on innovation adoption as in reality it is.

3. Data

3.1 Innovation adoption: definition and measurement

The analysis of innovation adoption faces the problem that as a concept it is usually proxied by using indirect data on technology spillover. Our approach is different in the sense that we exploit direct survey data on innovation based on the CIS3 survey which concern the innovative activities carried out between 1998 and 2000. The CIS survey can be used to analyse the process of technology spillover by identifying the innovation that relies on an adoption process. For each firm, the CIS gives information on the way both (i) product and (ii) process innovations have been developed. When answering the CIS questionnaire, firms have to choose between three answers related to the nature of their declared innovation: (i) innovation developed mainly by the firm, (ii) innovation developed mainly together with other firms or institutions, (iii) innovation developed mainly by other enterprises or institutions. The nature of the proposed CIS question, therefore, allows us to disentangle all the product or process innovations which have been developed (totally or at least in part) outside the interviewed firm. Hence, we are able to distinguish between the creation of innovation (those products and processes developed directly by the interviewed firm) and those innovations which have been, instead, adopted from other firms or made in collaboration with them.

We therefore consider that innovation adoption occurs as soon as the firm declares that its process or product innovations have been developed “Mainly together with other

enterprises or institutions" or "Mainly by other enterprises or institutions". On the basis of this definition, the magnitude of adoption at the national level is then measured as the share of adopting firms, using the following ratio:

Adopting enterprises / Number of innovative enterprises [6]

Our definition of innovation adoption is a broad one in the sense that we do not only consider explicit innovation adoption but also the adoption coming as a result of innovation developed together with other enterprises, that is, adoption that relies on knowledge sharing. Most studies stress the importance of effective collaboration to adapt the technology and make it suitable for the adopter (Rosenberg, 1972). We believe, therefore, that the broad definition employed in this contribution is apt to consistently capture the phenomena of innovation adoption from an interesting and wide perspective. In Appendix 1 we present the sample used in this research both at the national and sectoral level.

On the other hand, even though imperfect, the indicator we are proposing in order to measure innovation adoption has the great advantage of being the only systematic information available to measure innovation adoption within the EU based on direct (weighted) data coming from a large micro database. Of course, this measure of technology adoption has many advantages w.r.t. other commonly used measures such as TFP data which instead rely on model theoretical assumptions and indirect estimation.

[6] The denominator is measured following the standard definition used by the EU to measure the share of innovation within countries or NACE. Innovative firms are those which innovate in product and/or process, including "ongoing or abandoned innovation activities" (process or product).

3.2 Proxying for IM directives

From an empirical point of view (and for the scope of our econometric analysis), it is crucial to find a set of indicators which may adequately proxy for the implementation of the IM across the EU Member States in order to study its effect on the innovation adoption. In this sense, two considerations are important. The first is that the IM *per se* cannot be straightforwardly approximated or quantified. It can only be approximated by making use of variables/categories which have to proxy for the objectives the IM directives want to achieve (i.e. greater European market integration, the removal of obstacles to the free movement of services and capital and freedom of establishment). The second point is that the directives which constitute the IM are not enforced equally by all countries and their implementation, therefore, differs across countries and time. This second fact allows us to econometrically estimate the existence of a statistical relation between the full/partial implementation of the directives proxying for the IM and the adoption of innovation, aim of our research.

A first proxy of the extent by which the IM is implemented can be found in the use of the Transposition Deficit indicator (TDI henceforth). The TDI shows the percentage of directives communicated as having been transposed, in relation to the total number of directives which should have been transposed by the deadline for each Member State (European Commission, 2007).

The TDI is provided at a considerable disaggregated level for different policy areas. The areas covered by the disaggregated TDIs are the followings: (i) Agriculture and Fisheries, (ii) Environment, health and consumer protection, (iii) Enterprises, research, education and statistics, (iv) Competition, (v) Internal Market, (vi) Justice, (vii) Energy

and transport, (viii) Employment and Social Affairs, (ix) Taxation and custom unions, (x) Education and Culture (xi) Health and consumer protection, (xii) Eurostat. In the estimation of the regressions all the different measures of TDI have been tried in order to disentangle the partial effect of different "policy areas" on the adoption of innovation along with the overall Total TDI measure.

In approximating the idea of IM, however, we cannot only rely on the data on the percentage of the directives which have been adopted by each country. This is because these data cannot possibly weight for the actual impact that the adopted directives have had on each member state, that is, they cannot provide information about the effect these directives have had within each country in promoting for instance, competition, labour mobility and so on as the goals of the IM. From an empirical point of view, in the strand of other recent works (Griffith and Harrison, 2004, or Nicoletti and Scarpetta, 2003) we believe the best approximation of the IM is to make use of available data on political and structural reforms which have the aim to create such IM.

With this aim, the annual Economic Freedom of the World Report uses 42 distinct pieces of data to measure economic freedom in 141 nations. The index measures the degree of economic regulation with 5-year span intervals in between 1970 and 2000[7] in five major areas: (i) Size of Government: Expenditures, Taxes, and Enterprises, (ii) Legal Structure and Security of Property Rights, (iii) Access to Sound Money, (iv) Freedom to Trade Internationally and (v) Regulation of Credit, Labour, and Business.

[7] Due to the fact that the data for the EFW do not precisely coincide in time with those of the CIS database we decided to use in the regressions the data of EFW for the year 1995. This is also due to the fact that some time lag may be experienced between the application of the regulations and their effect on the channels and on innovation adoption.

Another fundamental data source we are going to exploit in our empirical investigation is the OECD product market regulation (PMR) database. This is an economy-wide set of indicators of policy regimes in OECD countries which have been estimated for 1998 and 2003. These indicators summarize a wide array of different regulatory provisions across OECD countries. The indicators cover formal regulations in the following areas: (i) state control of business enterprises, (ii) legal and administrative barriers to entrepreneurship, (iii) barriers to international trade and investment. The main sources of information used to construct the PMR indicators are the responses of OECD member governments to the Regulatory Indicators Questionnaire and data published by the OECD and other international organizations. Among the variables which we are going to use there are: Product Market Regulation, Outward Oriented Policies, Administrative Regulations, Economic Regulation, Barriers to Trade and Investment, Explicit Barriers to Trade and Investment and Tariffs[8]. These variables have been built in such a way that higher scores imply stricter and burdensome regulations in the analyzed economy. See Appendix 2 for a detailed description of the variables used in this paper.

4. First Stage: the impact of IM regulations on the three dimensions of the institutional quality

4.1 Trade openess

Most of the empirical literature on trade analyses the determinants of bilateral trade through the estimation of gravity models. A first explanatory factor of the volume of

[8] Conway, P., V. Janod, and G. Nicoletti (2005), "Product Market Regulation in OECD Countries, 1998 to 2003", OECD Economics Department Working Paper, No 419. This paper is available at: http://www.olis.oecd.org/olis/2005doc.nsf/linkto/ECO-WKP(2005)6.

trade at the country level is the relative country size. Deardorff (1984) considers that there seem to exist certain regular relationships between income levels of trading partners and the volume of trade that economists have tried to explain for many years. Similarly, in Helpman (1987) it is stated that changes over time in relative country size can explain trade-income ratio whereas Deardorff (1998) points to the fact that the size of a country obviously puts an upper limit on the amount that this can trade, so that small countries necessarily trade little.

Although some other determinants such as the relative price levels as well as the similarity in factor composition are also included when intra-industry trade is analysed, for our objective in this paper, it is more interesting to consider the impact that regulations may have on the volume of trade in a country. According to Francois and Manchin (2007) institutional quality and regulation are significant determinants not only of export levels, but also of the likelihood that exports will take place at all. Even more, Bolaky and Freund (2004) find that in highly regulated economies, increased trade is more likely to occur in the wrong goods, that is, goods where comparative advantage does not lie. This result would imply that countries must create a sound business environment before trade can be used as an engine of growth. In the same vein, several papers find that institutional differences across countries are important determinants of trade patterns (Levchenko, 2007) and trade volumes (Anderson and Marcoullier, 2002).

Since we pursue to analyse the determinants of total volume of trade in each of the European countries (whose fitted value will be considered subsequently in the second stage of our estimation method) we will base our analysis on the ideas given by the

literature surveyed above while transfering them to a non-bilateral context. Specifically, our dependent variable is the log of turnover that is exported in industry i and country c (LNTRADE), as shown in equation (9). A first explanatory variable is the logarithm of turnover as a proxy of the size of the different countries and sectors, as suggested by the literature (LNTURNOVER).

As for the variables proxying regulation, we will focus on the ones than within the IM strategy are related to trade. In this sense, we include the one that comes from the Economic Freedom of the World Index (www.freetheworld.org) and goes under the label of "Freedom to trade Internationally". Due to the way this index is built (higher values are attributed to countries where trade is made easier by regulations) this variable should present a positive coefficient meaning that regulations which improve the easiness of trade are actually impacting positively the volume of turnover exported.[9] Secondly, we consider the variable "involvement of government in business operation", which is the weighted average of two regulation indicators coming from the OECD Product Market Regulation database (see Conway, Janod and Nicoletti, 2005): Price Controls and Use of command and Control regulation. This proxy is expected to have a negative sign, implying that trade is hindered by a heavy involvement of government in business operations which, eventually, acts as an implicit barrier to the amount of turnover exported.

[9] If we look more in detail the index of Freedom to Trade Internationally we can notice that this is built as the average of other sub-indices. These are: taxes on international trade (representing the revenues and mean tariff rates applied in each country as well as the standard deviation of these tariffs), regulatory barriers (as the average of hidden import barriers and cost of importing), actual size of trade sector compared to its expected size (derived from gravity analysis), differences between official exchange rates and black-market rate and finally international capital market controls (as the average of an index controlling for the access of citizens to foreign capital markets and *viceversa* and the restrictions on the freedom of citizens to engage in capital market exchange with foreigners). All these sub-proxies together give the index for the easiness by which trade transactions may take place across countries.

Table 1 shows the results of the estimation of the trade equation. The coefficient of determination is particularly high (0.83) pointing to a very good fit.[10] As one would expect, the coefficient for the variable proxying for the size is in fact positive and statistically significant at 1% significance levels. In other words, the higher the value of the total turnover in one sector and country, the higher will be the turnover exported. Other unobserved effects are controlled for by the sectoral dummies we inserted in the regression so that we may be confident that the remaining variability in the data could be well ascribed to the regulatory explanatory variables. In this sense, the econometric estimates are consistent with theoretical assumption showing that the reduction of trade barriers is positively and statistically correlated to an increase in trade flows in the observed EU sample and that a strong involvement of government in business operations reduces the volume of trade, as predicted above.

4.2 Cooperation

The topic of cooperation has been analysed in different contexts, mainly at the firm and the individual level. Less has been done at the national level, which is our context in this paper. Therefore, we will base our analysis on the existing economic literature although translated into a more macroeconomic area. Among the main determinants of cooperation we find those of social and human capital. Although with the focus on specific types of cooperation agreements at the local-level, Molinas (1998) presents an econometric analysis with a main conclusion on the idea that cooperation increases as the level of social capital increase. Similarly but at the firm level, Das and Teng (1998) find that a firm needs to have an adequate level of confidence in its partner's

[10] Other specifications as robustness checks have been tried and can be provided upon request. All of them also perform well even if some of the explanatory variables used as robustness checks do not show statistically significant coefficients and are therefore not used in the system of equations later on in the paper.

cooperative behavior. Pretty and Ward (2001) signal to the point that social capital facilitates cooperation as it lowers the costs of working together, so that people have the confidence to invest in collective activities, knowing that others will also do so. Although there are many different descriptions of social capital, in most papers analyzing its impact on cooperation, once central aspect is identified, namely relations of trust. On the other hand, human capital has also been found to be a determinant of cooperation, and more specifically of cooperation in innovative activities, since a certain absorptive capacity is needed to be able to engage in cooperation agreements (Mowery and Rosenberg, 1989; Cohen and Levinthal, 1989).

In addition to social and human capital, the economic literature on cooperation argues that this cooperation also depends on the countries' size. For instance, the collaboration rate per country varies strongly, and is directly related to the countries' scientific size, as has already been shown by Luukkonnen et al (1992) and Gómez et al (1999). In the same line, it is widely recognized that the level of international co-authorship is, in the first instance, determined by the size of the country (Zitt et al, 2000). However, on the other hand, part of the literature has obtained that for firms operating in smaller sectors and countries, part of the fixed costs of innovation can be better internalized if the innovation is made in cooperation with other firms, whereas firms in big sectors/economies would develop their innovations by themselves in a more competitive environment (Link and Bauer, 1987; Fritsch and Lukas, 2001).

Having in mind the main determinants of cooperation as reviewed above, we estimate the equation corresponding to the channel of cooperation whose endogenous variable is expressed as the percentage of firms which have cooperated (within the EU territory) in

any kind of activity related to innovation (COOP). This variable is computed directly by using data coming from the CIS3 survey. Our first explanatory variable is a proxy of the level of social capital (TRUST) in each country. It is well known that social and cultural features are at the basis of the different level of trust experienced across European countries (see Vadi, 2004). The variable we use is a proxy of the degree of trust ("most people can be trusted") coming from the World Social Survey. Secondly, we introduce a proxy for human capital, measured as the number of Science and Technology graduates as given by EUROSTAT. Finally, as signaled by the literature, another aspect particularly important when accounting for the degree of cooperation is the average size of the country. We therefore introduce the log of Gross Value Added of each sector in each country, to take into account the average dimension of the sector in each country in our sample so as not to incorrectly attribute this size effect to other variables in the regression.

Along with trust, human capital and the economic size of the country, the regulatory environment and the implementation of the principles of the IM is expected to play a role in the degree of cooperation across firms and countries in the EU. In order to verify this point, we include several regulations aimed at improving the general environment that can facilitate cooperation agreements. The variable we consider in our regression is that of "regulatory and administrative opacity" coming from the OECD PMR database as a driver of cooperation. Due to the way this variable has been built, we expect a negative coefficient arguing that regulations leading to easier communication (less value of the indicator) are expected to boost cooperation across firms and countries.[11]

[11] If we examine this regulatory and administrative opacity index more in depth we can notice this is a composed measure of different sub-indicators. One of the sub-indicators is the "communication and simplification procedure" index which measures the extent by which national governments reduce information and cooperation costs. This sub-indicator is itself the result of the quantification of different

In Table 2 we offer the results for the first stage regression of cooperation, that is, the one which is going to be used in the second step of the estimation in order to check the impact of this particular channel on innovation adoption. As expected according to the theoretical and empirical literature surveyed above, the variable on trust, proxying for social capital, shows up to be statistically significant and positive. Another explanatory variable that results to be very important in shaping the extent of cooperation across countries and firms is human capital. It is found to be statistically significant and positive, arguing that better trained workforce and specifically those graduated in scientific areas is usually more prone to cooperation. In fact, those projects which usually need cooperation across firms (or countries) are those which more than other require high skill levels. Additionally, the size of the sector and country is significantly relevant. This way, for firms operating in smaller sectors and countries, part of the fixed costs of innovation can be better internalized if the innovation is made in cooperation with other firms (which cooperate in the same project). The average size of the sector in each country is negatively and significantly related to the degree of cooperation. This is to say that firms in small sectors are more likely, on average, to cooperate in innovative projects with other firms, whereas firms in big sectors would develop their innovations by themselves in a more competitive environment. Finally, and more relevant for our final objective of analyzing how the IM affects innovation adoption through the cooperation channel, the empirical evidence in Table 2 strongly supports the hypothesis

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aspects related to the easiness with which business operation can be carried out in the EU member states. To give an example, the third item "There are inquiry points where affected or interested foreign parties can get information on the operation and enforcement of regulations" is actually providing a measure of the extent by which national government foster and ease cooperation among national firms/individuals and other firms/individuals in other countries. Another example is the 8th item of the indicator which measures the presence of "a program to review and reduce the number of licenses and permits required by the national government". The presence of such type of programs is undoubtedly helpful in fostering cooperation across firms making the start-up of business relations much easier not only at the national level but especially for foreigners who do not have to face too many "unknown" procedures in order to start their businesses abroad.

for which the correct implementation of these EU directives drives to higher levels of cooperation across firms and therefore across industries and countries, given the negative coefficient implying that regulations leading to easier communication are expected to boost cooperation across firms and countries.[12]

4.3 Competition

Among the main determinants of the competition level, economic literature signals the number of firms in the market as well as the regulatory environment in which firms work. Related to the first issue, there is a conventional result that increasing the number of firms increases the effective degree of competitiveness in the market. In the limit, as the number of stores increases to infinity, the price decreases monotonically from the monopoly price to a price that is lower (Stiglitz, 1987). However, according to the result in Fama and Laffer (1972), when there are at least two non-colluding firms in an industry, there is no clear-cut relationship between the number of firms and the degree of competition.

As for the role that regulation may have on competition, and more specifically when we want to analyze the IM regulations which may affect the degree of competition, several variables can be considered. First of all, the Transposition Deficit Indicator for Competition regulations (TDI COMPETITION). The TDI indicators, as already pointed out before, measure the percentage of EU directives and regulations which have been correctly applied in each member state in a particular field of interest. In the case of the TDI COMPETITION these regulations are those planned to impact and boost

[12] We re-run the baseline specification of the cooperation channel but using as a dependent variable the degree of cooperation between firms within the same country. Results are basically the same. We argue, therefore, that the same IM policies affecting the cooperation across EU countries are likely to affect also the degree of cooperation within firms in the same country, as one would expect.

competition at the EU level. A second variable proxying for regulation in the competition area is the OECD PMR proxy named "state control". This indicator is the weighted average of two items, namely of "involvement in business operation" and of "public ownership".[13] Due to the way the "state control" index has been built this implies that higher values of the index imply tighter and burdensome regulation such that this will actually impede competition. The expected sign on markup is therefore positive. Similarly, we introduce the variable "sectoral and ad hoc State aid as a percentage of GDP" coming from the Internal Market Score Board of EUROSTAT. Intuitively, the more the state aid, the less it will be the actual competition among firms since some of them will be actually subsidized while others will not. This, inevitably, creates strong market distortions and therefore leads to higher rent extractions and less competition.

Additionally, we also control for the transfers and subsidies from national governments as a percentage of GDP. This proxy comes from the EFW index and scores higher values for little subsidies granted to the national firms by their national governments. Obviously, the less the subsidies, as we were pointing before, the more competition will be faced by firms in any given market. Finally, other proxies of the quality of bureaucracy in each country, which makes business more cumbersome, can affect competition. In particular, we introduce a variable proxying for the "Number of bodies to be contacted in order to open a Business" and another for "The Number of days spent by managers dealing with bureaucracy".

[13] The first low-level indicator has already been examined in the text in the analysis for the trade channel. The second, instead, is itself a weighted average of three other items, namely "scope of public enterprise sector", "size of public enterprise sector" and "direct control over business enterprises".

With all the ideas surveyed above, we run the regression on the competition channel, where the proxy that we use for measuring competition at the EU level is a measure of markup built in the fashion of Griffith and Harrison (2004)[14]. The higher the markup (above the value of 1), the less the competition achieved in the market under analysis since more rents can be extracted by the distortion/absence of competition. On the opposite, perfect competition would imply a markup with a value equal to the unity. The results are shown in Table 3. Here we control for the number of firms in the sector. Although the economic intuition granted by economic literature that in markets where a fewer firms are active, the competition will be lower (higher mark-up) since the market structure will be similar to an oligopoly and further away from strong competition, we find direct evidence of such an assumption since the coefficient for this variable is negative (the more firms in the sector, the lower the mark-up, the more the competition), it is not statistically different from zero. In our opinion, two reasons can be behind this lack of significance. First, this may suggest that the sectoral dummies are already capturing part of the observed sectoral variability in the markup, since the size of the sector is highly related to the kind of industry, leaving little significance to these other control variables. Secondly, some authors already point to the fact that the number of firms in a market is not necessarily related to the level of competition since when there are at least two non-colluding firms in a sector (avoiding monopoly), the relationship between a higher number of firms and the degree of competition is not so clear (Fama and Laffer, 1972).

As for the regulatory variables, all of them present the expected signs. The coefficient of the TDI Competition variable is highly statistically significant and negative as expected,

[14] The proxy is calculated as the ratio Value Added/(Labor costs+ Capital costs).

so that the more the regulations correctly applied, the lower the markup in each economy under consideration, and therefore more competition in the market. Our empirical evidence also strongly support that tighter control by the national government is actually reducing competition levels and leading to higher markups and rent acquisitions, as shown with the significant and positive estimated coefficient for the overall "State control" index. Similarly, the estimated markup level is also showed to be empirically related to the value of the "sectoral and ad hoc State aid as a percentage of GDP"[15]. Intuitively, the more the state aid, the less it will be the actual competition among firms since some of them will be actually subsidized while others will not. This, inevitably, creates strong market distortions and therefore leads to higher rent extractions and less competition. Again, empirical evidence strongly supports this reasoning with the coefficient for the measure of the public aid being positive and highly statistically significant. Also, empirical evidence strongly supports the reasoning that the less subsidies, the more competition will be faced by firms in a given market, with high statistical significance for the variable Transfers and Subsidies from National Governments. Finally, the two variables proxying for the quality of bureaucracy (Working days spent to deal with bureaucracy and Number of bodies to be contacted to open a business) are positively correlated to the level of markup (and therefore negatively correlated to the degree of competition as one would expect).[16]

[15] This variable comes from the Internal Market scoreboard, Eurostat.

[16] We run some alternative specifications through the use of some different explanatory variables. Along with "state control" also a proxy for "regulatory barriers", "barriers to entrepreneurship" seem to explain the competition level across countries. When these same variables are accompanied also to the "outward oriented policy" item of the OECD PMR indicators, again the signs of the coefficients are those expected so that tighter regulations and direct control by the national government on the private business reduce the competition level (increases the value of the indicator). Other combinations of the same regulatory proxies have been tried such as "Government enterprises and investment as a percentage of total investment" (EFW) and they all show qualitatively the same result.

5. Second stage: The impact of the institutional quality on innovation adoption

The rationale to consider cooperation, competition and trade as channels of influence on innovation adoption grounds on theoretical and empirical evidence. There are different reasons to believe that trade openness should be considered itself as an important driver of innovation adoption. Coe and Helpman (1995) and Coe et al. (1997) argue that international R&D spillovers are substantial and that trade is an important channel of such spillovers. Markusen (1989), Verspagen (1997) and Keller (1999) analyzed initially the impact of trade (and in particular of the import of intermediates) on the diffusion of technology and innovation within and across countries. Empirical studies such as Syrquin and Chenery (1989), Wei (1993) or Sachs and Warner (1995) provided a solid evidence of the positive impact of trade on technology diffusion and growth.

Technology flows, however, do not only depend on the exchange of tangible assets but also stand on the exchanges of intangible assets. Ideas are not freely accessible to everyone. They are instead, at least partly, embodied into people (Lucas, 1988). Therefore, the diffusion of tacit knowledge and their absorption relies on effective interpersonal interactions or on cooperation among economic agents. Again, IM reforms had the goal of allowing workers (and their embedded knowledge) to move freely across European countries and to cooperate on innovation activities which are likely to have led to knowledge spillovers under the form of innovation adoption. Additionally, cooperation is considered to impact the adoption of innovation on the assumption that the more the cooperation in innovation activities (for example fostered by the EU framework programs, see Varga et al. 2008), the more we expect innovation to diffuse across borders, industries and firms by spillover effects.

Another channel which may jointly affect the adoption of innovation is that of competition. The economic literature (both theoretical and empirical) has already studied the effect that the market structure and the degree of competition may exert on innovative output. In particular, recent theoretical models (see Aghion and Howitt 1996) argue that in a situation where firms which compete in innovation are leveled (as it is somehow the case for the EU firms) the competition neck-to-neck is going to increase the incentives to produce, exploit and adopt innovation. Increasing competition has been shown to lead to increasing pressure on firms which, in order not to be displaced from an increasingly competitive market, or to simply retain their market shares and stay ahead of the competitors (Griffith et al, 2006), will have to be more productive and innovative. One way is therefore that of absorbing (and not only producing) new technology so as to increase productivity levels.

In what follows, therefore, we are going to show the main results of this second stage estimation where the fitted values of the first stage regressions on trade, cooperation and competition of the previous sections are going to be used as explanatory variables along with other specific variables which can be directly affecting innovation adoption (i.e. R&D expenditures and IPRs controls). Hence, we are going to estimate equation (12) as presented in section 2. We will consider how the fitted transmission channels impact on innovation adoption in general terms (section 5.1) but also on product and process innovations separately (section 5.2).

5.1 Total Innovation Adoption

The idea is to check whether (and how much) the transmission channels (proxied by their fitted values coming from the first stage regressions) are impacting the overall

index of innovation adoption. Along with the impact that the channels may have we will control for specific regulations (enforcement of IPRs for instance) which the economic literature argues may be directly affecting the adoption of innovation and technology across countries, sectors and firms (Helpman, 1993, and Lai, 1998).

As shown in the first column of Table 4, the overall fit of the regression is rather good (R-square is 0.79). Cooperation is statistically significant and shows the expected positive sign. More cooperation across firms and countries is going to be beneficial to the process of innovation adoption. In fact, what we are measuring here is the indirect impact that IM regulations (those which foster and boost cooperation) are exerting on the level of total innovation adoption through the cooperation channel. An increase, for example, in the level of the "communication and simplification procedures", as detailed in the first stage regression for the cooperation channel through its impact on the index of "regulatory and administrative opacity", is going to impact positively the fitted value of "cooperation" which is used in this second stage regression. Indirectly, therefore, due to the positive and statistically significant coefficient of the "fitted cooperation" variable we can infer, for example, that the IM "regulatory and administrative opacity" and its subcomponents which foster cooperation (as well as the general level of trust and the stock of human capital) will positively affect the level of innovation adoption from a cross section point of view.

The coefficient for our fitted markup value (proxying for the channel of competition) presents the expected negative sign indicating that higher mark-ups imply lower innovation adoption, in other words, competition would generate incentives to the adoption of innovation. However, the parameter is not statistically significant at

conventional significance levels. Hence, no clear impact is shown of the level of competition on the number of firms that decide to adopt innovation either in cooperation or when this adoption is the result of direct acquisition from other firms.

The trade channel does not either show up to be statistically significant in the regression proposed in column (i). There is not a clear explanation for this result. One may argue that trade acts differently depending on the specific kind of innovation and that, therefore, we may be averaging out its effect in the regression so that its coefficient is not significantly different from zero. This possibility is addressed by disaggregating innovation adoption into its main sub-categories, but the non-significance of this variable in explaining product and process innovation adoption separately is maintained (columns ii and iii in Table 4).

In column (i) of Table 4 we also insert a control for the legal structure and property rights protection of each country[17]. Empirical and theoretical literature points to the enforcement of IPRs (and the overall legal structure) as a determinant of innovation and technology adoption. If IPRs foster innovation creation, they are also usually considered a barrier to the free adoption (or appropriation) of innovation. Following this rationale, the expected sign, once we control for the other adopting channels, should be negative since the tighter the protection, the more difficult it will be for firms to exploit/adopt innovation discovered elsewhere. It is important to notice that this result does not imply immediately that, as a policy making decision, IPRs should be relaxed so as to achieve higher innovation adoption rates. In fact, it is important to bear in mind the balance between innovation production (boosted by IPRs enforcement) and innovation adoption

[17] This variable comes from the EFW index and is based on the Political Risk Component I (Law and Order) from the International Country Risk Guide. Source: PRS Group (various issues), International Country Risk Guide.

(slowed down by IPRs enforcement). The two effects are therefore difficult to be disentangled.[18] So, the interpretation of the negative coefficient for legal structure simply goes in the direction of saying that, on average, innovation adoption slows down when IPRs (among other factors) are strongly enforced[19]. This is a partial effect which abstracts from the overall (ambiguous and more complex) effect that IPRs may play on the creation of innovation which cannot be observed in the results we are presenting here.[20]

5.2. Product and process innovation adoption

As we argued before, the way the transmission channels (as well as other regulatory proxies) impact innovation adoption may depend on the particular kind of innovation adoption we are looking at. So for example one channel may be important for product innovation adoption but less (or irrelevant) for process adoption.

In columns (ii) and (iii) of Table 4 we redo the same analysis although this time for product innovation adoption and process innovation adoption separately. The main conclusions are maintained. The cooperation channel is again statistically significant in explaining the amount of product innovation adoption and also of process innovation adoption across EU member states. Also, competition, even if with correct sign, does not show up as a statistically significant channel of adoption when it comes to the

[18] In the case of EU countries, we may suspect that the first effect (that of innovation creation) may be stronger than the second (innovation adoption) due to the high-tech nature of innovative European firms if compared to other regions in the world where countries rely on innovation adoption more than in innovation creation. Further econometric investigation is anyway needed to confirm this hypothesis.

[19] Similar results are found in Manca (2010) on a larger cross section of countries for the period 1970-2000.

[20] Additional control variables have also been inserted in column (i). We inserted the R&D expenditures (in order to capture country and sectoral differences in the innovative effort) and other controls such as the share of firms "belonging to a group", "receiving public funds" or "having made any organizational change lately". Even if none of these controls shows up to be statistically significant, our main results on the impact of the transmission channels are maintained with the same statistical significance.

analysis of product or process innovation. The trade channel is still not significant at the conventional confidence levels. However, the Trade channel changes the sign of the coefficient (from negative to positive) pointing to a potential role played by trade in the adoption of these two kinds of innovation when analyzed separately. Again, also, the Legal structure proxy shows to be a statistically significant explanatory variable for the adoption of product innovation whereas it loses the significance for process innovation. It seems the protection of property rights is particularly important for product (the coefficient is slightly more significant w.r.t. the case of overall adoption) and especially when this is compared to the non significant impact that protection of property rights and legal structure seems to have on process innovation adoption. The non-significant result for process innovation adoption is unfortunately robust to the insertion of various control variables as we did for the total innovation adoption.

Although not presented in the paper to save space, it is worth pointing out that most of the results are maintained when we consider separately those innovations that have been adopted as a result of the cooperation in innovation made with other firms or institutions and the innovation adopted as a result of the acquisition from another firm. Competition (which was not significant in the previous specifications) seems to strongly explain the diffusion and adoption of product innovation as a result of the direct acquisition from other firms, but not in the case of adoption of product innovation as a result of a cooperation agreement. The econometric results seem to point to the fact that a more developed competition would allow firms to buy and exchange products (and eventually technology) in a much easier way. This directly affects the amount of product innovations which are actually adopted. To be slightly more specific, all the IM regulations which we used to proxy the competition channel imply that as soon as the

involvement of the national government decrease, competition will rise. This may happen when the national governments reduce their control over firms in different sectors. The item “national, state or provincial government control on at least one firm in one sector” (which we used to proxy for markup levels across countries) controls for the possibility given to foreign investors to acquire market shares or compete in the same sector with the national governments. Also, the use (or non-use) of the golden share option by the national government is likely to reduce the possibility of mergers and acquisitions (and therefore reduce the chance of direct product acquisition by foreign firms for instance). All these aspects are then likely to affect the amount of product innovation adoption through direct acquisition of the innovation from other firms.

6. Conclusions

In the empirical analysis that we just proposed we focused on the impact that different IM regulations have on some major macroeconomic dimensions (which we called transmission channels) and therefore on the impact that these IM regulations have on the intensity of innovation adoption through these channels. Two kinds of issues have been, hence, tackled in our analysis.

The first relates to the role played by IM regulations on the macroeconomic dimensions: the transmission channels. EU Internal Market regulations are put in place in order to grant free movement of goods (trade), free movement of people (cooperation) and to remove barriers, thus simplifying life for consumers and for businesses (competition). Crucially, therefore, the majority of the IM regulations and directives are aimed at boosting these three channels, namely trade, cooperation and competition. We

econometrically analyzed the relationships between the creation and implementation of the IM and these macro magnitudes. This is an interesting analysis *per se* which showed, in a large database for EU countries, how the implementation of the IM directives has actually reinforced trade flows, cooperation and helped increasing competition.

Nonetheless, (and this is the second issue tackled in the present empirical research) these same IM regulations are likely to have an impact (this time an indirect one) on the adoption of innovation across the EU member states. In fact, the IM's impact is likely to work through the transmission channels; in other words, although most IM measures are not devoted to impact innovation adoption, they may have an indirect impact on it through the influence that the IM exerts on trade, cooperation and competition, and the ulterior effect of those on the adoption of innovation. Recent empirical and theoretical literature points, in fact, to the role of trade, cooperation and competition as drivers of innovation and innovation adoption.

In order to correctly disentangle the direct effect of the IM on the transmission channels and the indirect one on the degree of innovation adoption we made use of a two-stage estimation procedure by using Instrumental Variables estimators. In the first stage we define the impact of some major IM regulations on trade, cooperation and competition across EU countries whereas the second stage defines the impact of these three channels on innovation adoption. Our main results show how the impact of the transmission channels on innovation adoption is especially important for cooperation and competition, leaving trade as apparently a minor channel of overall innovation adoption. Therefore, what we are concluding here is the indirect impact that IM regulations (those

which foster and boost cooperation) are exerting on the level of total innovation adoption through the cooperation channel. An increase, for example, in the level of the "communication and simplification procedures" used in the first stage is going to impact positively the fitted value of "cooperation" which is used in this second stage regression. Indirectly, therefore, due to the positive and statistically significant coefficient of the "fitted cooperation" variable we can infer, for example, that the IM "regulatory and administrative opacity" and its subcomponents which foster cooperation (as well as the general level of trust and the stock of human capital) will positively affect the level of innovation adoption from a cross section point of view.

Different specifications have also been used as robustness checks where we inserted a considerable number of control variables. In particular, we find that legal structure and protection of property rights, once we account for the transmission channels, reduces the speed by which innovation spills over across firms and countries. However, this result should be considered within a broader context where the legal structure and the protection of property rights (especially of IPRs) will lead to an increase in the innovative activity leading, contextually, to a potential increase in adoption also not captured directly by the regression analysis.

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Table 1. Trade equation

Dependent Variable: Ln TRADE

Ln Turnover	1.143
	(7.62)***
Involvement in Business Operation	-0.823
	(3.34)***
Freedom to Trade	1.335
	(3.09)***
Dummies	Yes
Constant	-14.117
	(4.28)**
Observations	80
R-squared	0.83

t statistics in parentheses
***, ** and * significant at 1, 5 and 10 %

Table 2. Cooperation equation

Dependent Variable: Cooperation

Most People Can Be Trusted (TRUST)	0.276
	(4.22)***
Science and Technology Graduates	0.008
	(3.31)***
Log GVA sector	-0.044
	(-5.30)***
Regulatory and Administrative Opacity	-0.036
	(-2.86)***
Dummies	Yes
Constant	0.507
	(5.55)***
Observations	69
R-squared	0.51

t statistics in parentheses
***, ** and * significant at 1, 5 and 10 %

Table 3. Competition equation

Dependent Variable: Mark up	
Log of number of firms in each sector	-0.007
	(-1.23)
TDI Competition	-0.007
	(-6.32)***
State Control	0.016
	(1.52)
Sectoral and ad hoc State Aid (% of GDP)	0.077
	(3.29)***
Transfers and Subsidies from Governments (% of GDP)	-0.039
	(7.46)***
Working days spent to deal with Bureaucracy	0.000
	(1.89)*
Number of bodies to be contacted to open a Business	0.005
	(2.85)***
Dummies	Yes
Constant	0.855
	(6.94)***
Observations	76
R-squared	0.70

t statistics in parentheses
***, ** and * significant at 1, 5 and 10 %

Table 4. Determinants of innovation adoption

Dependent Variable	Total Innovation Adoption (i)	Product Innovation Adoption (ii)	Process Innovation Adoption (iii)
Cooperation	4.22	4.15	5.53
	(2.26)**	(1.86)*	(2.14)**
Competition (Mark-up)	-7.83	-8.22	-6.28
	(-1.30)	(-1.58)	(1.04)
Trade	-0.04	0.01	0.002
	(-1.50)	(0.27)	(0.05)
Legal Structure and Property Rights Protection	-0.51 (-1.77)*	-0.53 (-2.13)**	-0.46 (-1.60)
Other controls	yes	no	no
COUNTRY DUMMIES	Yes	Yes	Yes
SECTOR DUMMIES	Yes	Yes	Yes
Constant	6.45	5.41	4.48
	(1.73)*	(1.61)	(1.15)
Observations	50	52	52
R-squared	0.79	0.64	0.55

Appendix 1. Sample size and CIS3 survey data aggregation

The analysis of innovation adoption faces strong constraints when it comes to the exploitation of a consistent and large database for the approximation of its main variables of interest. In order to proxy for innovation adoption we rely on two samples extracted from the CIS3 survey which concern the innovative activities carried out between 1998 and 2000. The first has been provided by the European Commission as a micro anonymized dataset whereas the second is a macro-aggregated dataset available on Eurostat website.

The data at the macro level are in principle available for *"all 25 EU Member States plus Iceland and Norway as well as Turkey and Romania"*. However, when analysing the availability of data more carefully, many missing observations are present for some of the relevant countries to our research which, *de facto*, constraints some cross-country comparisons and a full exploitation of the data. In particular, the innovation adoption items are available in the CIS3 version for only 14 countries.[21]

The micro dataset contains 49761 firms belonging to 15 different European countries and several different NACE2 sectors. Data are available for the following 14 countries: *Belgium*, Bulgaria, Czech Republic, Estonia, *Spain*, *Greece*, Hungary, *Iceland*, Lithuania, Latvia, *Norway*, *Portugal*, Romania and Slovakia (in italics the ones available in both the micro and the aggregated databases). Hence, some important "core countries" are notably missing in the micro database: Germany, France, Italy, Austria, Sweden, Finland and Netherlands. It is important to stress that these countries are probably the most important ones when the

[21] The countries for which data are available at the macro level for the required CIS3 items are: Belgium, Germany, Greece, Spain, France, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, Iceland and Norway.

analysis focuses on some issues related to innovation, as they are those with a higher level of innovative activity.

Since our research is broad in scope, we try to overcome the scarce data availability by merging the information coming from the micro and macro data of the CIS3 by aggregating them in the most coherent way possible. To be more specific, micro data have been finally used to produce aggregate measures of innovation adoption for the countries (and sectors) for which the two datasets were initially available[22]. This is for two reasons. First we believe the micro data of being of better quality due to the higher number of observations available for their direct aggregation. Secondly, our choice is also due to the fact that, using the macro dataset, we face a "double counting problem"[23] in the construction of the general indicator of innovation adoption. Additionally, only seven sectors are in principle available from Eurostat website. This is therefore the smaller breakdown we can use once micro and macro data are merged:

1. Mining and quarrying (NACE 10-14)
2. Manufacturing (NACE 15-37)
3. Electricity, gas and water supply (NACE 40-41)
4. Wholesale trade (NACE 51)
5. Transport, storage and communication (NACE 60-64)

[22] Concerning the micro dataset, we also face difficulties because micro databases are not harmonised between countries. In particular, this concerns such areas as the data type, the code for non-response, etc. Once more this is likely to constraint some cross-country comparisons and a full exploitation of the data. Moreover on the micro database, some missing or inconsistent observations have led to a reduction of the size of the sample. For example, because of individuals answering "yes" to the items "product and process innovation" and giving no answer to the item "innovation mainly developed by others or in collaboration with other firms", 622 observations have been dropped from the sample. So, the dataset contains 49139 firms after cleaning. Deleting missing and inconsistent observations has a very weak influence on the spatial and sectoral characteristics of the sample.

[23] Briefly, this refers to the fact that at the macro level we are not able to verify whether a firm is replying yes to the two specific items (adoption in product and process) of the CIS3 necessary for the construction of the innovation adoption indicator (or only one of them) and, therefore, we may double count such a firm.

6. Financial intermediation (NACE 65-67)
7. Computer and other business activities (NACE 72, 73, 74.2 and 74.3)

Appendix 2. Summary of the main variables and databases

Variables	Description	Year	Source
Innovation adoption rate	Share of adopting firms (in percentage of total number of innovatives firms)	2000	CIS3
Cooperation-based adoption	Share of innovatives firms which mainly cooperate for developing innovation	2000	CIS3
Other organisation-based adoption	Share of innovatives firms which rely on innovation developed mainly by others	2000	CIS3
Product adoption	Share of product adopting firms (in percentage of product innovative firms)	2000	CIS3
Process adoption	Share of process adopting firms (in percentage of process innovative firms)	2000	CIS3
Involvement in Business Operations	Weighted average of two regulation indicators: Price Controls and Use of command and Control regulation	1998	PMR OECD
State Control	Overall index for Scope of public enterprise sector, Size of public enterprise sector, Direct control over business enterprise, Use of command & control regulation, Price controls	1998	PMR OECD
Regulatory and Administrative Opacity	Overall index for: (License and permits system, Communication and simplification of rules and procedures, Administrative burdens for corporation, Administrative burdens for sole proprietor firms, Sector-specific administrative burdens)	1998	PMR OECD
Product Market Regulation	Overall index of Product Market Regulation as in Conway, Janod and Nicoletti, (2005). The indicators are constructed from the perspective of regulations that have the potential to reduce the intensity of competition in areas of the product market where technology and market conditions make competition viable. They summarize a large set of formal rules and regulations that have a bearing on competition in OECD countries	1998	PMR OECD
Working days spent to deal with Bureacracy	Index of bureaucratic quality	1998	PMR OECD
Number of bodies to be contacted in order to run a business	Index of bureaucratic quality	1998	PMR OECD
Sectoral and ad Hoc State Aid as a % of GDP	Proxy for fair competition	1999	Eurostat, Internal Market Scoreboard
TDI indexes	Number of EU regulations (according to areas) which have been transposed by each member state over the total	1999	Eurostat
Freedom to Trade	Overall index for: taxes on international trade regulatory barriers, actual size of trade sector compared to its expected size, differences		Economic Freedom of the World Index

	between official exchange rates and black-market rate and finally international capital market controls		
Legal Structure and Security of Property Rights	Overall index for protection of property rights	1995	Economic Freedom of the World Index
Trust	"Most people can be trusted" index in each country	2000	World Social Survey
Total R&D expenditure	Expenditure for innovation (only for innovatives firms and transformed with neperian logarithm)	2000	CIS3
Science and technology graduates	Share of labor force in science and technology domain	2000	CIS3
Organizational changes	% of innovative firms having implemented new or significantly changed organisational structures	2000	CIS3
Cooperation	Share of innovative firms engaged in R&D cooperation	2000	CIS3
Markup	Value-added as a share of labour and capital costs	1998	Griffith et al. (2006)
Trade	Share of export sales (in percentage of the turn over)	2000	CIS3