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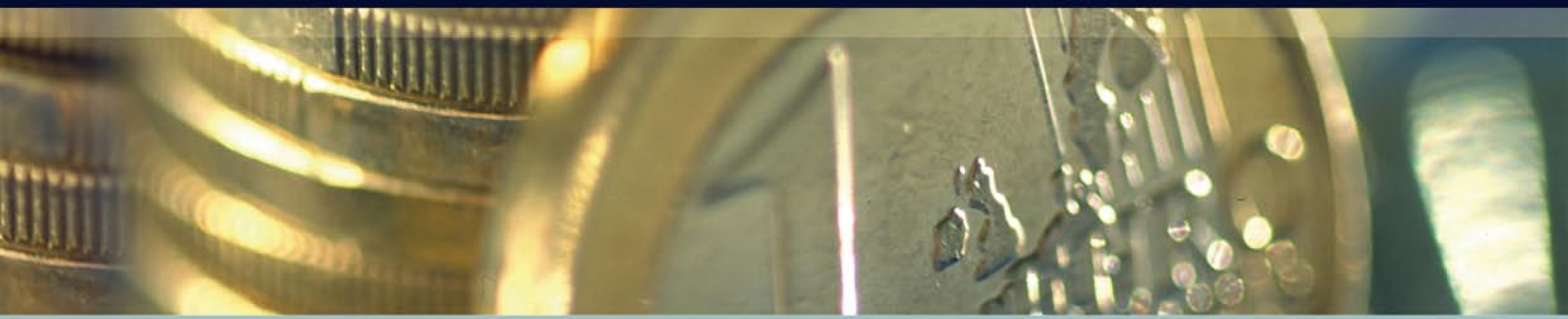

Extension of the Study on the Diffusion of Innovation in the Internal Market

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Executive Summary

In the **Europe 2020 Strategy**, the Member States and the European Commission recognised that increasing innovation is a key to respond to the challenge offered by globalisation and more specifically by the **crisis**. According to the Strategy, "The crisis has wiped out years of economic and social progress and exposed structural weaknesses in Europe's economy. … We need a strategy to help us come out stronger from the crisis and turn the EU into a smart, sustainable and inclusive economy delivering high levels of employment, productivity and social cohesion." In order to get a smart growth, Europe 2020 puts forward a priority on developing an economy based on knowledge and innovation.

When studying this innovation process, part of the literature understands the technological change process into three distinct phases: the invention process (whereby new ideas are conceived), the innovation process (whereby those new ideas are developed into marketable products or processes), and **the diffusion/adoption process** (whereby the new products spread across the potential market). The adoption stage is where the impact of the technological change on the economy takes place. And this adoption of innovation, as empirically showed in this report, seems to be related to productivity growth, especially in the case of the countries that are experiencing productivity decreases. Therefore and according to our results, a long-term investment in intangible assets such as innovation adoption may be of some help to increase productivity and, as a consequence, to attenuate the present crisis.

In this context, **the main aim of the present study** is to analyse the drivers of innovation adoption, specifically the identification of the channels through which innovation adoption takes place and the estimation of the main determinants of this adoption process in the Internal Market (IM). In doing so, we follow the idea that **public policies play an important role**. Among such policies, the full implementation and enforcement of IM rules is essential to reap the benefits and the innovation potential of the large European domestic market. The impact that IM regulations may have on the adoption of innovation is likely to be channelled through the role that the IM regulations have on some macroeconomic dimensions. For example, the IM EU regulations are aimed at fostering the free movement of goods and people and at increasing competition and cooperation across member states. These dimensions, which we will call **"transmission channels"**, are those **directly affected by the IM regulations, and they will have an ulterior impact on the adoption of innovation**.

Main statistics of innovation adoption within the EU

This research study is based mainly on two samples extracted from CIS3 and CIS4, which concern innovative activities carried out between 1998 and 2000 and between 2002 and 2004, respectively. A micro dataset has been provided by EUROSTAT while the macro dataset have been downloaded from the EUROSTAT website. The database contains 26 countries and 7 sectors. Next, we give some statistics to describe the innovation adoption process in Europe.

1. 52% of EU innovative firms in 2004 relies on innovation adoption, whereas the remainder "generates" internal innovation. However, this rate greatly varies according to countries and sectors [Figures 1 and 2]. Generally speaking, countries with the highest level of innovative activities are also those exhibiting the highest rate of adoption. It seems that fostering innovation activities may also be associated with spillover effects leading to higher levels of adoption of innovation.

Fig 1. Innovation and adoption rates by countries

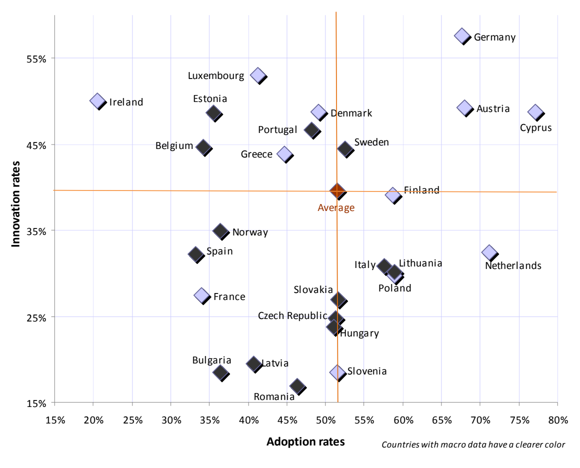
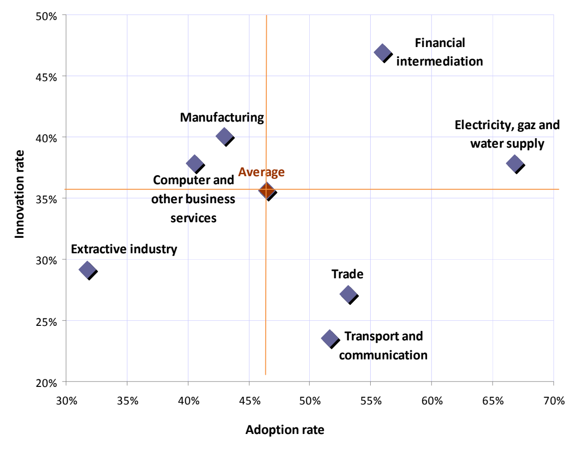
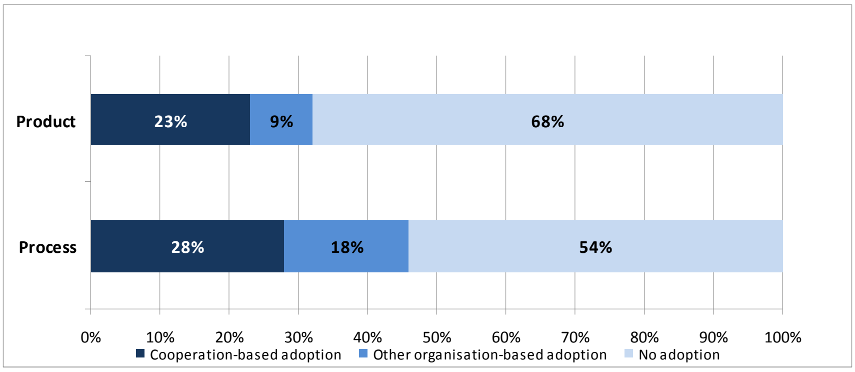


Fig 2. Innovation and adoption rates by sectors



2. ***Cooperation activities are driving innovation adoption at the EU level while the acquisition of innovations from external innovators is a less important source of adoption of innovation (both process and product)*** [Figure 3]. The nature of innovation adoption can differ according to the way adoption occurs. In particular, adoption may result from adoption of external technologies but it also relies often on the joint production of innovation. This last pattern seems to be more frequent than the first one.

Figure 3. Innovation adoption rates in the EU



3. ***The comparison between two waves of the CIS (1998-2000 and 2000-2004) shows that the evolution of the adoption rate between the two periods is different depending on the type of innovation.*** **The average product adoption decreases by 2 points of % and process adoption increases by 2 points of %.** Therefore, there is not a conclusive evolution for general adoption rates but they must be studied separately for product and process innovations.

Assessing the role of the Internal Market on innovation adoption

From our literature review on innovation diffusion/adoption, the causality among the variables we used for our empirical research on innovation adoption goes as follows:

Internal Market reforms ⇒ Channels (Cooperation, Competition, Trade) ⇒ Innovation adoption

In order to correctly disentangle the **direct effect** of the IM on the **transmission channels** (Cooperation, Competition and Trade) and the **indirect** one on the degree of innovation adoption we implemented a two-stage estimation procedure by using Instrumental Variables estimators. In a first stage we define the impact of some major IM 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 transmission channels. In the second stage we obtain how innovation adoption is affected directly by these channels, and indirectly by the IM reforms.
The study stresses that one of the determinants of innovation adoption is **cooperation**. This is especially true for the case of adoption of innovations, which are obtained jointly with other enterprises or institutions. This is to say, making cooperation easier will incentivize innovation adoption resulting from actual cooperation across firms, irrespective of the type of innovation, product or process innovations. The econometric study allowed us analysing what the drivers of cooperation are from an Internal Market point of view. In particular, a key role seems to be played by the level of trust among people within each country, by the improvement of communications and simplification procedures, as well as by high educational levels.

On the one hand, the **transposition of EU directives oriented to the employment sphere** is expected to increase cooperation by making easier and more uniform the legislation on firing and hiring procedures. This would increase the possibility of workers to be employed across different countries and then their changes of participating in cooperative projects. Also, EU regulations related to "social affairs" have the important objective of creating, building or increasing the existent social capital in each country, which is likely to increase the social framework within which cooperation activities take place. Therefore, policies contributing to **reinforce social trust** within/across countries especially through "**communication and simplification procedures**" (within the broadest proxy for "regulatory and administrative opacity") are likely to develop cooperation among firms and consequently to achieve higher levels of diffusion/adoption. On the other hand, strengthening Human Capital is shown to be statistically significant when explaining the degree of cooperation (especially in innovative projects). The use of **framework programmes** (such as the last EU 7FP) may therefore be seen as a way of efficiently exploiting the existing human capital and to foster additional cooperation at the EU level which, ultimately, will be conductive to innovation adoption and diffusion.

Along with cooperation, competition has been identified as another factor likely to affect process adoption acquired from outside the firm but not the other types of innovation adoption. Indeed, augmenting competitive pressure is likely to discourage product innovation adoption made in cooperation. A sort of trade-off appears here: **augmenting the global level**

of competitive pressure within Europe could help firms developing market exchanges of processes and technologies but, at the same time, it could impede cooperation between firms and thereby interactive activities favourable to innovation.

Econometric estimates of the main drivers of competition show that competition is negatively affected by the level of public ownership within each country, by the level of transfer and subsidies, as well as by the administrative burdens. In other words, those state members that implement more EU directives in the specific areas of competition are also experiencing lower markup levels and therefore stronger competition. As a consequence, **policies reducing unnecessary rents, administrative burdens and national government controls should be implemented at the EU level in order to achieve higher levels of competition** and eventually higher shares of process innovation adoption. From a more specific regulatory point of view, we detected how the **intrusiveness of national government** (when "national, state or provincial government controls at least one firm in one basic sector") is going to reduce competition, so these kinds of behaviours should be strongly opposed. At the same time we detected how the **size of the public enterprise sector should diminish** so as to foster more competition. Finally, we find a **negative relation** between competition and the use by national governments of the **golden rule option**, or the presence of any **constitutional constraint to the sale of the stakes** held by national governments **in publicly controlled firms**.

The third determinant of innovation adoption which emerges as statistically significant in this study is the level of **trade**. Trade is shown to be more statistically significant in explaining overall process adoption, and more precisely the ones made in cooperation with other firms. It seems therefore that if a new process innovation is obtained, then similar firms will get to know it, especially if the result of this innovation is actually traded and commercialized in their markets. Concerning the determinants of trade, we showed how the indirect effect of policies reducing prices controls or the national government controls on the transportation sector are going to foster international trade, although not significantly, and eventually affect the extent by which innovation can freely move within the EU borders and eventually been adopted. The result on the lack of significance of most of the EU regulations on trade is puzzling and it seems to need further research.

Although not significant, our results show that regulations which imply heavy "**price controls**", especially those on air travel, road freight, retail distribution and telecommunications are going to decrease the amount of trade. The intuition is that companies will trade more where they can freely decide prices or where the transportation sector (crucial for the export industry) is not heavily regulated by national governments. **Trade** is also positively affected by **less restrictive trade barriers** and, in general, we showed how trade is positively associated with well known indexes of trade openness which suggest how, among other things, providing an **easier access of citizens to international capital markets** and *viceversa* for **foreign investor the access to national capital markets** is going to foster international exchange also in tradable goods.

Empirical verification of the relationship between innovation adoption and productivity

Economic literature in the late nineties has stressed 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. In the following paragraphs we show the main empirical results with respect to the relationship between innovation adoption and productivity growth.

1. ***Productivity growth rates are positively but not significantly correlated with changes in innovation adoption rates.***

If looking at the countries, it can be observed how **this positive relationship is mostly due to the correlation among both variables for the countries with productivity decreases.** They seem to benefit more from the adoption of innovation (lower decreases of productivity as innovation adoption grows), probably due to the fact that they have a higher gap in order to take more advantage of such intangible asset. This would be the case of Estonia, Bulgaria, Latvia, Spain, Portugal, Luxembourg and Hungary. On the contrary we do not observe such a clear relationship for the countries with increasing growth rates of productivity.

2. ***When considering separately product and process innovations we observe a statistically significant positive relationship.***

If we disaggregated adoption into its main categories, for both product and process innovation adoption, **the relationship seems more clearly positive and significant than in the general case**. Although both are now significant, it is even 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.

3. Through the estimation of a growth equation, we have obtained that the parameter of the innovation adoption rate is positive and significant, indicating that those countries that increase their rates of innovation adoption tend to present higher productivity growth rates.

It seems that the IM regulations analysed above providing **incentives for 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.

Finally, as a result of the experience of working with the CIS dataset in order to study the innovation adoption process in the EU countries, the report offers some suggestions for future implementation of CIS data and questionnaires, which goes beyond the scope of this executive summary. However, it is necessary to stress that this report has the value added of having used the current CIS framework with the objective of policy evaluation.

Introduction: Previous research, objectives and outline of the report [1]

[1] AQR acknowledges the support provided by Erika Raquel Badillo, Sandra Nieto and Diana Ordad for their helpful research assistance.

Introduction: Previous research, objectives and outline of the report

Previous research

The recent Economic Paper by AQR-IREA and CREUSET published by the European Commission under the title "**The Diffusion/Adoption of Innovation in the Internal Market**", as a result of a research contract between these two institutions and the DG-ECFIN highlighted the importance of the role played by the Internal Market (IM from now on) in the diffusion and adoption of innovation across EU member states and European firms. The previous research addressed the study of the role of different transmission channels through which the IM regulation seems to impact the diffusion and adoption of innovation across firms and countries.

It has been argued that the IM cannot be simply defined by an indicator such as GDP or consumption indexes. In fact the IM is a "**set of rules of the game"** which has to be put in place for the EU citizens and firms in order to be able to freely move, locate, compete and exploit market potential wherever within the European boundaries. As argued in the document on "The Diffusion/Adoption of Innovation in the Internal Market", the creation of an IM has possibly many effects on the innovation diffusion across countries and firms. This is because it sets up new (better) conditions (legal directives) which should encourage movement of goods, people and services, a better allocation of resources and therefore increases in productivity. This said, it is evident how any research devoted to the study of the impact of this "set of rules" (the IM) has to define accurately the channels by which IM may affect innovation diffusion.

The channels by which the set up of the IM affects innovation diffusion are indirect in the sense that the IM influences and affects other macro-magnitudes. In the previous project, our research group identified three main transmission channels which served for the study of the indirect impact that IM directives would finally have on innovation adoption across countries and firms, namely, trade, competition and cooperation.

All these above mentioned macro-magnitudes influence the speed and extent by which innovation diffuses both within and across countries and firms. A better functioning job market (one which allows workers to move freely and find the best job opportunities as well as for firms to find the more suitable human capital) is achieved by permitting the free movement of people as well as setting a common legal framework on a EU basis giving similar incentives (or at least decreasing the barriers to the entry) to work in all Member States. This implies higher levels of cooperation across firms and countries. The same reasoning goes with all the norms and legislations regulating, for example, the weight of each national government on the functioning of its market. If the national government is heavily present in the markets by transferring resources or subsidies or by participating in the markets with government enterprises, less incentives are given to firms (and especially European firms) which may want to enter those heavily regulated markets. One of the goals of the IM is to reduce the burden (direct or indirect) that firms have to face when entering a EU market. So, reducing state intervention is likely to make European markets more attractive for FDI, trade and firms' investment location since it increases competitiveness. At the same time, the reduction of state intervention as well as of tariff barriers is going to be beneficial for trade flows across countries and, ultimately, to innovation adoption through this channel. Hence, the above mentioned IM directives, through their effects on the transmission channels have been proven to be fundamental in promoting innovation diffusion.

From an empirical point of view, the causality within the variables which was used in the previous research went as follows:

IM reforms* $\Rightarrow$ *Channels (Trade, Competition, Cooperation)* $\Rightarrow$ *Innovation adoption

Hence, the empirical strategy had to take into account that the variables proxying the IM are not used as direct explanatory variables of the adoption of innovation but as indirect ones through their impact on the *channels*. The c*hannels* have to be considered so, in the sense that they are the way through which the IM has its impact on the adoption of innovation.

In order to specify the empirical system one of the most important points was that of depicting and finding the proxies for the IM directives, which in turn would affect the transmission channels and then ultimately the diffusion of innovation. In empirical works of this kind it is usually very difficult to find sound proxies for institutional quality which may be used in econometric analysis. Recently, however, a variety of indicators were elaborated at the country level with the aim of capturing differences across countries in the implementation of policies, institutional frameworks and regulations: the ones provided by the OECD of product market regulation (PMR) and the annual Economic Freedom of the World Report (EFW).[2]

Apart from the definition of the way the IM impacts innovation diffusion/adoption, an important contribution of the previous study was that of **identifying clearly the definition to be used in order to measure innovation adoption**. This was based mainly on the exploitation of the micro and macro data available for the Community Innovation Survey (3rd wave) or CIS3.[3] Information is available on the use and adoption of external sources of knowledge and innovation, the location of partners (within the same region, the same country, the rest of Europe, US or other part of the world), etc. For this reason, we used (and we are going to use) it as our main source of information.

For each firm, the CIS micro database gives information on the way the product and process innovations have been developed. Firms have to choose between three answers:

- innovation developed mainly by the firm
- innovation developed mainly together with other firms or institutions
- innovation developed mainly by other enterprises or institutions.

Therefore, we considered 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".**[4]

Hence, our previous empirical analysis for innovation adoption across EU countries made use of a broad definition of adoption rate defined as follows:

[2] See section II.4.3. for a deep presentation of such databases.
[3] In the EU countries, under the coordination of Eurostat, a common core questionnaire was agreed upon and surveys were launched under the acronym of CIS (Community Innovation Surveys). These surveys were repeated every four years until 2004. Therefore, up to now there exist four waves of CIS (CIS 1 for 1990-1992, CIS 2 for 1994-1996, CIS 3 for 1998-2000, and CIS 4 for 2002-2004). A last wave has been released but for which micro data do not seem to be already available. This wave goes under the name CIS6 (for the years 2004-2006).
[4] A set of known limitation applies to the use of these data. Only part of the innovation diffusion process is accounted for by CIS. Our definition refers to innovation adoption and does not allow us to address all the issues associated with the process of innovation diffusion. Also, a second set of limitations is due to the inaccuracy of the information contained in the CIS. For instance, we do not have, for each firm, the number of innovations that fits with the definition. This is a strong limitation to account for the extent of adoption.

Number of adopting enterprises / Number of enterprises with process and/or product innovation or with ongoing or abandoned innovation activities.

The results of the study performed by AQR and CREUSET, based on the analysis of the CIS3 data, showed very interesting insights both at a descriptive level of the innovation adoption process in the European Union and also on the role played by the IM on innovation adoption across firms and countries.

With respect to the descriptive analysis of innovation adoption in Europe, generally speaking, **countries which display the highest level of innovation are also those which show the highest adoption rate** and conversely countries with weak capacity to innovate are also weak adopters. Thus, the complementary dynamics linking innovation and adoption seems to be at work in most of the European countries. However exceptions exist which are certainly not to neglect if we are to understand how countries can react to European incentives. These **exceptions are Luxemburg, France and Sweden which display low level of adoption compared to their innovative capacities, and Bulgaria which has a very high rate of adoption compared to its rate of innovation**. Specific characteristics of their system of innovation strongly oriented toward internal resources or sectoral specializations towards sectors of high intensity of internal innovation may explain the three former exceptions. Indeed, some sectors are essentially relying on adoption (Whole sale trade, Transport and communication, Electricity, gaz and water supply) while others are recording at the same time very high innovation rate and very low adoption rate (Manufacturing and Computer and other business services).

In relation to the analysis of the role played by the IM on innovation adoption through the three identified channels (cooperation, competition and trade), a key role seemed to be played by the level of trust among people within each country, by the improvement of communications and simplification procedures, as well as by high educational levels. Therefore, policies contributing to **reinforce social trust** within/across countries especially through "**communication and simplification procedures**" (within the broadest proxy for "regulatory and administrative opacity") are likely to develop **cooperation** among firms and consequently to achieve **higher levels of diffusion/adoption** and increase in the **efficiency of process innovation adoption. Strengthening human capital** also appears as an efficient way **to enhance cooperation and consequently innovation adoption**.

Along with cooperation, but to a much lesser extent, **competition was identified as another factor likely to affect product innovation adoption directly acquired from external firms**. As a result of the impact of competition on product innovation adoption, also productivity levels seemed to be affected by differences in the competition level (product, rather than process innovation adoption is shown to impact productivity levels). Econometric estimates of the main drivers of competition showed that competition is negatively affected by the level of public ownership within each country, by the level of transfer and subsidies, as well as by the administrative burdens. As a consequence, **policies reducing unnecessary rents, administrative burdens and national government controls should be implemented at the EU level in order to achieve higher levels of competition** and eventually higher shares of innovation adoption and eventually productivity.

The third determinant of innovation adoption which emerged as statistically significant in this previous study was the level of **trade**. Its negative impact on adoption seemed rather small and limited to product innovation acquired from external firms. The result is however of difficult interpretation since this channel is probably affecting both innovation creation and adoption at the same time. Concerning the determinants of trade, we showed that the higher the "price controls" and regulations within each country, the lower the level of trade. The composite index "Freedom to trade" (OECD) exerts on the contrary a positive impact on trade. Therefore, **policies reducing price controls or the national government controls on the transport sector** are likely **to foster international trade. This would however favor the "generation of innovation" more than the "adoption of innovation"**

Objectives and outline of the report

The objective of the present study is that of updating the previously mentioned findings by using data drawn from the fourth wave of the CIS (namely the CIS4) and to provide a consistent econometric analysis (as well as a descriptive one) of the main IM determinants of innovation adoption across the widest number of EU member states possible.

Different studies, recently, have been exploiting the data coming from the CIS4 database. This is specially the case for researches using national data which are of interest but restricted to the corresponding national scopes. Additionally, some papers have appeared using the Sectoral Innovation Database (SID), a major database based on CIS and recently developed at the University of Urbino including most variables of the three comparable waves of the CIS (CIS 2, 3 and 4) for 8 European countries. We insert in this recent strand of empirical literature with the aim of enlarging the geographical comparability of the results drawn from the CIS4 as well as to make comparisons with the previously obtained results with the CIS3 data and therefore to exploit also the available temporal dimension of the two waves of data for a higher number of countries.

The study, therefore, follows in part the same structure of the previous report provided by AQR and CREUSET with results obtained with this new wave of the CIS (CIS4). Specifically, the study is divided into five parts, as follows:

I. **First part aimed at providing an operational literature review** of both the theoretical and empirical works focusing on innovation adoption and diffusion with a special emphasis on the new works which have been using the CIS4 database. This literature review takes stock of the previously presented while amplifying the study of those factors affecting the creation and adoption of innovation.

II. **Second part aimed at providing a descriptive statistical analysis** of the diffusion process at the EU level with a very similar outline as the already presented in the previous research by AQR and CREUSET. As in the previous report, special attention is devoted to the country and sectoral analysis. In particular, we examine innovation adoption both at the **country level and at the NACE2 industry** level with the deepest disaggregation detail that the data actually allows. This time, however, due to the specificity of the new work and of the use of the CIS4 database, the statistical descriptive analysis also aims at comparing the information contained in the CIS3 with that in the CIS4 with the aim of highlighting the dynamics of innovation adoption across EU member states for the two different time spans of the CIS3 and CIS4.

III. **The Third part of the report analyses the determinants of innovation diffusion in the Internal Market.** The study is carried out on the basis of a detailed econometric analysis which tries to disentangle the different factors, channels and determinants which may affect the innovation diffusion across member states. Also, as already done in the previous report, we investigate what are **the factors and barriers impeding the diffusion of innovation** in the Internal Market and which ones are, instead, the channels and forces driving to a faster diffusion of innovation. For this task we rely on the databases provided by the OECD (the PMR database) and by the Fraser Institute (the EFW index). These databases, along with the data already present in both waves of the CIS surveys help address the identification of the directives, norms and channels through which the Internal Market may shape the extent and speed of innovation adoption across EU member states. Also, we take into consideration the **specific innovation framework conditions** within which firms, and ultimately countries, pursue both innovation and its adoption. In this sense, special care is paid to empirically **proxying competition level differentials across countries, the quality of business as well as other important factors such as the quality of the workforce and of the human capital stock** in defining the possibility of innovation adoption of the EU analysed member states. Finally, in order to control for unobserved heterogeneity across the sample, we make use of **sectoral specific characteristics** (where data are available in the CIS3 and CIS4) in order to control for the robustness of the econometric results.

IV. **In the Fourth part** we disentangle the effects that the diffusion of innovation may have played in the growth of productivity of the examined countries. We firstly make a descriptive analysis to ascertain the relationship between both variables. Secondly, by means of **adequate estimation techniques we empirically test whether the diffusion of innovation has consistently raised the productivity growth of countries**.

V. **In the Fifth part of the report**, finally, we discuss the overall results of the comparative research made on both the CIS3 and CIS4 data and on the diffusion of innovation in the Internal Market. Hence, we try to provide the clearest policy making recommendation possible based on both interpretation of the statistical descriptive results and of the econometric estimations. We then try to consider which ones of the examined IM directives (and through what channels) have been slowing down or boosting up the process of innovation adoption so as to provide some policy suggestion on the way to increase and speed up this process even more and achieve higher productivity levels and sustainable economic growth.

PART I

Literature review

I.1. Stock of the review of theoretical and empirical studies in the previous project[5]

As reviewed in the previous project, according to Stoneman (1986) technological diffusion is the process by which innovations, be they new products, new processes or new management methods, spread within and across economies. Diffusion involves the initial adoption of a new technology by a firm (inter-firm diffusion) and the subsequent diffusion of the innovation within the firm (intra-firm diffusion), being the later the process by which the firm's old technologies and facilities are replaced by new ones.[6]

There are two stylized facts in technological diffusion: the spread notion of the S-curve (diffusion rates first rise and then fall over time, leading to a period of relatively rapid adoption sandwiched between an early period of slow take up and a late period of slow approach to satiation) and the importance of both economic and social factors in the individual decisions to begin using new technologies, decisions which are the result of a comparison of benefits and costs of adopting the new invention. Despite these two stylized facts and regularities in technological diffusion, different theoretical approaches have been pursued to describe and give the rational behind the main characteristics of the diffusion process: the demand and the supply models.

On the demand-side based studies, basically there are three main conditions for innovation diffusion:

- **being aware of the new technology,** which is stressed by epidemic models
- **being able to use and adapt the new technology,** which refers basically to demand models, although is also related to the supply side as we will see afterwards
- **profitability of adopting the new technology**: depending on the price, on the expected returns, and on the level of risk.

[5] This section is a summary of the literature review in the Economic Paper published by the European Commission under the title "**The Diffusion/Adoption of Innovation in the Internal Market**".
[6] As it can be seen in the definition by Stoneman, diffusion and adoption of innovation are not exactly the same process, although both terms have sometimes been used in the literature interchangeably. However, strictly speaking adoption would refer to the initial adoption of a new technology from another firm. Therefore, in the review of the literature made in this Part I we will refer to the process of innovation diffusion, the widest term, which besides is the one more commonly used in the literature.

Therefore, from the demand side perspective, several factors are likely to affect the ability to be aware of the new technologies and the ability to use and adapt them (what is referred in the literature as the absorptive capacity), as well as the expected returns of adoption: user's investments in human capital and R&D, user's organizational innovation and size and market features, among the main ones.

Based on the literature focusing **on the supply-side** factors we can identify two main drivers of innovation diffusion:

- **Supplier's R&D and innovation**: New technologies are rarely commercialized in their very first version. They need to be improved and adapted to the specific needs of users. The capability of firms to improve their technology but also to provide users with complementary products is very important. Moreover, the price is often high at the first stage of innovation diffusion. In order to ensure a higher rate of diffusion, suppliers have to perform innovation in order to reduce the costs. For these reasons, the R&D and innovative capacity of new technology suppliers is thus essential.
- **Supplier's financial means**: They are of course important to be able to adapt the new technology (to cover the R&D costs) as mentioned above. But financial means play also a role to inform potential users, for instance through advertising costs. The edition of users' guide may also generate important expenditures (in the aerospace industry for instance).

Additionally, these different factors stemming from supplier features (cost reduction, complementary products, etc) are facilitated by the number of adopters already present on the market. In other words, innovation diffusion may be driven by suppliers and users interaction.

Another important issue regarding the main drivers of innovation diffusion refers to the **regulatory environment**. The regulatory environment displays several factors likely to influence innovation diffusion. Firstly, **normalisation and standardisation procedures** reduce uncertainty and creates network effects that increase the profitability of adoption (David, 1985 and David and Greenstein, 1990) showing that compatibility standards constitute a factor likely to favour innovation diffusion. Secondly, the **insurance system** may also reduce the risk, at least for some sectors like medicines. Other drivers of innovation diffusion that can be of more interest from our perspective of analysing the role of Internal

Market measures are those related to the **competition environment** in which firms operate as well as the **integration level across the countries** in which such firms work. The **IPR regime** may have an impact (not always positive) on all the conditions of the innovation diffusion (see the report of the previous project for a deeper review and Table I.1 for a summary of the main determinants of innovation diffusion).

Table I.1. Determinants of innovation diffusion

Demand side:

- Users' investment in human capital (increases ability to adopt innovations)
- Users' investment in R&D (increases ability to adopt innovations)
- Level of prior related knowledge owned by the firm adopting the innovation
- Balance between specialisation and diversity in order to absorpt external knowledge
- Organisational innovation, ability of users to make organisational changes, kind of organisational structure
- Size of the user firm
- Market characteristics of potential users; share of the market; market dynamism; demand growth; number of previous adopters in the market

Supply side:

- Suppliers' R&D and innovation capacity of new technology suppliers
- Suppliers' financial means (advertising costs, users' guide, …)
- Interaction between users and suppliers:
  - Exchanges of tangible assets: trade, FDI,…
  - Exchanges of intangible assets: face to face contacts, labour mobility, …
  - ICT facilitates awareness about the new technology
  - Market structure: horizontal integration favours flows of tangible and intangible assets
  - Geographical concentration facilitates the awareness of the new technology

Regulatory environment determinants:

- Role played by normalisation and standardisation procedures
- Insurance system
- IPRs
- Competition
- Integration of the economies

In addition to the different determinants of innovation adoption surveyed above, since the Internal Market aims at modifying the functioning of the European markets, it is therefore likely to produce changes in the user and supplier features or in their interactions. For these reasons, the Internal Market may impact on innovation diffusion. More related to our research, the EU reforms associated with the IM may also act on innovation diffusion through several main channels: **Trade** (implying larger markets), **higher competition and cooperation,** among others**.** For a review of the main ideas on how IM affects innovation diffusion see Table I.2.

Table I.2. How IM affects innovation diffusion

Awareness about new technologies: ("Trade Channel")

- Trade policies
- Increase in cross-border merges and acquisitions
- Capital market policies, which facilitates FDI, giving access to foreign capital markets

Awareness to use and adopt new technologies: ("Cooperation Channel")

- Labour reforms
- Facilitation of the mobility of workers,
- Normalisation and standardisation procedures

Profitability of adoption: ("Competition Channel")

- Reforms reinforcing competition
- Capital market reforms
- Enlargement of the size of the market (increasing the expected returns)
- Labour market reforms

Contrary to the empirical literature on the analysis of the impact of innovation diffusion on economic growth, the literature analysing the determinants of innovation adoption at an empirical level is more micro than macro-oriented. However, as we surveyed in the previous project, both micro- and macro-economic analyses of the determinants of innovation adoption refer to specific technologies. The same is true for the study of the impact of regulation measures on innovation adoption since most studies analyse the effect of one measure of regulation on a specific innovative technology. As a step forward, in this study (following the same line as in the previous report) we analyse the determinants of general innovation adoption processes across countries and sectors in the European Union, in contrast to most empirical studies on innovation diffusion in which the determinants of the adoption of a specific technology is analysed. Therefore, an initial important issue was the definition and design of the variable(s) proxying such innovation diffusion/adoption process. Exploiting the

Commnunity Innovation Survey (CIS) data at the EU level (and not only a country case analysis), we covered most EU countries with a sectoral disaggregation for the case of CIS3 and we plan to do it for CIS4. This is why, before entering in detail in the construction of the indicators as well as their description for CIS4, we survey first in section I.2 the empirical studies using the Community Innovation Survey.

I.2. Review of empirical studies using the Community Innovation Survey

I.2.1. General overview

Previous empirical studies on innovation diffusion are mainly based on monographic studies which quantify innovation diffusion by looking at the adoption of a specific technology (ICT, seed, medical technologies for instance). However, our aim is to provide a general picture of innovation diffusion/adoption in EU, in order to analyse the impact of the EU Single Market and to assess the effect on global performances. Therefore, databases covering all EU countries and a wide range of sectors have to be used. Regarding innovation, global dataset allowing international comparisons are not numerous. Countries started only recently to collect systematically information on this topic, and the issues covered by the surveys remain restricted. Most empirical studies rely on three main data sets: R&D surveys, data on patents and innovation surveys. Only the latter can be used to address the issue of innovation diffusion.

In the EU countries under the coordination of Eurostat, a common core questionnaire was agreed upon and surveys were launched under the acronym of CIS (Community Innovation Surveys). These surveys have been repeated every four years. Up to now there exist four waves of CIS (CIS 1 for 1990-1992, CIS 2 for 1994-1996, CIS 3 for 1998-2000, and CIS 4 for 2002-2004). A last wave has been recently released under the name of CIS2006 for the years 2004-2006, but micro data do not seem to be already available. The different parts of the survey allow us to deal with most of the issues addressed in this study, both for CIS3 and CIS4. For this reason, we are going to use it as our main source of information.

As surveyed in the final report of the previous project, we can divide studies based on innovation survey into four main groups. A first set of studies (Blundell et al. (1999), Hollenstein, (1996) Raymond et al (2007) among others) examines the **determinants of innovation** (sources of information for innovation, cooperation for innovation, obstacles to innovation). These studies also provide sectoral taxonomies for innovation based on principal components analysis (Hollenstein, 1996) or on probability tests of model of innovation determination (Raymond et al., 2007). Few studies so far have estimated dynamic models using panel data from successive innovation surveys. Peters (2005), Duguet and Monjon (2002), Cefis (2003), Raymond et al. (2007) highlight the persistence of innovation. Enterprises that innovate in one period tend to innovate also in the subsequent periods.

A second set of studies tests the existence of **complementarities between different innovation strategies**. There are complementarities between innovation strategies when two strategies tend to be adopted together rather than in isolation because their joint adoption leads to better results. This issue has been investigated for various aspects of innovation: complementarities between different types of innovation, e.g. product and process innovation (Miravete and Pernías, 2006) or between internal and external technology sourcing (Cassiman and Veugelers, 2006). Complementarities between different types of cooperation strategies have also been highlighted (Belderbos, Carree, Lokshin, 2006) as well as complementarities between internal skills and cooperation (Leiponen, 2005).

A third set of studies explores the **effects of innovation**, looking at productivity level or growth, exports, patenting or employment. For instance, Crepon-Duguet-Mairesse (1998) revisit the relationship between R&D and productivity. They estimate a model composed of three equations: first, an equation explaining the amount of R&D; second, an innovation output equation where R&D appears as an input, and, finally, a productivity equation, in which innovation output appears as an explanatory variable. Their results confirm the rates of return to R&D found in the earlier studies of the 80s and 90s, as long as proper account is taken of selectivity and endogeneity in R&D and innovation output.

Finally, a last set of studies relies on innovation survey to deal with **innovation policy issues**. See Arundel et al. (2008) for a summary of the findings regarding government support for innovation in various innovation surveys. Linking government support and firm performance, most studies find additionality (instead of crowding-out) of government support for innovation. Complementarities between innovation policies also occur (Mohnen and Roller, 2005) calling for a policy mix.

I.2.2. Studies using data from CIS4

We review now the studies that more recently have used data from CIS4 to figure out which are the topics that have been covered with this wave of CIS. The bulk of the literature has used the information provided by CIS4 for just one specific country. In relation with papers **analysing patterns of innovation**, for instance, the paper by Castellacci (2008) uses data coming from the CIS4 and investigates the one in Norway. Even if the analysis is mainly focusing on the Norwegian case, some interesting comparisons are drawn at the European level. On the one hand, Norwegian sectoral systems appear to be very innovative, often above the European average. On the other hand, these high-tech sectoral groups are relatively small in Norway, accounting for a much lower share of production than their European counterparts. Therefore, this leads the author to the reassessment of the so-called Norwegian paradox: "the problem is not with innovative activities, as frequently asserted, but it has rather to do with the sectoral composition of the economy". Schmidt and Rammer (2006) examined German data, plotting technological (product and process) innovation against organisational change. Their results indicate, on the one hand, that more technologically innovative sectors tend to be more organisationally innovative, and on the other hand, that this correlation is imperfect with manufacturing tending to emphasise technology-based product and process innovation while the service sector emphasises organisational innovation.

A substantial number of studies analyse **the determinants of innovation**. Exploiting the data coming from the CIS4 database for the case of firms in the UK we find those of Criscuolo et al (2009) and d'Este et al (2009). The first one explores how patterns of innovation differ between start-ups and more established firms, through the combination of descriptive analysis and an econometric matching estimator approach. According to their results being a new firm increases the likelihood of being innovation active in the service sector, while it decreases this likelihood in the manufacturing sector. The second one, by d'Este et al (2009), looks at the factors that represent the most important barriers to innovation and that define the groups of innovators and of non-innovators. Belonging to a group or the other is found to depend on the environment within which these firms operate so as in the assumption of our previous work

Following with the use of the CIS4 for the UK case, we find several papers focused on the analysis of the **complementarities between different innovation strategies**. Battisti and Stoneman (2009) show how for the British case wider innovations (such as marketing, organizational, management and strategic innovations) and traditional innovations (process, product and technological innovations) are complements and not substitutes for each other and confirms that wider innovative activities have almost doubled whereas the extent of product and process innovation remains largely unchanged since CIS3. More focused on the issue of design in innovation, Tether (2009) shows that relatively few innovating firms engage in design activities outwith research and development, although a significant proportion also appear to invest in design without recognising these as design activities. And particularly these activities are undertaken by firms with deep commitments to innovation and tending to complement other investments, such as investments in R&D and marketing, rather than substitute for them.

Similarly, the work by Mol and Birkinshaw (2009) explores how management innovation affects performance as well as the determinants of management innovation using CIS3 and CIS4. Management innovation is shown to come about when firms encounter problems of rapid growth or severe decline, or problems in producing technological innovation. Management innovation is also more likely to occur together with product and process innovation. By linking the CIS to other database to get a measure of changes in productivity, these authors show that management innovation is shown to improve future productivity growth positively, unlike product or process innovation.

Additionally, the work by Swann (2009), through the use of simple statistical analysis, uses CIS4 to explore some different questions about the ways in which companies collaborate with the research base and use it as a source of information, presenting some exploratory analysis. Even with a narrower geographical scope, Freel and Harrison (2007) detail the innovative performance of the 1,270 Scottish firms that provided useable responses to UK CIS4. In placing the analyses in context, it appears that Scotland's performance is, by and large, in line with the UK average. Beyond general innovation performance, the report also recognises two trends: the growth in cooperative innovation (or innovation networking) and the growing importance of knowledge intensive and financial services.

Several papers focused on just one country analyse the **impact of innovation on different economic performance measures**. For the case of France, we find the paper by Mairesse and Robin (2009) which investigates the effect of innovation on labour productivity through the estimation of a three stages econometric model, where the estimated output at a given stage is used as an input in the next stage. With information from two waves of the French CIS (CIS3 and 4) they obtain that in the manufacturing industry, labour productivity was driven by process innovation between 1998 and 2002. Whereas in that same industry, between 2002 and 2004 labour productivity was driven by product innovation. With the same objective, although with a restricted geographical scope, the work by Segarra-Blasco (2008) analyzes the effect of intramural and external R&D on the productivity level in a sample of 3,267 Catalan firms. By applying usual OLS and quantile regression techniques both in manufacturing and services industries, results suggest that the elasticity of intramural R&D activities on productivity decreased when we move up the high productivity levels both in manufacturing and services sectors, while the effects of external R&D rise in high-technology industries but are more ambiguous in low-technology and services industries. In other words, he obtains different patterns of the impact of both innovation sources as we move across conditional quantiles. Also, Masso and Vahter (2008) analyse whether there is a significant relationship between technological innovation and productivity in the manufacturing sector of Estonia with firm-level data from CIS3 and CIS4. Applying a structural model that involves a system of equations on innovation expenditure, their results show that during 1998-2000 only product innovation increased productivity, while in 2002-2004 only process innovation had a positive effect on productivity.

All these works focus only on firms for just one country and, even if of much interest, the conclusions are restricted to the specific national cases. **Few studies consider different countries covered by CIS** probably due to the lack of homogeneity found in the data available (some sectors missing in some countries, different classification of sectors in the different countries, among other problems). One step forward in the harmonisation of the information provided by CIS is the "**Sectoral Innovation Database** (SID)" recently developed at the University of Urbino. This major database based on CIS has been created through cooperation agreements with national data providers -either national statistical institutes or research groups with access to CIS data and authorisation to exchange the data (CIS2 and 3). For the case of CIS4 data are taken from Eurostat, except for the UK, whose data are obtained from the national data provider. The assembling of the database has been carried out using common data protocols and statistical procedures on data integration and standardisation.

The selection of countries and sectors in the SID was made in order to make sure that no confidentiality problems in the access to data would emerge (due to the policies on data release by national statistical institutes or to the low number of firms in a given sector of a given country). Countries' coverage includes 7 major European Union countries – Germany, France, Italy, the Netherlands, Portugal, Spain, and the United Kingdom, and one country outside the EU, Norway - that represent together more than eighty percent of the European Economy. Data are available for the two-digit NACE classification of both manufacturing and service industries. The time span covered is therefore 1994-1996, 1998-2000 and 2002-2004. Data are available at the two-digit NACE classification of 21 manufacturing and 17 service industries (covering all manufacturing and business services). It includes most variables of the three comparable waves of the CIS (CIS 2, 3 and 4), besides a large amount of statistical information on economic performance and employment at the same sectoral level, drawn from different sources. Data in the SID are representative of the total population of firms. For each variable, firm level data have been weighted by the weighting factors provided by National Statistical Institutes in order to report survey data to the universe of firms. As commented above, the innovation dataset has been merged by the University of Urbino with an economic performance dataset containing data on economic variables at the same two digit industry level for manufacturing and services. The integration with the economic performance dataset has been carried out using the STAN database (drawn from OECD).[7]

Several papers have made empirical researches using the SID. The one by Bogliacino and Pianta (2009) provides a comprehensive and dynamic account of the complex process that over time links innovative activities and economic performance. The relevance of the two parallel strategies of technological and cost competitiveness, and the feedback loop between

[7] The confidentiality restrictions on the access to industry data and the small number of firms that can be present in each industry in several smaller EU countries mean that efforts at extending the country coverage would lead to a large number of missing values and a distorted dataset. Moreover, the initial CIS2 data are often incomplete or lack comparability for many of the countries that are not included in the database. Therefore, the SID offers a trade off between the need to investigate a large number of EU countries and the need to cover a long time span, using reliable data with few missing values.

profits, R&D and innovative performance driven by technological competitiveness are analysed in this paper, highlighting crucial aspects of the nature, dynamics and effects of innovation. Also using the SID, Bogliciano (2009) present empirical evidence of the reasons behind the wage decline in many sectors of the eight European countries covered by SID and investigate the role played by different types of innovation, increasing international openness, demand, norms limiting competition and employment change. Among the results, the authors signal that increasing wages are found in industries characterized by product innovation, while process innovation and greater international openness are associated to a reduction of real wages. Also related with the labour market and with similar conclusions, Croci et al (2009), with information from SID and from two waves of the European Community Household Panel (ECHP) study the impact that different technological strategies, labour market patterns, education and training have on the levels of wage polarisation within industries. Higher wage polarisation is found in industries with strong product innovation and high shares of workers with university education. Wage compression is associated to the diffusion of new process technologies and to high shares of workers with secondary education.

The **sectoral dimension** has also been analysed using CIS4. The research by Kanerva et al (2006) offers a cross-section analysis examining services and using CIS4 data in depth. The main result they obtain is that the services are found to be less likely to engage in innovative actrivity than comparable manufacturers. Manufacturing seems to be slightly more inclined to undertake process innovation and combined product and process innovation. Another interesting result is that there is a great variation among services: Knowledge intensive business sectors and financial services emerge as outstandingly innovative and have a tendency to combine product and process innovations. These sectors resemble manufacturing more than do other services with respect to their innovative behaviour. Also, with the aim of comparing manufacturing and services, Castellaci (2008) puts forward a new taxonomy of sectoral patterns of innovation that combines manufacturing and service industries within the same framework. The taxonomic model, in a nutshell, suggests that it is the interaction between technologically advanced manufacturing and service industries that sustains the dynamics of national systems in each long-run paradigmatic phase. Additionally, the author highlights the existence of several peculiarities in the process of knowledge creation in services. First, the great importance of customization and interactivity emphasizes the role of user–producer interactions. Secondly, the relevance of human resources and capabilities for the performance of service firms, so that training activities and organizational changes may prove to be a more crucial factor of competitive advantage in services than the amount of resources spent on R&D investments. Finally, the lower reliance on formal means of appropriability (e.g. patents).

Apart for the academic papers using CIS, it is important to signal that seven of the 25 indicators analysed in the **European Innovation Scoreboard** (EIS), a statistical instrument developed by the European Commission to evaluate the innovation efforts undertaken by the EU Member States and to make them comparable, are based on data from the CIS. As presented in Parvan (2007), the seven EIS 2006 indicators from the CIS4 are the following:

- Share of enterprises receiving public funding for innovation
- Small and medium sized enterprises innovation in-house
- Innovative SMEs cooperating with others
- Innovation expenditure
- SMEs using organisational innovation
- Sales of new-to-market products
- Sales of new-to-firm products

The first indicator proxies for knowledge creation, the last two for application and the remaining ones for "innovation and entrepreneurship". Therefore, the CIS questionnaire produces a wide range of raw data which are partly used for the European Innovation Scoreboard. However, as indicated in Parvan (2007) "the current EIS indicators look closely at the input and output of innovation, but other aspects could be included, such as the successful use of new technologies". This would be the concern of the indicators related to innovation diffusion as the ones we analyse in this project.

As a result of the review of papers using CIS4 (see Table I.3 for a summary) we can conclude that most of the available CIS indicators are simply frequency indicators based on one CIS survey question. Complex indicators based on the response to more than one question are the exception[8] albeit can be more revealing of firm strategies than simple ones. As commented in Arundel (2006) "with data available for several consecutive CIS surveys, one would think that

[8] A clear exception is the percentage of innovative firms, which is constructed from the results to four CIS questions.

the European policy community would be actively using CIS indicators to assess the ability of national innovation systems to respond to the challenges of the knowledge economy. Unfortunately, this hasn't happened to anywhere near the extent that one would have expected in 1996." "… the European policy community still relies on long-established indicators for R&D and patents". Therefore, although more complex indicators on innovation can be constructed with the information provided by CIS, this has not been the case. Among the main reasons raised by the author we find that of a continued focus on a science-push or linear model of innovation based on R&D, although no one refers to it anymore by its name. This could have led to a lack of demand of policy makers for a wider range of CIS indicators and a lack of supply from academics. Another reason can be found in the missing information for some countries in some specific sectors, which leads to uneven coverage so that not all the countries/sectors can be included when analysing certain topics.

Table I.3. Review of papers using CIS4

	TOPICS	MAIN RESULT	PAPER
ONE COUNTRY	**Patterns of innovation**	➢ **Norway**: the highly innovative high-tech sectors are small ➢ **Germany**: complementarity between innovation and organisational innovation	➢ Castellacci (2008) ➢ Schmidt and Rammer (2006)
	Determinants of innovation	➢ **UK**: being a new firm increases the likelihood of being innovative in services and decreases in manufactures ➢ **UK**: environment influence firms to be innovative or not	➢ Criscuolo et al (2009) ➢ D'Este et al (2009)
	Complementarities between innovation strategies	➢ **UK**: wider innovations (marketing, organizational, management and strategic) and traditional ones (process/product(are complements) ➢ **UK**: Few innovative firms engage design activities although some time do without recognising these as design activites ➢ **UK**: management innovation is more likely to occur when firms encounter problems of rapid growth or severe decline ➢ **UK**: Explore the ways in which firms collaborate ➢ **Scotland**: observes growth in cooperative innovation and of knowledge intensive and financial services	➢ Batisti and Stoneman (2009) ➢ Tether (2009) ➢ Mol and Birkinshwa (2009) ➢ Swann (2009) ➢ Freel and Harrison (2007)
	Impact of innovation on economic performance	➢ **France**: Labour productivity was driven by process innovation between 1998-2002 and by product innovation between 2002-2004 ➢ **Catalonia**: the impact of intramural R&D on productivity decreased in the case of high productivity levels ➢ **Estonia**: during 1998-2000 only product innovation increase productivity whereas in 2002-04 only process innovation did	➢ Mairesse and Robin (2009) ➢ Segarra-Blasco (2008) ➢ Masso and Vahter (2008)
SID	**Sectoral Innovation Database:** ➢ 8 countries ➢ 94-96; 98-00; 02-04 ➢ 21 manuf & 17 serv ➢ + STAN dababase	➢ Analysis of the two parallel strategies of technological and cost competitiveness ➢ Increasing wages found in industries characterized by product innovation while process innovation is associated to reductions ➢ Higher wage polarisation in industries with product innovation; wage compression with process technologies	➢ Bogliciano and Pianta (2009) ➢ Bogliciano (2009) ➢ Croci et al (2009)
SECTORIAL	**Comparison between manufacturing and services**	➢ Services are less engaged in innovative activity than manufactures ➢ Manufactures tend more to combine product and process innovation ➢ Great variation across services: Knowledge intensive business and financial services resemble more manufactures wrt innovation	➢ Kanerva et al (2006)

		➢ It is the interaction between technologically advanced manufacturing and service industries that sustains the dynamics of national systems
		➢ Peculiarities in the creation of knowledge in services:
		    ➢ Importance of customization
		    ➢ Relevance of human resources (training, organisational changes)
		    ➢ Lower reliance on formal means of appropriability (patents)
			➢ Castellaci (2008)

An important issue that remains relatively unexplored with the information provided by CIS is **innovation diffusion/adoption**. To our knowledge, nothing has been done to derive an analysis of innovation diffusion/adoption on the basis of this survey. This latter provides statistical data on the modality of innovation and the effects of innovation on economic performance. Therefore, innovation survey can be used to address the question of innovation adoption. However, we should be careful in building indicators of innovation adoption from the CIS since innovation adoption is not assessed directly. There is no specific item to account for it. We have to deduce it from several items. Our project can thus be seen as a first attempt to quantify these phenomena at the EU level. In fact, Arundel (2006) gives some examples of new complex indicators of relevance, pointing to the ones on knowledge diffusion, among others. His paper considers as the main indicator of knowledge diffusion that consisting of as a positive response to one or more of three questions: the firm's product innovations were developed mainly in cooperation with other enterprises or institutions, or the firm's process innovations were developed mainly in cooperation with other enterprises or institutions, or the firm had one or more cooperation arrangements on innovation with other firms or institutions. Other types of indicators for diffusion could be constructed, according to Arundel, combining knowledge diffusion through both technology adoption and through active collaboration by including firms that give a positive response to acquiring advanced machinery and equipment, or which report that their product and process innovations were mainly developed by other firms.

Our previous report gave a step forward in the discussion of the different indicators for knowledge diffusion that could be constructed using CIS3 and in the present one we extend them to the case of CIS4.

PART II

Descriptive statistical analysis of the innovation diffusion in the EU

Previous empirical studies on innovation diffusion are mainly based on monographic studies, quantifying innovation diffusion by looking at the adoption of a specific technology (ICT, seed, medical technologies for instance). However, our aim is to provide a general picture of innovation diffusion/adoption in EU, in order to analyse the impact of the EU Single Market and to assess the effect on global performances. Therefore, databases covering all EU countries and a wide range of sectors have to be used. Regarding innovation, global dataset allowing international comparisons are not numerous. In the EU countries under the coordination of Eurostat, the statistical office of the European Union, a common core questionnaire was agreed upon and surveys were launched under the acronym of CIS (Community Innovation Surveys). These surveys have been repeated every four years. Up to now there exist four waves of CIS (CIS 1 for 1990-1992, CIS 2 for 1994-1996, CIS 3 for 1998-2000, and CIS 4 for 2002-2004). The different parts of the survey allow us to deal with most of the issues addressed in this study. Information is available on the use and adoption of external sources of knowledge and innovation, the location of partners (within the same region, the same country, the rest of Europe, US or other part of the world), etc. For this reason, we used it in its third wave (CIS3) as our main source of information for the previous research project and we will incorporate the fourth wave (CIS4) in the present one.

II.1. Using innovation survey to account for innovation diffusion/adoption

The innovation surveys provide us with three broad groups of measures: innovation inputs, innovation outputs, and modalities of innovation (Mairesse and Mohnen, 2008). With this statistical information most empirical papers on innovation have analysed its determinants, the complementarities between different innovation strategies, the effects of innovation or innovation policy issues. However, an important issue that remains relatively unexplored is **innovation diffusion/adoption**. To our knowledge, nothing had been done to derive an analysis of innovation diffusion/adoption on the basis of this survey until the report from our previous project. In such report, the CIS3 was used to address the question of innovation adoption. However, we should be careful in building indicators of innovation adoption from the CIS. Firstly, innovation adoption is not assessed directly. There is no specific item to account for it. We have to deduce it from several items. Secondly, CIS faces several problems, due to the target population, data collection and methodological specificities (as discussed in section II.1 in previous report). This is why we suggested different indicators and considers the pros and cons of each design. As mentioned by Arundel et al. (2006) in the Trend Chart Methodology report, technology diffusion is among the indicators that have to be developed. Our approach can thus be seen as a first attempt to quantify these phenomena at the EU level.[9]

II.1.1. Target population of the CIS

The target population in CIS is the population of enterprises related to market activities, with 10 employees or more. The CIS3 database covers the three-year period from the beginning of 1998 to the end of 2000 whereas CIS4 covers 2002 to 2004. However, not all NACE market activities are covered in these two waves. A core target population is observed. "Non-core" activities can be included as well. Activities belonging to each population are listed below.

The following 9 sectors are included in the **target population** of CIS4:

- mining and quarrying (NACE 10-14)
- manufacturing (NACE 15-37)
- electricity, gas and water supply (NACE 40-41)
- wholesale trade (NACE 51)
- transport, storage and communication (NACE 60-64)
- financial intermediation (NACE 65-67)
- computer and related activities (NACE 72)
- architectural and engineering activities (NACE 74.2)
- technical testing and analysis (NACE 74.3)

Additional coverage, in order of descending priority (to be done by the countries on a voluntary basis):

[9] See Appendix II.1 for a list of the variables included in CIS4.

- research and development (NACE 73)
- construction (NACE 45)
- motor trade (NACE 50)
- retail trade (NACE 52)
- legal, accounting, market research, consultancy and management services (NACE 74.1)
- advertising (NACE 74.4)
- labour recruitment and provision of personnel (NACE 74.5)
- investigation and security activities (NACE 74.6)
- industrial cleaning services (NACE 74.7)
- miscellaneous business activities (NACE 74.8)
- real estate activities (NACE 70)
- hotels and restaurants (NACE 55)
- renting of machinery and equipment without an operator (NACE 71)

These economic activities should be regarded as non-core and do not necessarily have to meet the same quality requirements as for the core coverage (e.g. for item and unit non-response) or the required level of precision. This is why it is difficult to get homogeneised information among countries and we have been forced to discard these additional sectors.

II.1.2. Data collection in the CIS4 and characteristics of the data

Both in CIS3 and CIS4, countries can use census or samples or a combination of both. In both waves, the selection of the sample should be based on random sampling techniques, with known selection probabilities, applied to strata. It is recommended to use simple random sampling without replacement within each stratum. Member States are free to use whatever sampling methods they prefer, as long as the quality thresholds for the results are achieved. As usual, this data collection leads to non-response problems. More precisely, two kinds of non-response problem arise: unit non-response and item non-response. These two problems are treated in CIS4 in the same way they were is CIS3 (see previous final report, pages 69-70 for a detailed exposition).

Similarly to what happened with the information in CIS3, the imputation made in case there are items which are not filled in the questionnaire[10] has not been made systematically. Quite a lot of missings are therefore present in the database we have got from Eurostat. A first work has been done to identify these missing observations. The database has then been cleaned. The procedure is detailed in Appendix II.2.

As commented in the previous report, some characteristics of the data are likely to raise **some statistical problems**. Firstly, the CIS data are mainly **qualitative and subjective data.** Secondly, innovation survey provides **only cross sectional data**. Also, in addition to temporal comparisons, **international comparisons are still difficult** to perform. Moreover, innovation survey **does not allow us to provide comparison with the American case**. Finally, **some variables are censored data** (see section II.1.4 in the previous report for a detailed explanation of these problems).

II.1.3. The database building

The main descriptive work in this report is based on two samples extracted from the CIS4 survey which concerns innovative activities carried out between 2002 and 2004. 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 micro dataset contains 104717 firms belonging to 16 different European countries and several different NACE2 sectors.
- The macro-aggregated dataset covers 25 EU member state countries as well as Iceland and Norway and provides information for Core sectors aggregated into 7 sectors. Malta and UK appear in the webpage but the information on innovation is missing.

Before pursuing with the descriptive analysis, an initial comparison analysis will allow us to underline some main limitations of these datasets (section II.1.3.1). Then we will explain how we built the database (II.1.3.2).

[10] If an item is not filled in, a value is attributed according to the answer given by the other firms in the same stratum (e.g. same size and same NACE).

II.1.3.1. CIS4 Macro and Micro data comparisons

The data at the macro and micro level show significant differences in two specific dimensions:

- the number of countries for which the CIS provides data
- the sectoral disaggregation level

The number of countries available

The data at the macro level would be available for "*all 25 EU Member States, Iceland and Norway as well as Bulgaria and Romania.*".[11] 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 not available for Iceland, Latvia, Malta and Slovenia in the CIS4 version. Additionally, many missings appear: for Bulgaria only the sector of Trade is available, whereas in the cases of Romania, Denmark and Estonia only two sectors are available (Manufacturing and Trade in the first two countries and Manufacturing and Transport for Estonia).[12] This is something to be taken into account, since the national averages we compute in those Member States for the descriptive analyses in Part II can be driven by this sector data availability.

When instead we analyse the data availability for the proposed indicator of innovation adoption at the firm level (CIS4 "micro" level) data are available for the following 15 countries: Belgium, Bulgaria, Czech Republic, Spain, Estonia, Germany, Greece, Hungary, Italy, Lithuania, Latvia, Norway, Portugal, Slovakia and Slovenia. In fact, for only one country, Romania, it was not possible to get the adoption indicators with the micro database.

When we compare the micro CIS4 data with the macro ones some important "core countries" are notably missing in the micro database: Austria, Denmark, France, Finland, Sweden and Netherlands. It is important to stress that these countries are probably the most important ones when the analysis focuses on the adoption of innovation, as they are those with a higher level

[11] See notes to the CIS4 in the Eurostat web-site:
http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/inn_cis4_sm1.htm.

[12] Notice, these countries are available under the definition: type of innovation breakdown "*innovative activities*" and "*Product/process, developed by the enterprise together with other enterprises or institutions or developed mainly by other enterprises and institutions*".

of innovative activity. Table II.1 recaps the countries in the two databases both for CIS3 and CIS4.

Table II.1. Countries' presence in macro and micro datasets both in CIS3 and CIS4

	CIS3 macro	*CIS3 micro*	*CIS4 macro*	*CIS4 micro*
Austria	X		X	
Belgium	X	X	X	X
Bulgaria		X	X	X
Cyprus			X	
Czech Republic		X	X	X
Denmark			X	
Estonia		X	X	X
Finland	X		X	
France	X		X	
Germany	X	X	X	X
Greece	X	X	X	X
Hungary		X	X	X
Iceland	X	X		
Ireland			X	
Italy	X		X	X
Latvia		X		X
Lithuania		X	X	X
Luxembourg	X		X	
Netherlands	X		X	
Norway	X	X	X	X
Poland			X	
Portugal	X	X	X	X
Romania		X	X	X
Slovakia		X	X	X
Slovenia			X	X
Spain	X	X	X	X
Sweden	X		X	
Obs.	14	15	25	16

Iceland, Malta and UK appear in the webpage but the information on innovation is missing

Sectoral disaggregation issues

The CIS4 macro data are normally available for the following sectors:

1. Mining and quarrying (NACE 10-14)
2. Manufacturing (NACE 15-37)
3. Electricity, gas and water supply (NACE 40-41)

4. Wholesale and retail trade (NACE 51)
5. Transport, storage and communication (NACE 60-64)
6. Financial intermediation (NACE 65-67)
7. Computer and other business activities (NACE 72, 73, 74.2 and 74.3)
8. Construction
9. Hotels and restaurants

This said, most countries have missing data for the sectors of Construction (information is available in only 9 countries) and Hotels and restaurants (only available in 4 countries). This is why we decided not to consider them and work with 7 sectors.

The CIS4 micro dataset allows a much higher disaggregation level than the macro data source. However, this level of disaggregation is uneven across countries. Aggregation by sector is not the same according to the countries under consideration (see Appendix II.2 for more details on this point).

II.1.3.2. A database built from Micro and Macro data

In order to obtain the best country coverage, a database was built from micro and macro data following the availability of information according to countries. The sectoral classification is as presented above, that is to say, in 7 domains. Micro data have been favoured for the countries for which we have the two datasets. This choice is due to the fact that, using the macro dataset, we face a double counting problem[13] in the construction of the indicators of innovation diffusion/adoption. This latter prevents to cross some information. As we will see below, this problem constrains a lot in the set up of the innovation adoption indicators.

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 lead to a reduction of the size of the sample. For example, there are some firms which do not offer information on the sector they belong to.

[13] We detailed this issue in Appendix II.1 of the previous report. However, briefly, this refers to the fact that at the macro level we are not able to verify whether a firms is replying yes to two specific items of the CIS4 data used in the construction of the innovation adoption (process and product) indicator and, therefore, we may double count it.

This prevents us to classify them and we had to drop them from the sample. Additionally, we proceeded to compare the values of the innovation rates obtained with the micro and the macro databases for those countries available in both. The differences we found between both values were of less of 1 percentage point in most countries, and between 1 and 6 percentage points in Estonia, Belgium, Slovakia and Czech Republic. However, the difference in the case of Greece and Germany is of 36 percentage points. This alerted us and we decided to use the macro information for these two countries, since Eurostat has probably cleaned the information for these two countries.

Finally, the database contains 26 countries. The source is micro dataset for 13 of them. For the other 13 countries, the risk of double counting is present because of the use of macro dataset. This problem is dealt with as explained in Appendix II.1 of the previous report. However, in order to keep in mind that potential differences may arise between the two sources of information, different colours are used in the descriptive part for countries coming from micro and macro sources (see Table II.2 for a review of the database source according to countries). Regarding the sectoral coverage, as mentioned above, only seven sectors are available from Eurostat website. This is therefore the smaller breakdown we can use once micro and macro data are merged.

As a means to develop the descriptive analysis in this Part II of the report as well as the regression analysis in Part III, we have developed a database with considerable information, not only on the topic of innovation and innovation diffusion/adoption, but also on the different determinants of this innovation adoption and on the Internal Market proxies in the reference period of CIS4, 2002-2004. Since the same was done with CIS3 and the variables on the determinants of innovation adoption in the period 1998-2000, a first deliverable of this project is the database that has been constructed as homogeneous as possible for all EU countries and sectors finally included in this project in these two time periods.

According with the information in the webpage of Eurostat, comparability of data between the third and fourth Community Innovation Survey was improved in comparison with previous surveys due to the fact these ones were based on the similar survey methodology, target population, the survey questionnaires and the definition on innovation. The CIS4 questionnaire was shorter and considerably less difficult than the CIS3 questionnaire previously used. In most countries the CIS4 was launched in 2005, based on the reference period 2004 and an observation period running from 2002 to 2004 while for the CIS3 countries used several observation periods. In order to gain additional information on the innovative capabilities of enterprises in CIS4 was implemented questions regarding organisational and marketing innovations and their effects. However, some interesting variables for our study that were present in the CIS3 questionnaire are no longer present in CIS4. This is the case of the value of exports or the percentage of human resources in science and technology. This results problematic for our study since they are relevant as determinants of innovation adoption and it will be necessary to look for such information in other sources different from CIS.

Table II.2 Database source according to countries

	CIS4 macro	***CIS4 micro***
Austria	X	
Belgium		X
Bulgaria		X
Cyprus	X	
Czech Republic		X
Denmark	X	
Estonia		X
Finland	X	
France	X	
Germany	X	
Greece	X	
Hungary		X
Ireland	X	
Italy		X
Latvia		X
Lithuania		X
Luxembourg	X	
Netherlands	X	
Norway		X
Poland	X	
Portugal		X
Romania	X	
Slovakia		X
Slovenia		X
Spain		X
Sweden	X	
Obs.	13	13

II.2. Measuring innovation adoption

After a discussion in the previous project on the pros and cons of different alternative measures of innovation adoption, we chose the following indicator:

Number of adopting enterprises / Number of enterprises with process and/or product innovation or with ongoing or abandoned innovation activities

To construct such indicator, firms are considered as adoptive ones if they declare that their process or product innovations have been developed "Mainly together with other enterprises or institutions" or "Mainly by other enterprises or institutions".

The nature of innovation is firstly taken into account by looking at the distinction between product and process innovation. The innovation adoption presented above can be different according to the nature of innovation (product and process).

Number of firms identified as actors of innovation adoption *and* introducing **product** innovation / Number of **product** innovative firms.

Number of firms identified as actors of innovation adoption *and* introducing **process** innovation / Number of **process** innovative firms.

The second kind of characteristics related to the nature of the adoption process refers to the channels it relies on. In particular, adoption may result from adoption of external technologies. But it also relies often on the joint production of innovation. Two indicators can be derived from this information.

Number of firms declaring that their **process or product innovation** has been developed "mainly **together** with other enterprises or institutions"/ Number of innovative firms.

Number of firms declaring that their **process or product innovation** has been developed "mainly by **other** enterprises or institutions"/ Number of innovative firms.

II.3. Descriptive statistics of innovation adoption in the EU

Based on the definition and measures of innovation adoption given in section II.2, this third part will characterize innovation adoption in Europe. As in the previous report, we put the stress on three kinds of comparisons:

- **Nature innovation-based comparisons**: A distinction will be made according to the nature of innovation: in particular, product vs process innovation and collaboration vs external sources of innovation will be analysed.
- **Geographic comparisons**: Comparison across European countries in relation to the main variables characterizing innovation adoption.
- **Sectoral comparisons**: For the indicators available at a sectoral level, comparisons will allow us to identify some differences across industries in the adoption process and barriers to innovation adoption.

II.3.1. Descriptive analysis of adoption rates: General strategies

In the graphs in this section and subsequent, the clearer colour given to the countries observed from the macro database will help us to keep in mind that the global indicator of adoption computed from macro data may be affected by the rescaling procedure undertaken to cope with the double counting problem arising with the macro data.[14]

Overall, our empirical evidence shows that the **percentage of adoptive firms in the period 2002-2004 is equal to 52%.[15] That it, 52% of the European firms that innovate rely on**

[14] The computation of a global adoption rate (at country or sectoral level) raises some difficulties. Because micro aggregated data allows the crossing of different items, an exact count of the number of adopting firms is possible. This is not the case with macro data, for which double counting of product and process innovation occurs (see previous report for a detailed explanation on this point). Therefore, the values from macro database are higher than those from the micro database. In order to cope with this issue, a rescaling procedure has been used to make the two databases information compatible.

[15] It is not possible to compare this result and subsequents with the ones in the final report of the previous project, due to some different sectors and countries considered in each case. With the information in CIS3 we did not consider the sector of Financial intermediation, whereas it is included in the present report. Similarly, Iceland is not considered in this project whereas it was with the information with CIS3. On the contrary we now consider 5 countries that were not considered in the previous report: Cyprus, Denmark, Ireland, Poland and Slovenia. Additionally, the average we compute in this report is weighted according to the economic size of the countries/sectors as given by their value added.

the development of innovation through collaborations with other enterprises/institutions or by acquiring directly from other innovative firms.

Now, we turn to analyse the general pattern of the use of adoption made by firms that are product innovators and those that are process innovators, to study whether their adoption intensity varies as well as the way it is adopted. In this sense, we distinguish two modalities of adoption. The firms can:

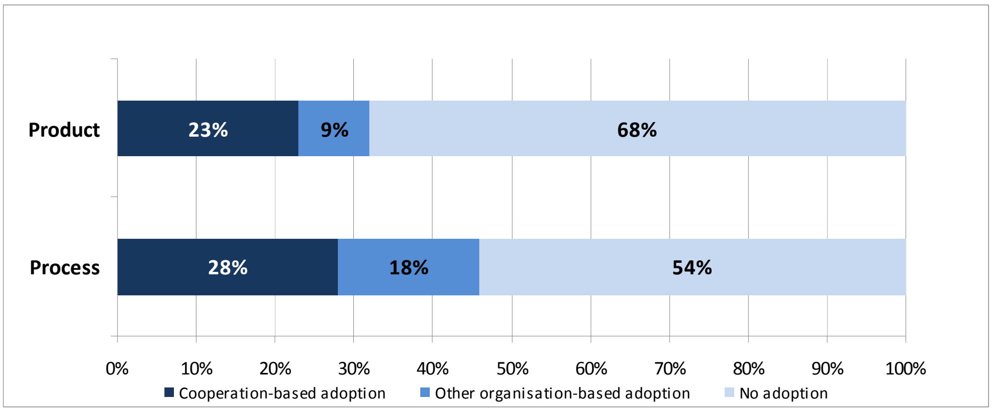
- either develop their innovation mainly in cooperation with other enterprises or institutions
- or rely on innovation developed mainly by other enterprises or institutions.

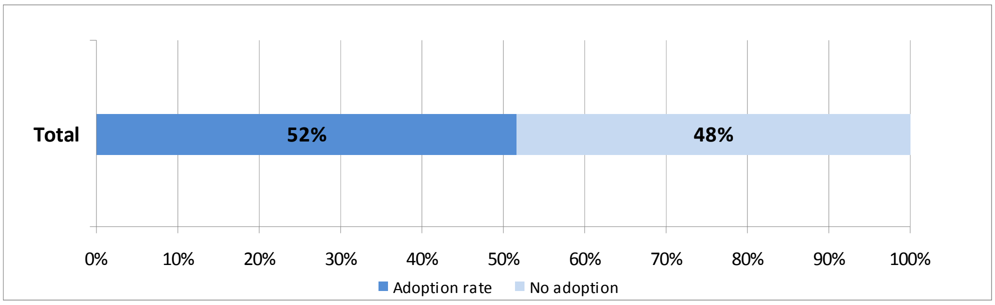
Is innovation adoption more important for *process* or *product* innovations and is this adoption the result of *Cooperation activities with other firms* or innovations are acquired directly from *other innovative firms*?

1) **Innovation adoption seems to be more important for Process innovations than Product innovations.**

2) **Cooperation activities are driving innovation adoption at the EU level while the acquisition of innovations from external innovators is a less important source of adoption of innovation (both process and product).**

Figure II.1. Innovation Adoption rates in the EU





MAIN INSIGHT: For all the countries, the adoption rate is higher in the case of process innovation (46%) than product innovation (32%). **So, innovation adoption is more process-oriented, a result in line with what happened with CIS3.** It is not surprising that process innovations appear highly adopting. Indeed, there is a close relationship between process innovation and machinery investment (Conte and Vivarelli, 2005). In turn, such embodied technology represents a very tradable component compared to i.e. intangible assets.

Our results seem to suggest that **process innovations need interactions between the firm and its suppliers and/or clients to be successful. Moreover, process innovations are often the results of supplier or client needs. This would encourage cooperation or outsourcing strategies to develop this type of innovation.** This result on innovation adoption being more process oriented is obtained in line with the pattern of innovation on its own which is also more process-oriented, 31 % of EU firms make process innovations vs. 26% which perform product innovations.

As for the nature of the adoption of innovation carried out by European firms, we obtain that cooperation activities are driving innovation adoption at the EU level while the acquisition of innovations from external innovators is a less important source of adoption of innovation (both process and product). This result reproduces the one obtained for the period 1998-2002 (CIS3).

II.3.2. Descriptive analysis of innovation adoption by countries

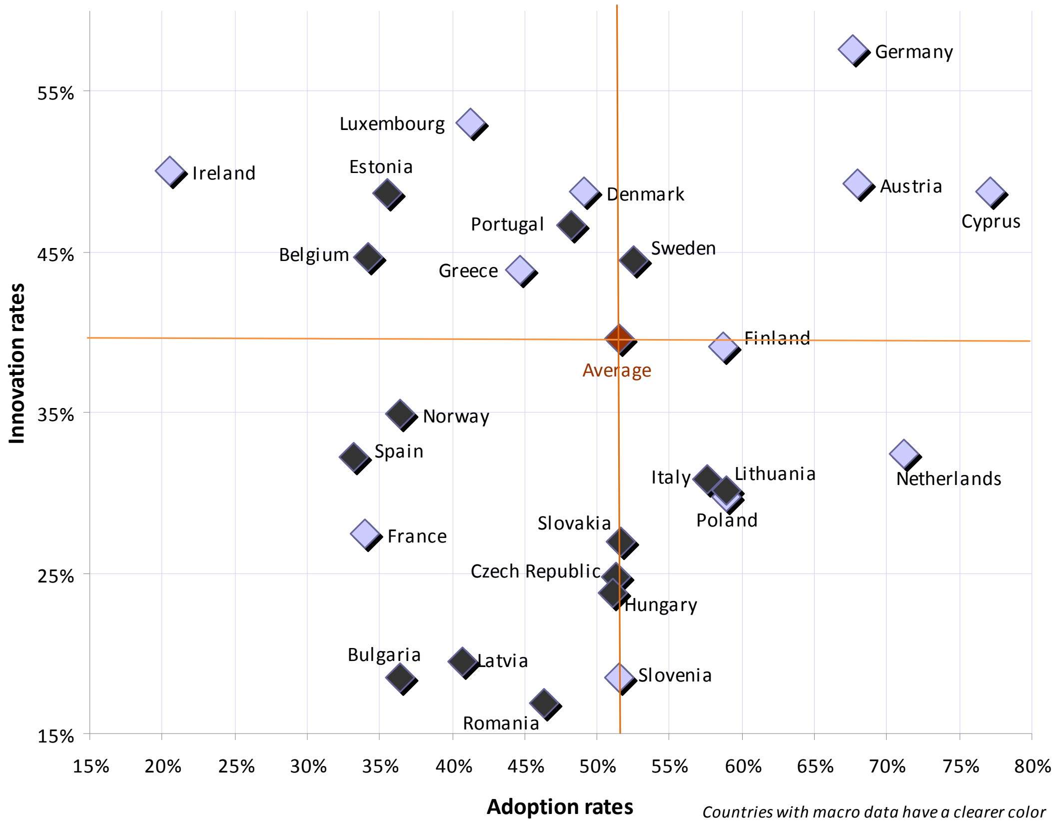
We firstly analyse the heterogeneity of adoption rates across EU countries, and then present the main correlations of innovation adoption vs. the total innovative effort with the idea of understanding whether differences can be actually observed among countries which "produce" innovation and those which, instead absorb or "adopt" this innovation.[16]

Are innovation adoption rates homogeneous across EU countries and are they correlated with innovation rates?

1) **No, innovation adoption rates vary substantially across EU member states.**
2) **We observe a clear positive relationship between being more innovative and being more engaged in adoption activities, in line with the conclusion that we reached with the information in CIS3.**

[16] It is important to recall that the national averages can be driven by the sector data availability (this is especially important in the cases of Bulgaria, Romania, Denmark and Estonia, for which we only have information on innovation adoption in some specific sectors).

Figure II.2. Innovation and Adoption rates by countries



Note: The average adoption rate given on the graph (and on all the following graphs) is computed as an average of the country rates and not as a global rate computed from the country and industry database.

MAIN INSIGHT: Despite the **average percentage of adoptive firms being equal to 49%, this rate varies considerable according to countries.** The highest values are observed for Cyprus (78%), the Netherlands (71%) and then for Germany and Austria (both with 68%). On the opposite, the minimum value is observed for Ireland with 21%. This percentage is low if compared to other countries since all other values are between 34% and 59%.

With respect to the evolution of this relationship between the 1998-2000 and the 2002-2004 periods, we maintain the same conclusion of a positive correlation between innovation and adoption. With the data on CIS3 we observed that countries with higher level of innovative activities seemed to be also those more dynamic in the context of innovation adoption. It seemed therefore that fostering innovation activities could be associated to some extent to spillover effects (which take place through "adoption mechanisms") leading to higher levels of diffusion and adoption of innovation. With the information with CIS4 we also obtain a positive and significant correlation between the two processes (Pearson correlation of value 0.5637; p-value: 0.0027), once the correlation is weighted by the size of the countries according to their GDP.

<u>Are Innovation Activities correlated with Adoption in the case of Product and Process Innovations or do we observe differences in both types of innovations across EU members?</u>

The same that happened for the period 1998-2000, EU countries with higher rates of Product Innovation are experiencing higher rates of Product Adoption from 2002 to 2004. The same occurs with Process Innovation activities, being innovators seems to be associated to higher rates of process adoption.

Figure II.3. Product innovation and product adoption by countries

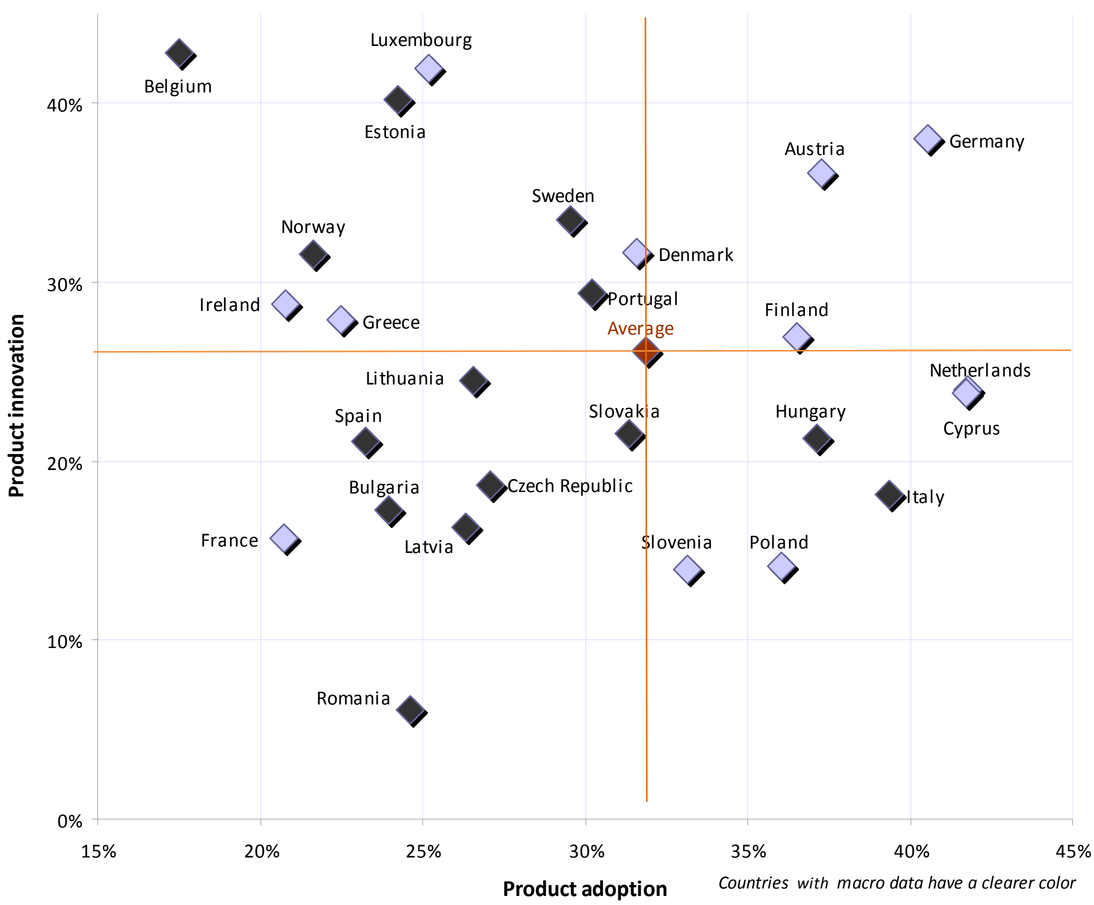
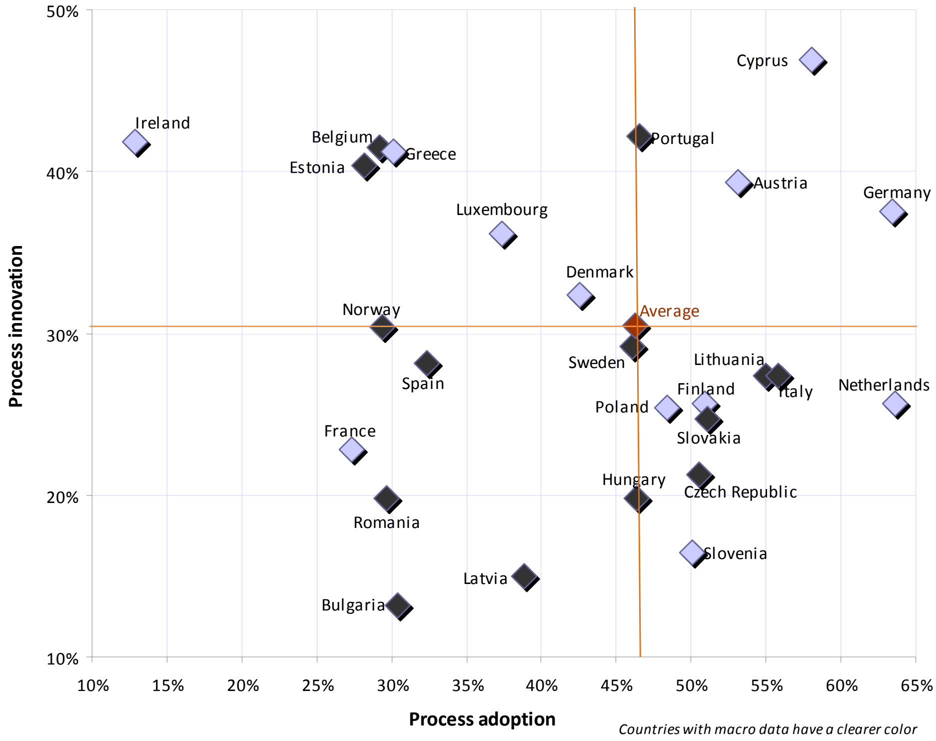


Figure II.4 Process innovation and process adoption by countries



MAIN INSIGHT:

Product innovations: In line with the results in the figures obtained with data for CIS3, in the case of CIS4 (Figure II.3) we also find evidence of a **positive correlation between being Product Innovators and being also Adopters of product innovations** across EU countries, significant at a 10% level (Pearson correlation coefficient: 0.3668; p-value: 0.0653).

Process innovations: Countries for which innovation activities are more process oriented (Figure II.4) are those in which the same processes are more adopted. This is the conclusion that is reached through the significant and positive correlation obtained between these two variables (Pearson correlation coefficient: 0.3616; p-value: 0.0695). However this is once the correlation is weighted according to the economic size of the country, since otherwise, some countries which make little process innovation, such as Slovenia, Hungary, Czech Republic and Slovakia, instead, present high levels of adoption (as a percentage of innovative firms). It seems therefore than they innovate little but once they decide to do it they cooperate with others or purchase the innovation made by others, rather than developing the innovation within the own firm. When we drop out Ireland, we obtain an even more positive correlation (Pearson correlation = 0.4537; p-value = 0.0227) among product innovation and adoption. Again, in line with the conclusion obtained with CIS3, **being innovators (this time process innovators) seems to be associated to higher rates of process adoption**.

Are there any differences in the nature of adoption when we look at product and process innovation in EU countries? Is more important cooperation or other organizations-based adoption and is this pattern consistent across EU countries?

Both the cooperation-based and other organization-based adoption rates are higher for process innovation than for product innovation. In both cases, firms innovate more in cooperation with other enterprises/institutions than purchasing innovation from others. Additionally, countries that trust on cooperation-based adoption also outsource innovations from other organisations.

Figure II.5. Adoption nature by country for product innovation

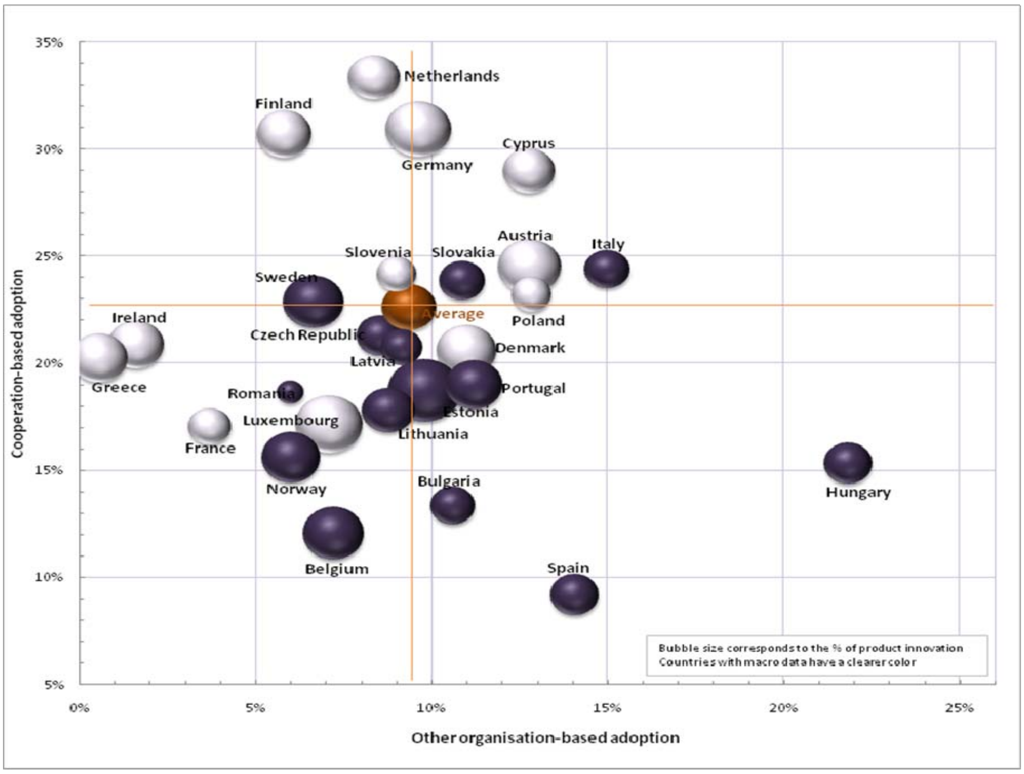


Figure II.6. Adoption nature by country for process innovation

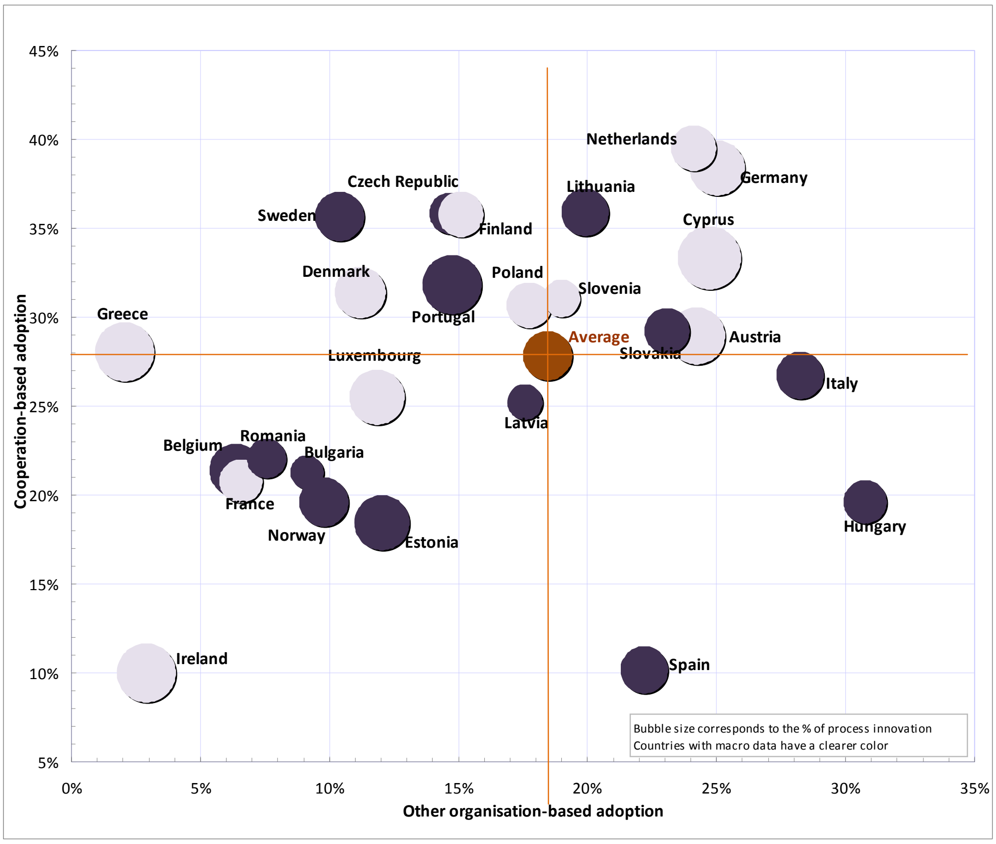


Table II.3. Pearson correlation matrix

		Rates related to PRODUCT				Rates related to PROCESS			
		Cooperation	Other organisation	Adoption	Innovation	Cooperation	Other organisation	Adoption	Innovation
Rates related to PRODUCT	Cooperation	1	-0.056 *0.786*	**0.782**** ***0.000***	-0.005 *0.979*	**0.738**** ***0.000***	**0.383*** ***0.053***	**0.699**** ***0.000***	0.170 *0.405*
	Other organisation		1	**0.555**** ***0.003***	-0.136 *0.509*	0.037 *0.857*	**0.809**** ***0.000***	**0.479**** ***0.013***	-0.149 *0.469*
	Adoption			1	-0.097 *0.637*	**0.627**** ***0.000***	**0.795**** ***0.000***	**0.864**** ***0.000***	0.081 *0.695*
	Innovation				1	0.033 *0.875*	-0.144 *0.484*	-0.053 *0.797*	**0.674**** ***0.000***
Rates related to PROCESS	Cooperation					1	0.326 *0.104*	**0.838**** ***0.000***	0.019 *0.929*
	Other organisation						1	**0.783**** ***0.000***	-0.085 *0.680*
	Adoption							1	-0.014 *0.946*
	Innovation								1

** The correlation is significant at 0.01 level

* The correlation is significant at 0.05 level

MAIN INSIGHT: According to Fig II.5 and II.6, **both the cooperation-based and other organization-based adoption rates are higher for process innovation than for product innovation** (a result also observed more generally in Fig II.1 and in line with that obtained with the information in CIS3). In terms of magnitude, **differences between countries are lower for product innovation than for process innovation**, a conclusion that is even more evident if we drop Hungary (with the highest value for other organization-based adoption specially in the case of product innovation). In such a case, the gap between minimum and maximum rates for process other organization-based adoption doubles the one in the product case. Also, if we drop Spain and Hungary, we obtain that both types of adoption (cooperation and other organisation) are positively correlated, implying that countries that trust on cooperation-based adoption also purchase innovations from other organizations.

For process innovation, Germany, the Netherlands, Lithuania and Cyprus strongly appear to be countries with high level of adoption based both on cooperation and entrusting to other (although always with higher rates for cooperation-based adoption). Some countries seem more cooperation oriented like Finland, Czech Republic and Sweden contrary to Hungary and Spain where the other organization-based adoption rate is higher.

The profiles observed for product innovation, even if country differences are smaller, are often the same as those for process innovation. Countries that strongly rely on cooperation for product adoption also strongly rely on cooperation for process adoption. Some exceptions are Lithuania (with less cooperation and other organization-based adoption in product than in process) and Ireland (with more cooperation –based adoption in product than in process).

From Pearson correlation matrix (see table II.3), we can see that both the cooperation and other organization-based adoption rates for product are significant and positively correlated with the ones of process, which means that **similar adoption strategies are followed for product and process**.

II.3.3. Descriptive analysis of innovation adoption by sectors

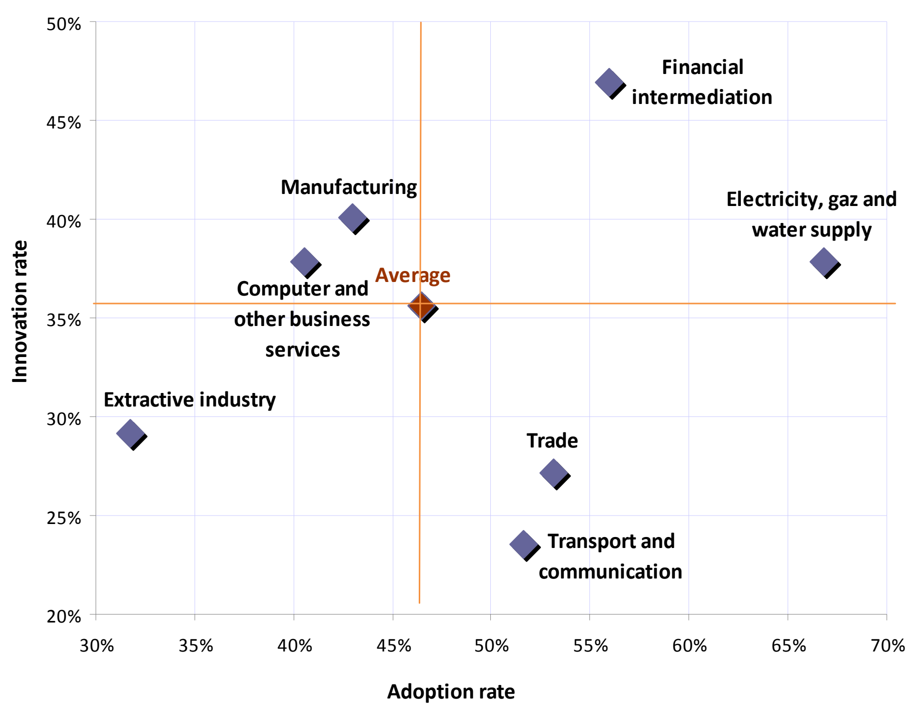
The descriptive analysis of innovation adoption is next carried out by productive sector to provide evidence of whether the innovation adoption patterns evidenced in the country analysis are also observed at the sectoral level. With the information for 2002-2004, we try to answer questions such as if innovation adoption is an activity mainly performed in highly innovative sectors or, instead, mostly performed in low-innovative sectors. Are there any differences in the way innovation is adopted when we focus disjointly on product vs process innovations?

Are adoption rates homogeneous across sectors and do they present any correlation with innovation rates?

1) Innovation adoption is far from being homogeneous across sectors ranging from 32% in Extractive industries and 67% in Electricity, gas and water supply.

2) In line with the results in CIS3, we also find now a negative (although not significant) correlation between innovation activities (those sectors which innovate more) and the sectoral adoption of innovation.

Figure II.7. Innovation and Adoption rates by sectors



MAIN INSIGHT: Sectors for which the **adoption rates are above the average are Electricity, gas and water supply (67%), then Financial intermediation (56%), Trade (53%) and Transport and communication (51%).**

As for the correlation between innovation rates and adoption rates, in line with the result with CIS3, it is also now negative although not significant (Pearson correlation: -0.2902; p-value: 0.5278). The lack of correlation between adoption and innovation at the sector level may highlight the occurrence of inter-sector technological flows. Generation of innovation would be mainly driven by some sectors (mainly Manufacturing and Financial Intermediation) and then adopted in other sectors.

Is innovation adoption relying on Cooperation activities or on External innovative activities when focusing on sectoral dynamics?

The same as with the data from CIS3, for both Product and Process innovations, Cooperation is the channel through which innovations are mainly adopted regardless if this is a process or a product innovation. The magnitude of the direct acquisition of innovation by the outsourcing to other organizations is only equal to the cooperation-based for the sector of Trade in the case of product adoption.

Figure II.8. Adoption nature by sector for product innovation

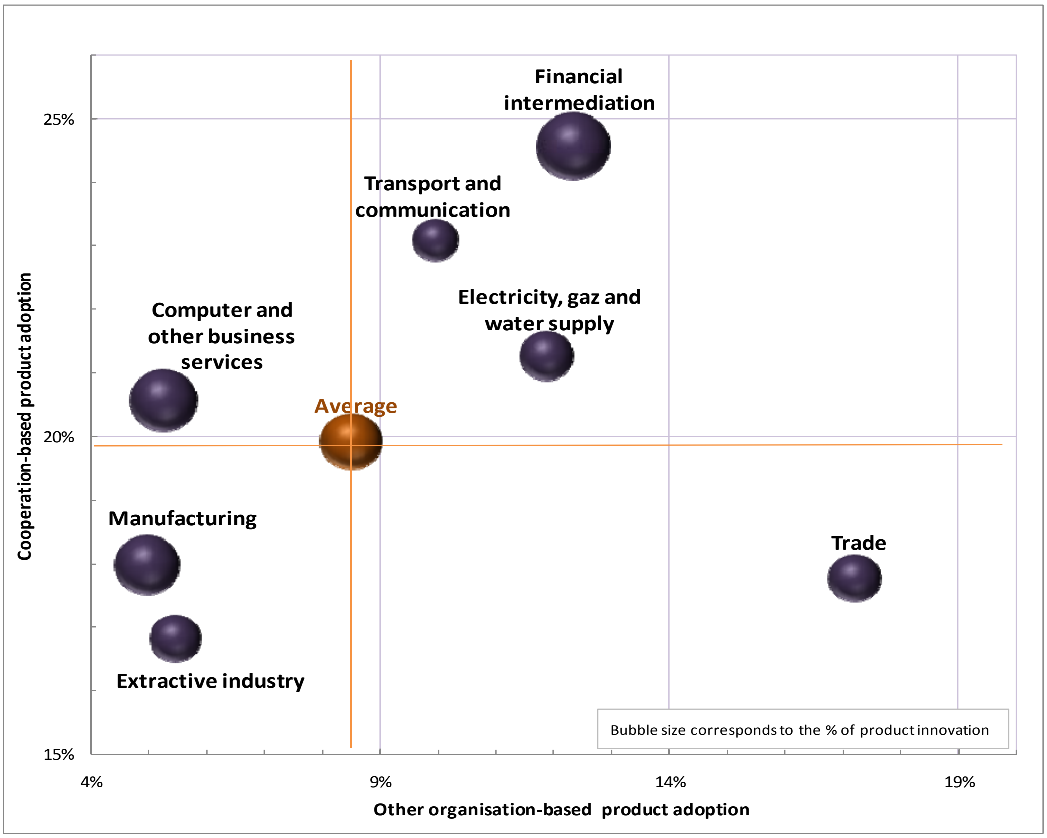
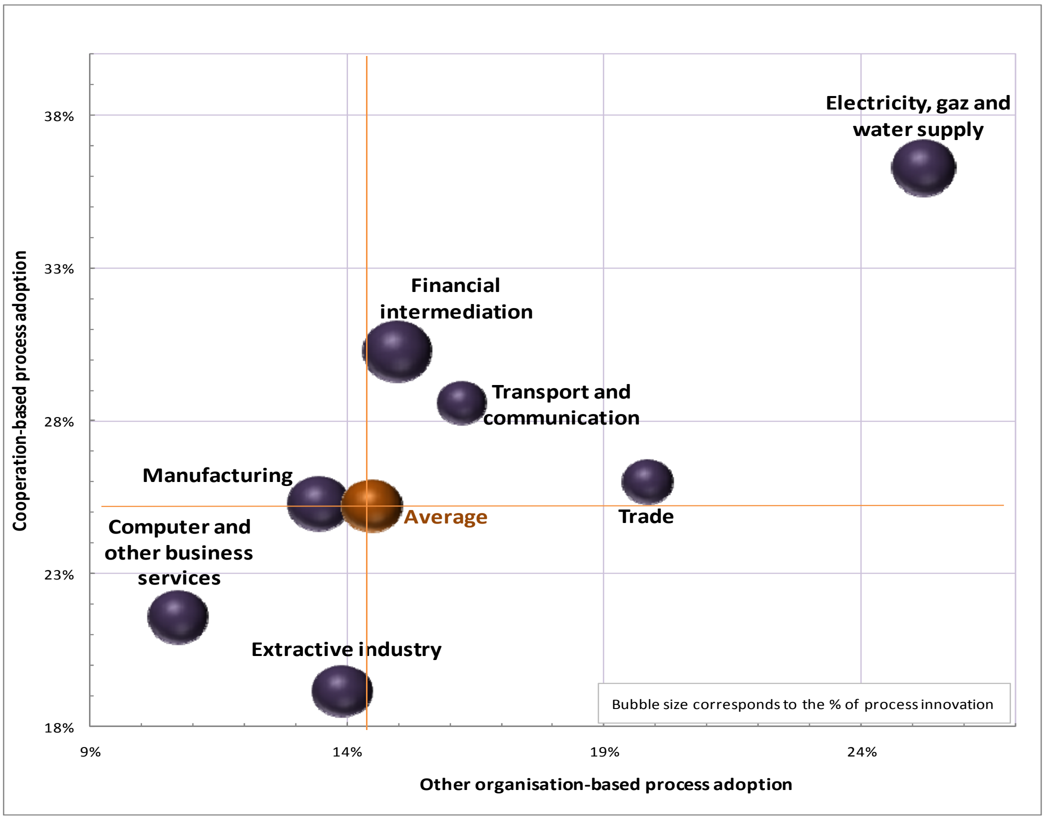


Figure II.9. Adoption nature by sector for process innovation



MAIN INSIGHT: Adoption is more cooperation-oriented than relying on outside resources, with the only exception of Trade in the case of product innovation, where both strategies are used with similar magnitudes, the same as in the previous period 1998-2000.

Concerning adoption behaviour in the sectoral case, we can relate the following facts:

- Whatever the sector and the nature of innovation (product/process), **cooperation is more frequent than outsourcing to other organisation** (except for Trade for product innovation for which both rates are about the same).

- There exists a positive relationship between cooperation-based and other organisation-based adoption rates. It seems therefore that the **sectors more cooperation-oriented also rely more frequently on outside resources.**

- Both for product and process innovations, **cooperation rates are above the average for Financial intermediation, Transport and communication and Energy.** On the opposite, Manufacturing and Extractive industry record the lowest rates.

- The sectors for which the share of innovative firms entrusting with other organisation is higher are Trade in the case of product innovations and Energy in the case of process innovations.

II.4. Descriptive statistics of the potential determinants of innovation adoption in the EU

As reviewed in Part I of the report, several factors are likely to influence the innovation adoption rates of firms. Some of them rely on the innovation inputs carried out by both adopters and innovators. Other potential determinants are related to other firm and market features. Finally, a third set of determinants refers to institutional environment (especially IPR regime and Internal Market regulations). In this subsection of the descriptive analysis, we study to what extent these three kinds of determinants are related to the innovation adoption rates in the EU countries. In Table II.4 we offer a list of the specific determinants of innovation adoption for which we will analyse their correlation with adoption rates.

Table II.4. Potential determinants of innovation adoption analysed in the descriptive

DETERMINANTS OF INNOVATION ADOPTION

A. Innovation inputs

- Sources of information for innovation
- Innovation expenditure
- Human capital resources
- Organisational changes
- Cooperation in joint R&D

B. Market features

- Competition
- Barriers to competition
- Trade
- Barriers to trade

C. Regulatory environment

- **Protection methods for inventions**
  - Patenting
  - Other legal and informal protection methods
  - Security of property rights
- **Internal Market regulations**
  - Transposition Deficit
  - Product Market Regulations by EFW

- Product Market Regulations by OECD

II.4.1. Innovation inputs and adoption

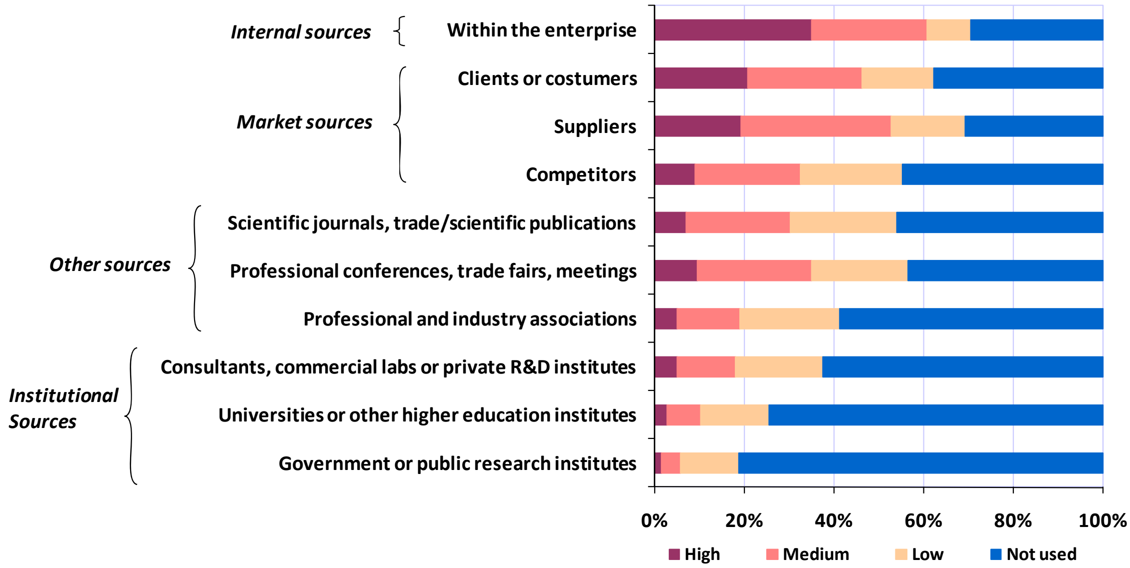
The literature review provided in Part I of this report highlighted that both demand and supply side determinants are likely to impact the firm ability to adopt new products or new processes. We cannot address separately the demand and supply side factors. Indeed, the CIS macro aggregated data from Eurostat website does not allow us to distinguish the features of firms that mainly adopt innovation from the one of firms that generate innovation. Therefore, the issue of the relationship of innovation inputs with innovation adoption is considered as a whole. The five types of innovation inputs studied in this section (sources of information, R&D inputs, human capital, organisational changes and cooperation activities) can thus reflect both suppliers and adopters' investments.

II.4.1.1. Sources of information for innovation: Different country profiles identified but not related to the level of innovation adoption

The CIS survey includes interesting information regarding the main sources of information used by firms in their innovation activities. In particular, a distinction can be made between sources of information that are internal to the firm or to the group, and the different external sources. As stressed in Part I of the report, the way information circulates among agents is an important channel of diffusion. This sub-section aims at analysing whether the different sources of information are associated with different level of innovation adoption. With this aim, we first characterize the EU countries according to their type of information sources (internal sources, market sources, institutional sources, etc.). We then study to what extent these different informational profiles are correlated with innovation adoption.

In terms of sources of information for innovation, sources within the enterprise are the most used (Fig.II.10). Information from market sources (from clients as much as from suppliers or competitors) or from other sources like professional conferences and trade fairs is also frequent. Indeed, between 58% and 70% of innovative firms exploit these sources of information. But only between 10% and 36% of firms use them with a high importance. On the contrary, the institutional sources, that is to say, information from consultants or from universities or government are weakly exploited: between 19% and 37%. In addition, the percentage of firms using them at a high level are very low (less than 5%).

Figure II.10. Sources of information for innovation for all the countries



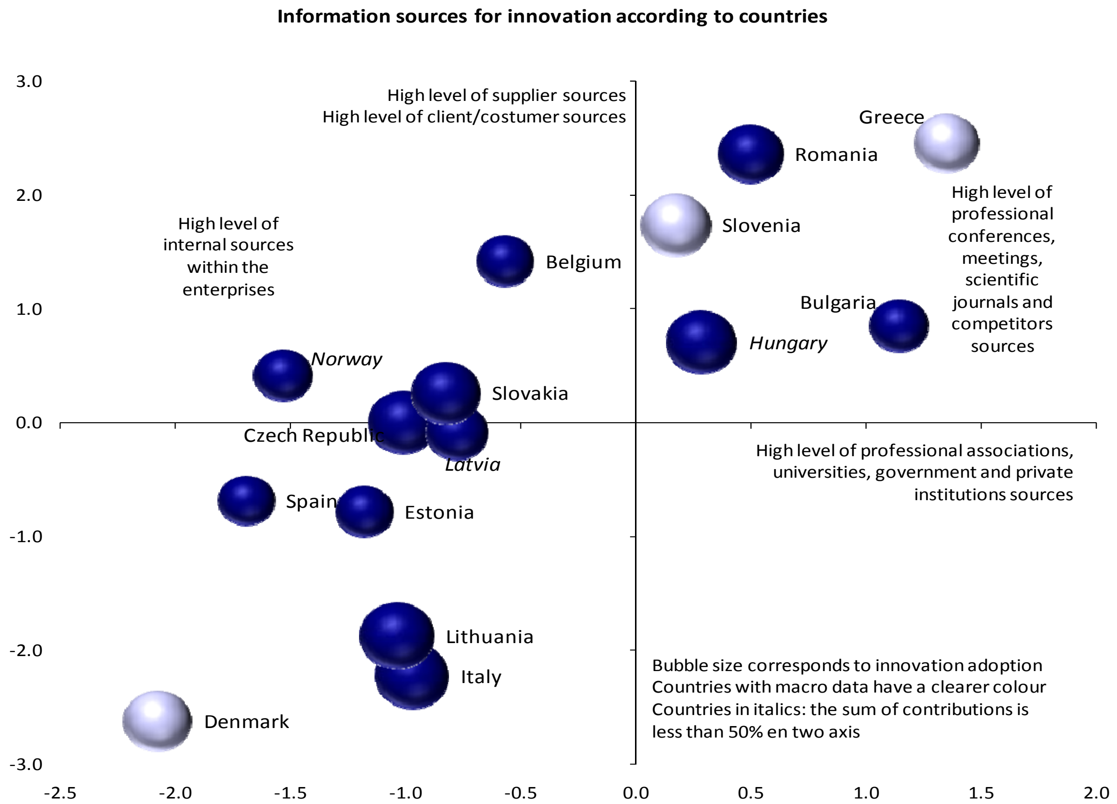
In order to analyse correlations between various variables about sources of information for innovation and to describe European countries according to the importance of these different sources and its relationship with their level of innovation adoption, a Principal Component Analysis (PCA) was carried out[17]. Here below we give the main results.

Is there a link between the use of sources of information for innovation and innovation adoption rates?

The link between the type of information sources used for innovation and the level of adoption is not really obvious, a result in line with that obtained with CIS3. However, 3 groups of countries can be identified according to the primary source of information used when making innovation.

[17] For technical details (eigen values, correlation circle and matrix), see Appendix II.3.

Figure II.11. Sources of information for innovation according to countries and adoption rates



MAIN INSIGHT: The factorial map (Figure II.11) clearly shows **3 groups of countries**:

- The first group (Greece, Romania, Slovenia, Bulgaria and Hungary) is characterised by a high level of institutional sources (universities, government and private institutions) as well as a a high level of professional conferences and exhibitions. So, this group is positioned on innovation sources that are currently encouraged in technological policies, that is to say, based on relationships between firms and public research activities and cooperation between enterprises within the same industry. The level of other market sources (relations with suppliers and clients) is also relatively high.

- The second group (Norway, Czech Republic, Slovakia, Latvia, Estonia and Spain) is generally characterized by a high level of use of information produced within the enterprise. Compared to the first group, the use of market sources is lower. For these countries, the exploitation of institutional sources is also very low.

- A third group (Denmark, Lithuania and Italy) mainly exploits internal sources, although at a lower rate than in the second group. The use of institutional sources is comparatively very low, the same as the use of market sources.

More interesting for our purpose of relating the sources of information with the adoption rates of the different countries, a one-way analysis of the variance confirms that **average adoption rates are not significantly different according to groups** (F-statistic being equal to 2,511 and the significance value of the F-test being to 0,108). Therefore, the fact of using one source of information or another does not imply different adoption rates.

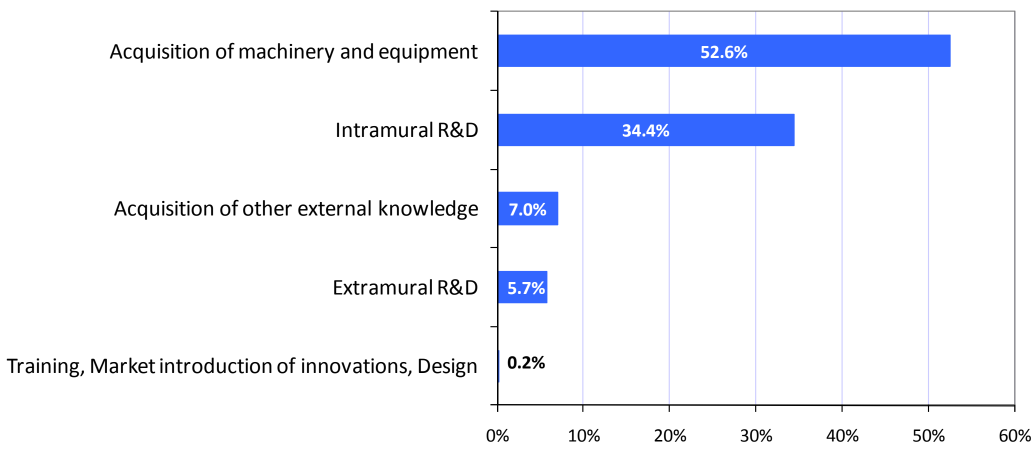
II.4.1.2. Innovation expenditure nature and the adoption rate are not significantly associated

The amount of expenditure associated with innovation activities has been stressed in the literature as an important condition of innovation diffusion. Indeed, the R&D and other innovation expenditure made by both the innovator and the adopter are needed to improve the technology, to reduce its price, or to adapt it to the adopter needs. The CIS survey contains detailed information about these expenditures. The total level of innovation expenditure can be observed, but also its distribution among different types of activity. Therefore we can analyse the impact on innovation adoption rates of both the global level of innovation expenditure and the different natures of this expenditure. Three countries however contain missing values for these items (Luxembourg, Austria and Sweden). They are thus excluded from this analysis.

Figure II.12 shows that innovation expenditure is mainly devoted to the acquisition of machinery and equipment (53%) and to intramural R&D (with 34% of expenditure). The other types of innovation activity concern a small part of total innovative expenditure. The acquisition of other external knowledge which contains purchase of rights to use patents and non-patented inventions, licenses, know-how, trademarks, software represents only 7% of European total innovation expenditure.

Figure II.12. Innovation expenditure distribution according to the nature of activities[18]

[18] In this calculation, Austria, Luxembourg and Sweden are not included because of missing values.

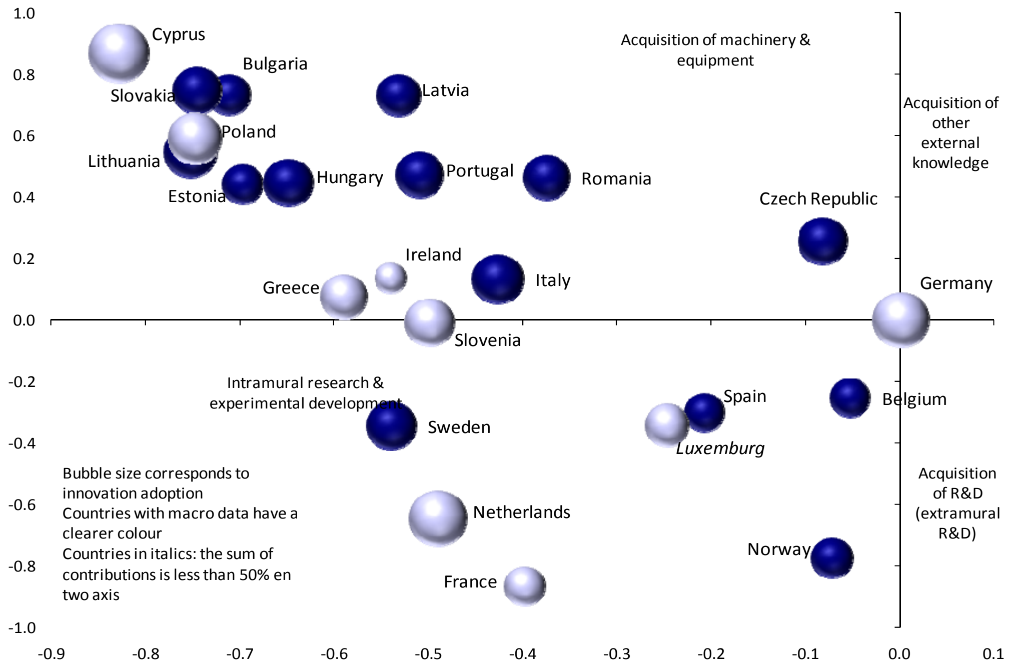


In order to analyse the correlations between various variables about innovation expenditures and to describe European countries according to the importance of these different resources, a Factorial Correspondence Analysis (FCA) has been done[19]. The factorial map (Figure II.13) clearly shows 5 groups of countries:

- The first group of countries (Cyprus, Slovakia, Bulgaria, Poland, Lithuania, Estonia, Hungary, Latvia, Portugal, and Romania) is characterized by an important share of acquisition of machinery and equipment and in lower proportion in terms of acquisition of other external knowledge. As seen, this group essentially gathers Eastern European countries.
- Germany and Czech Republic present relatively high share of acquisition of other external knowledge and acquisition of machinery and equipament but not as high than the former groups.
- Also with a relatively high acquision of machinery and equipment and also of intramural R&D we find a second group consisting of Greece, Italy Ireland and Slovenia.
- The fourth group (Sweden, Netherlands, France) is characterized by an important share of both intramural R&D and extramural R&D.
- Finally, the group with high acquisition of extramural R&D consists of Norway, Luxembourg, Spain and Belgium, but specially the first one.

[19] We use here a FCA (and not a PCA) because we work on R&D expenditure. This allows us to use a contingence table since the sums of rows and columns have a direct interpretation. The variable "Training, market introduction of innovations and design" is not included in this analysis because it gathers different modalities of innovation expenditures. These 3 modalities are three different questions in terms of engagement (yes or no modalities) but unfortunately they are gathered in only one question in terms of expenditure. For more details, see Appendix II.4.

Figure II.13. Innovative expenditure modalities by country



<u>Are higher innovation expenditures related to more innovation adoption across EU member states?</u>

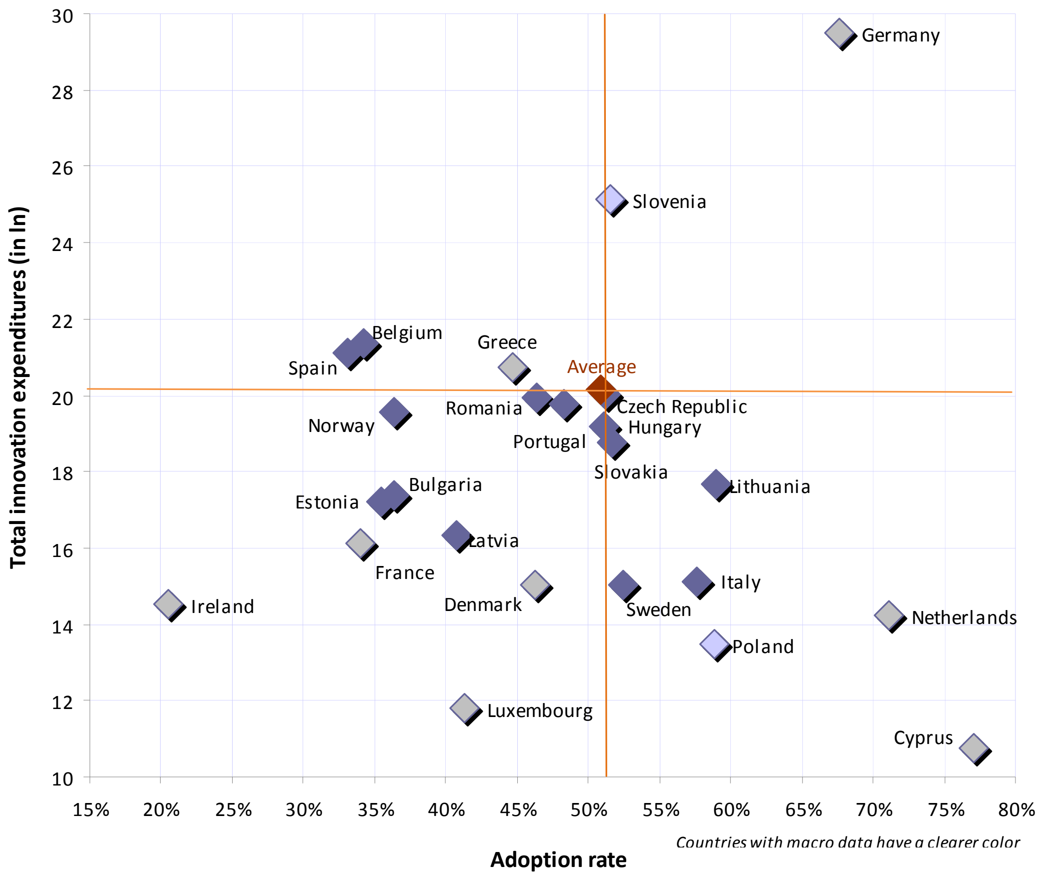
Evidence seems to point to a positive link between innovation expenditures and total adoption of innovation. This positive correlation is even more clear when process and product adoption are considered separately.

Table II.5. Pearson correlation Matrix

	Adoption rate	Intramural R&D share	Extramural R&D share	Acquisition of machinery and equipment share	Acquisition of the other external knowledge share
Adoption rate	1	**-0.4717****	0.1862	0.2889	**0.5755*****
		0.020	*0.384*	*0.171*	***0.003***
Intramural R&D share		1	**-0.5234*****	**-0.8264*****	**-0.5829*****
			0.009	***0.000***	***0.003***
Extramural R&D share			1	0.0264	**0.5904*****
				0.903	***0.002***
Acquisition of machinery and equipement share				1	0.1131
					0.599
Acquisition of the other external knowledge share					1

** The correlation is significant at a 1% threshold.
* The correlation is significant at a 5% threshold.

Figure II.14. Total innovative expenditure (in logs) and adoption rate by country



MAIN INSIGHT: From Figure II.13, **we do not see any clear correlation between adoption rate (represented by the bubble size) and the relative importance of the different modalities of innovation expenditure.** The correlation is, however, a bit clearer once it is weighted and computed separately for the different innovation expenditures. Specifically, the adoption rate is positive and significant when the innovation expenditures on acquisition of other external knowledge is considered (Table II.5).

The results are more promising when looking at innovation adoption disaggregated by product and process. We can detect that all the innovation expenditures CIS proxies are significantly correlated to process and product innovation adoption at 1%[20]. It seems therefore that more investments in innovation do actually boost number of process and also innovations which are ultimately adopted.

II.4.1.3. Human capital resources and adoption rate: a positive but non significant correlation

The education level can be a fundamental input in adoption behavior. Indeed, in order to assimilate knowledge produced out of the firm or in cooperation with partners, the firm needs qualified human resources. The internal absorptive capacity (Cohen and Levinthal, 1990) appears as a necessary condition to adopt external knowledge. This question could be addressed using CIS3 variables since the average number of employees with high education in innovative firms was asked in such a wave. However, this is not longer the case in CIS4. Therefore, we will address this issue using non CIS variables. Specifically, we are going to use the percentage of Human Resources in Science and Technology[21] in labour force in each country in 2002 obtained from EUROSTAT.

[20] Results are detailed in Appendix II.6 for both product and process innovation adoption separately.

[21] HRST is defined according to the Canberra Manual as a person fulfilling at least one of the following conditions:

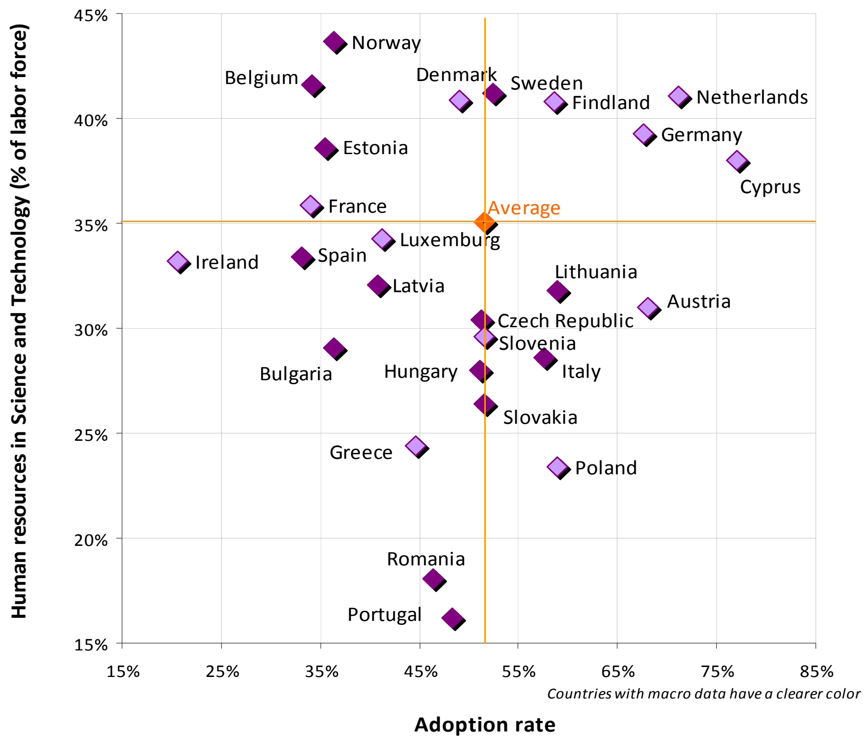
- Successfully completed education at the third level in a S&T field of study
- OR not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required.

Is Human Capital directly correlated to Innovation Adoption rates?

The link between our proxy for Human Capital and Innovation Adoption rates seems to be non-significant even if positive.

There is no correlation between the adoption rates of innovation and the skills of the observed workforce. As noticed previously for R&D expenditure, the absence of a strong correlation between adoption and human resources can be explained by the positive correlation between human resources and innovation. Indeed, as our adoption index is divided by the number of innovative firms, the positive impact of human resources on overall innovation increases the denominator and therefore reduces the rate of adoption. The correlation coefficient between innovation rate and human resources in S&T equals 0.4270 (with p-value: 0.0296). In other words, human capital may influence positively adoption, but also the other types of carrying innovation. **The impact of human resources on innovation adoption is not significantly stronger than its impact on the "generation" of innovation**. This potential direct impact of human resources on overall innovation performance will be more deeply dealt with in the econometric estimations provided in part III of the report.

Figure II.15. Human resources in S&T (% of labour force) and adoption rates by country



MAIN INSIGHT: We observe that, for the countries we have available in our sample, there is no correlation between the adoption rates of innovation and the skills of the observed workforce. When crossing adoption rate with the percentage of Human Resources in Science and Technology in labour force in each country (Figure II.15), the correlation is positive but very low, being no significant (Pearson correlation= 0.1367, p-value= 0.5053).

It is possible to notice how many countries with a low percentage of HRST also have adoption rates above the average. It is the case for many Eastern countries (Czech Republic, Hungary, Slovakia, Lithuania, Slovenia, Poland) together with Italy and Austria. By contrast, some countries with a high HRST rate display adoption rates below the average. It is essentially the case for countries located in the North of Europe such as Norway, Belgium, Denmark, as well as Estonia. These two facts would seems to point to a negative relationship between human capital and the level of innovation adoption. However, some countries have very high adoption rate at the same time than high shares of human resources in ST over their labour force. This is the case for Netherlands, Germany, Cyprus, Finland and Sweden. So, many different profiles can be observed which leads to the non-significant correlation obtained above.

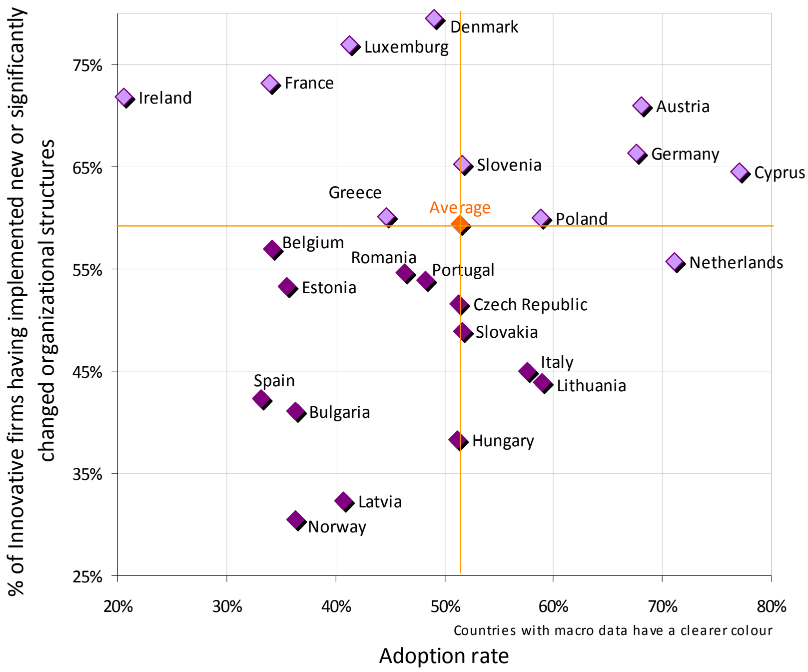
II.4.1.4. A positive relationship between adoption rate and organizational changes

Leading innovation adoption strategies can require changes in organisational structures. CIS data allows us to know if firms have implemented or not new or significantly changed organizational structures.

Are changes in the organisational structure correlated to Innovation Adoption?

There seems to be evidence that organisational changes are related to more Innovation Adoption if all EU countries and sectors in the sample are considered.

Figure II.16. Organizational changes and adoption rates by country



MAIN INSIGHT: We can see that the percentage of innovative firms with organizational changes varies substantially according to countries. Norway and Latvia record very low percentage (around 30%) whereas Denmark, Luxembourg, France, Ireland, Austria, Germany and Slovenia have the highest rate (higher than 65%).

According to Figure II.16, **the adoption rate does not vary in a systematic way with the percentage of firms that have implemented new or significantly changed organizational structures.** The correlation computed from all countries is positive but not significant (Pearson correlation = 0.0270, p-value = 0.9004). However, two comments are worth commenting: firstly, if the same correlation is computed using all the information for countries and sectors and not just the average for countries, then the correlation is significantly positive (Pearson correlation = 0.2407, p-value = 0.0051). Secondly, if we drop Ireland, France, Luxembourg and Denmark, the positive correlation between these two variables is now highly significant (Pearson correlation = 0.6894, p-value = 0.0008). These two facts indicate that the percentage of firms that have implemented new or significantly changed organizational structures tend to have positive adoption rate.

II.4.1.5. A non-significant correlation between adoption and cooperation in joint R&D

From the CIS survey, it is possible to know the number of firms that are engaged in innovation cooperation, that is, active participation in joint R&D and other innovation projects with other organisations (either other enterprises or non-commercial institutions). In addition to the general information about R&D cooperation activities, the CIS survey provides the distribution of these cooperations according to the location of the partners. Thanks to this information, two additional variables can be built, in order to assess the relationship between cooperation among EU countries and cooperation within EU countries. In the context of the internal market, a key issue concerns the impact of the diffusion of innovation across EU countries. Focusing on R&D cooperations that take place between EU countries might give first insights about the potential flows of knowledge that arise between firms that belong to different countries.

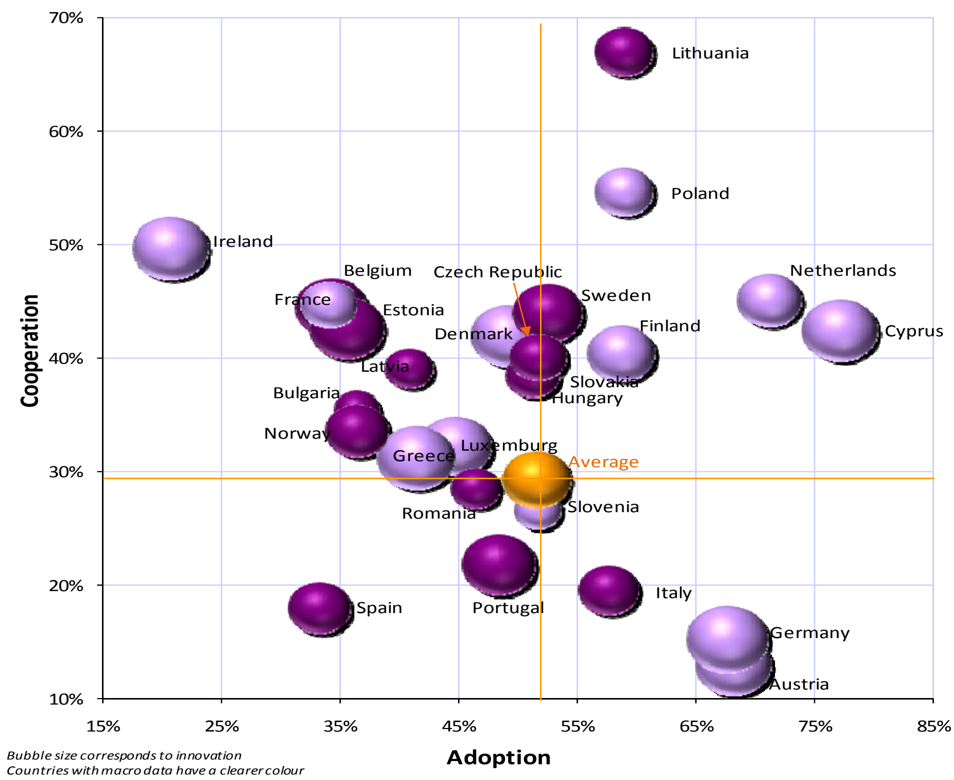
The overall rates of cooperation in EU countries are given below on Figure II.17. On average, a little more than one innovative firm over three cooperate for its innovation activities. Not surprisingly, countries that are most involved in R&D cooperation (above the average) are Scandinavian and Baltic States, plus Belgium, France and Ireland. Conversely, Spain, Portugal and Italy, but also Germany and Austria do not rely strongly on cooperation for their innovation activities (with less than 20% of cooperative firms).

Is there any correlation between cooperation activities and the rates of Innovation Adoption across EU member states?

Correlation between these two measures seems to be (surprisingly) negative and significant.

The correlation with innovation adoption is significant and negative (Pearson correlation: -0.4870; p-value: 0.0116). One can think that this could be due to a positive impact of cooperation on the overall level of innovation. This would increase the denominator of our adoption rate and counterbalance a positive effect on adoption. But this is not the case: the correlation rate between cooperation and innovation is also negative and significant (it equals to -0.5138, p-value: 0.0073). This result may seem surprising since the adoption rate notably contains information about cooperation in product and/or process innovations. When looking at Figure II.17, the negative relationship is not as clear. However, once the correlation is weighted by the national GDP, we observe that three big economic countries such as Germany, Austria and Italy present high levels of adoption together with little cooperation, whereas the opposite is found for Ireland, France and Belgium, making these negative correlation appear.

Figure II.17. Cooperation and adoption rates by country



If we turn to consider R&D cooperation activities according to the location of partners, we can observe from figures II.18 and II.19 that national cooperations are, not surprisingly, much more frequent than European cooperations. The average percentage of national cooperation is 33%, against 18% for inter-EU cooperation. However, there is a highly positive and significant correlation between these two scopes of cooperation (Pearson coefficient: 0.8079; p-value: 0.000) indicating that in many cases in which a firm decides to cooperate at an European level, it also does it nationally.

The share of innovative firms engaged in EU and National cooperations differs significantly from one country to another, with a stronger dispersion for national cooperations than for EU cooperations. However, the picture for national cooperation is nearly the same as the one observed for the overall cooperation rate: Countries registering cooperation scores above the average (many Baltic and Scandinavian contries) are exactly the same in the two graphs, except Cyprus. In this country, the high overall cooperation rate is mainly due to cooperation with partners located in other countries (highest than the average) whereas its national cooperation rate is below the European average. Additionally, the correlation between a firm cooperating at a national level and adopting innovation is also in this case negative and significant (Pearson correlation: -0.4434; p-value: 0.0264).

The figure for European cooperation is also similar to the other ones, but some changes are worth highlighting: Luxembourg exhibit one of the highest cooperation rate with European countries (whereas its national cooperation rate is clearly below the European average). The opposite pattern is observed for France, Netherlands and Poland, that rely more substantially on national cooperation (around 45% of their firms) than the cooperation maintained with other EU countries (16% of firms). Additionally, we observe that the correlation between a firm cooperating at a European level and adopting innovation is also negatively non-significant (Pearson correlation: -0.3068; p-value: 0.1358).

Figure II.18. National cooperation and adoption rates by country

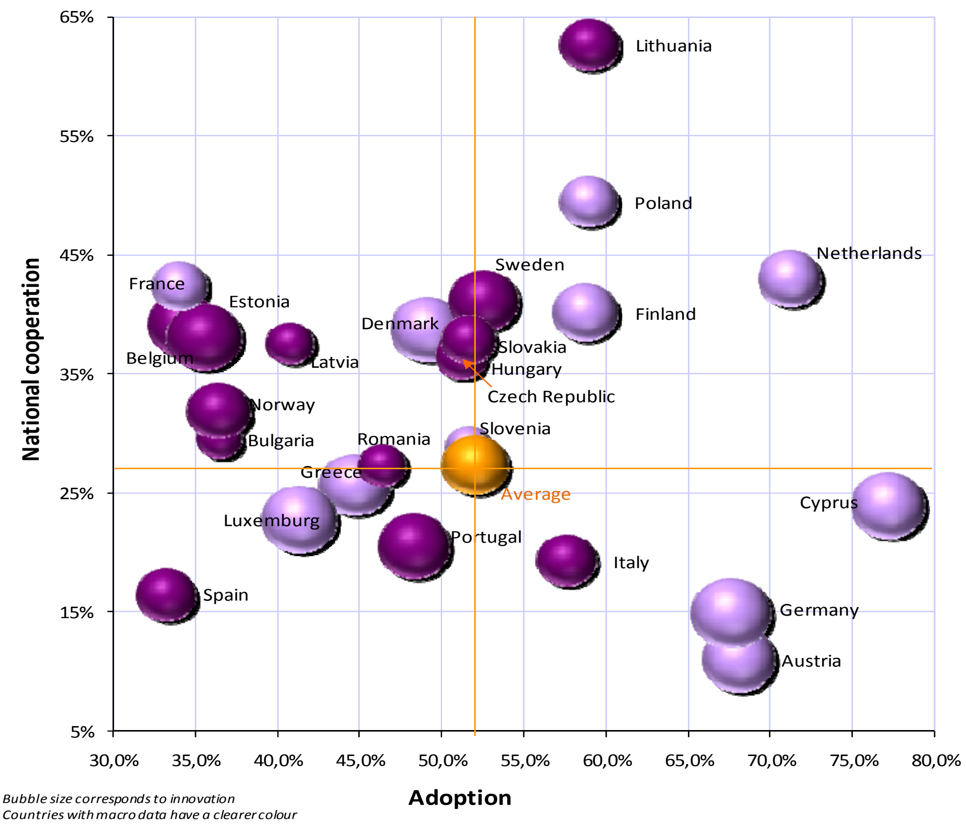
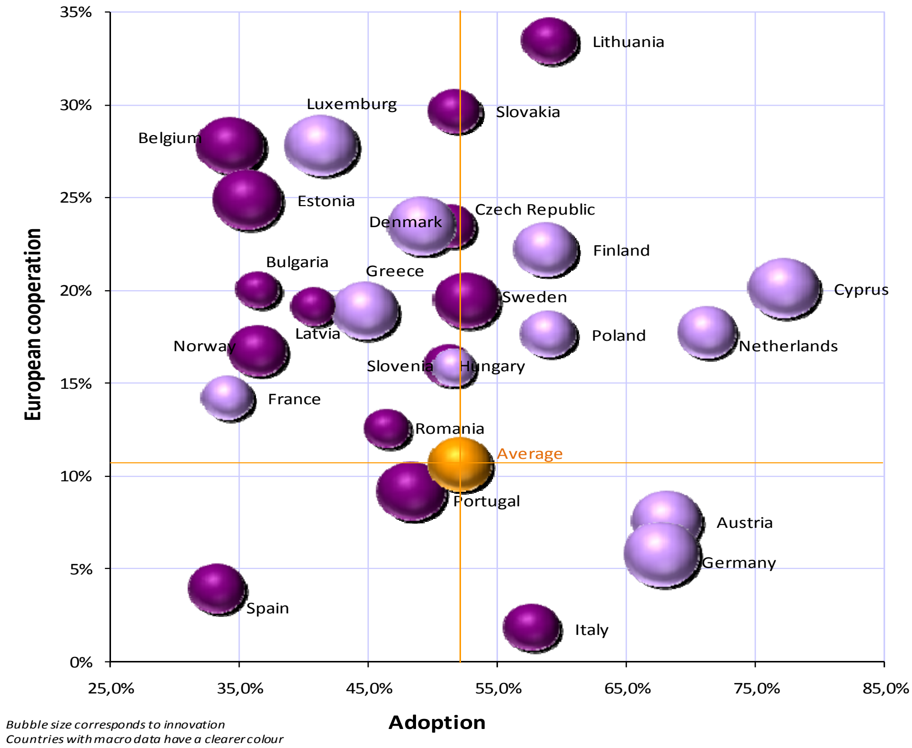


Figure II.19. European cooperation[22] and adoption rates by country

[22] European Union countries include Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden and the United Kingdom while European Free Trade Association countries includes Iceland, Liechtenstein, Norway, Switzerland.



MAIN INSIGHT: Specific profiles arise in terms of cooperation. Not surprisingly, countries that are most involved in R&D cooperation are Scandinavian and Baltic States. We observe a **non-significant correlation** between the share of innovative firms engaged in cooperation and the adoption rate. This is the case not only for cooperation in general terms, but also for cooperation at a national and at a European level. This result may seem surprising since the adoption rate notably contains information about cooperation in product and/or process innovations. This non-significant correlation may result from country aggregated data and from the fact that the question about cooperation focuses on R&D only.

II.4.1.6. Conclusion on the relationship between innovation inputs and innovation adoption

From all the descriptive analysis in this sub-section, one can conclude that **there is only little correlation between innovation adoption rates and the different variables proxying innovation efforts. We have only obtained a significant and positive correlation between innovation adoption and innovation expenditure and the fact of doing organisational changes. On the contrary, the different sources of information considered as well as human capital does not have a significant impact.** It seems therefore that although from a theoretical perspective these variables would influence the absorptive capacity of firms and therefore their ability to adopt innovations, the empirical evidence for the EU countries do not support such theories completely.

When we look at innovation adoption disaggregated at process and product level, our results show how neither human resources in science and technology nor organisational changes are significant. However, all the "sources of information" CIS proxies show a significant correlation with process and product innovation adoption[23].

II.4.2. Market features and innovation adoption rates

In this sub-section we analyse to what extent the data we have on innovation adoption rates are related to several issues concerning market features such as competition and the level of barriers to trade.

II.4.2.1. Competition and innovation adoption rates: non-significant correlation

Competition can be assessed only indirectly through proxy variables and in our study we follow the one given in Griffith and Harrison (2004). The markup is measured as the average level of profitability at the country-industry level. Specifically, our measure of average profitability (or markup) is value-added as a share of labour and capital costs –in country i, industry j and year t):

$$Markup_{ijt} = \frac{ValueAdded_{ijt}}{LabourCosts_{ijt} + CapitalCosts_{ijt}}$$

This profit level is obtained for manufacturing industries using the OECD STAN database, which provides information at the two-digit industry level on value added, labour and capital stocks. The higher the profit or markup (above the value of 1), the less the competition achieved in the market under analysis since more profits 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. Therefore, the higher the indicator, the lower is competition. As noticed by Griffith et al. (2006), Boone (2000) shows that this measure of competition is preferred to most other commonly used measures. It is more theoretically robust, particularly than those based on market concentration and market shares, and it is the

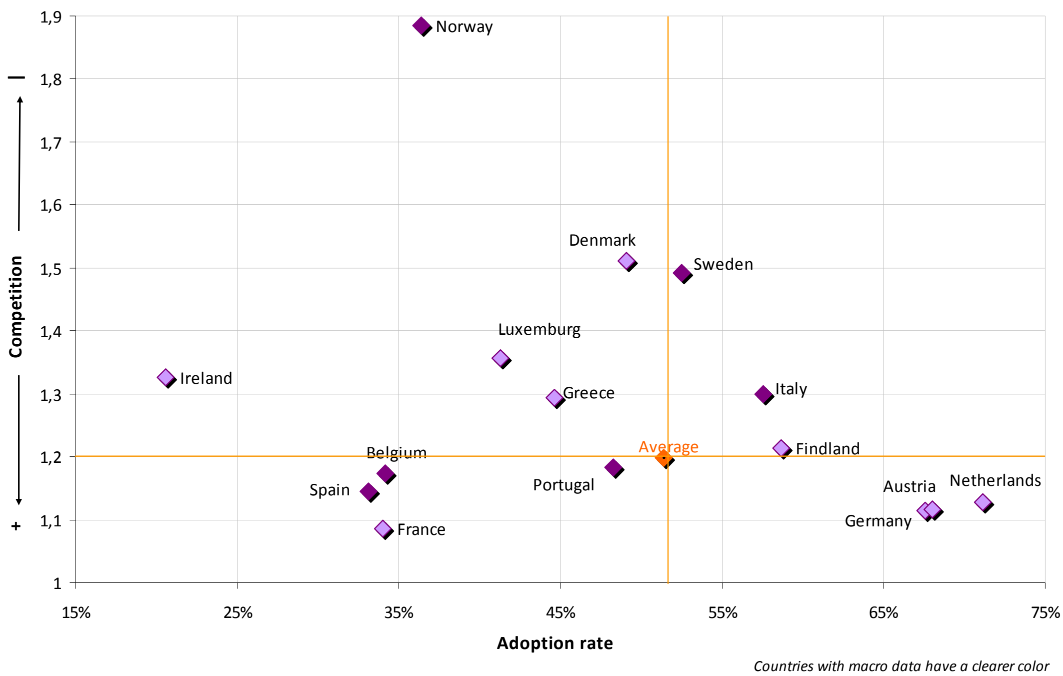
[23] Results are detailed in Appendix II.8 for both product and process innovation adoption separately

only commonly used measure of competition that is available across countries. In our case, this indicator is available for only 15 countries.

Are higher levels of Competition in each EU member state related to more Innovation Adoption?

No, more competitive markets do not seem to be significantly correlated to higher rates of innovation adoption.

Figure II.20. Adoption rate and competition index



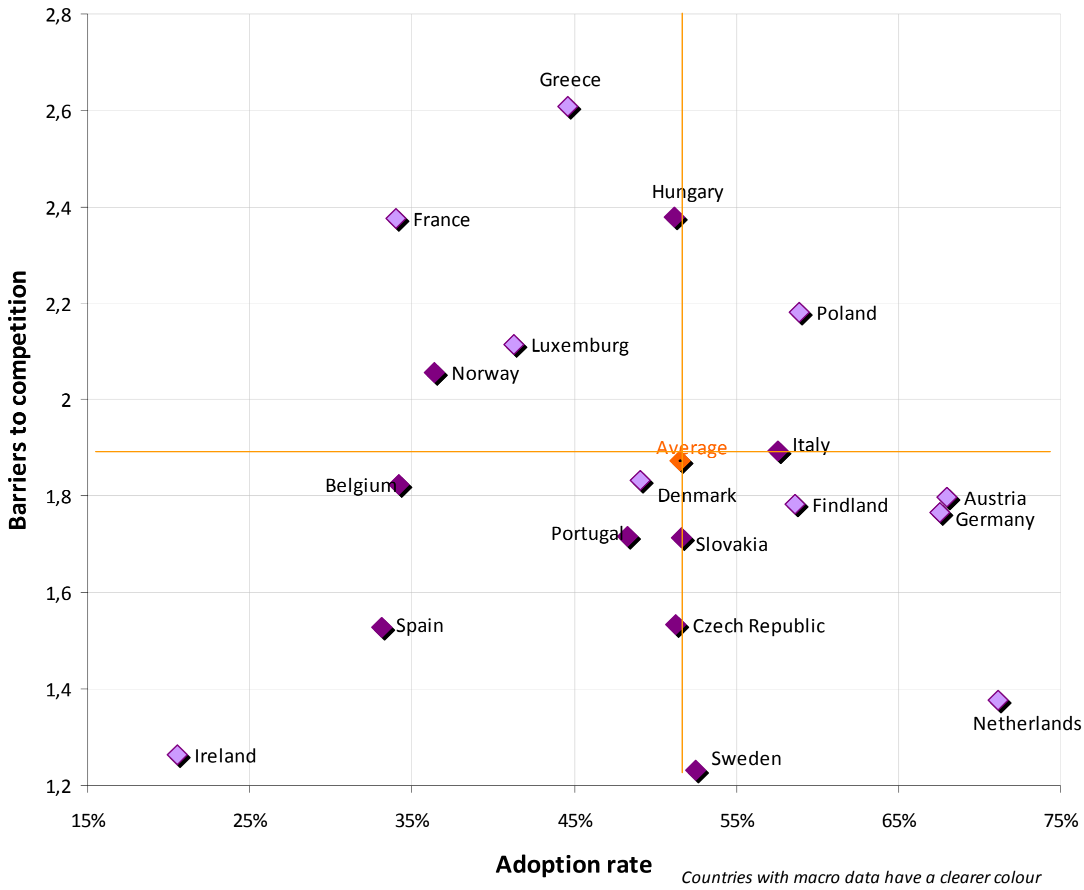
MAIN INSIGHT: We can observe that the most adoptive countries like Germany, Austria, and Netherlands have very small markup index (e.g. the highest level of competition), although such levels of high competition are observed for France, Spain and Belgium and they exhibit low levels of adoption rate. Additionally, Norway has a very specific profile since it has a very low competition level with a below the average adoption rate, which together with the case of the 3 countries commented above, force the relationship between the two variables to be negative. Without these four countries the relationship would turn to a positive value (correlation coefficient of 0.6616). However, with the whole sample of countries, **the correlation rate is not significant** (Pearson correlation=-0.0927, p-value= 0.7425) indicating that higher levels of competition are not significantly associated to higher innovation adoption rates.

The absence of significant correlation cannot be explained by a positive impact of competition on the overall level of innovation, that would reduce the denominator of our adoption rate. The correlation coefficient between mark-up and innovation rate is not significant. The correlation coefficient equals -0.0825 (with p-value: 0.77). Higher competition is thus not associated to higher innovation.

Although it is not a measure of competition, there is an indicator from the OECD Product Market Regulation indicators database called “barrier to competition” which is expected to be highly influencing competition. From this point of view, we think it can be of interest to analyse the relationship it maintains with the innovation adoption rates. This indicator can be interpreted as follows: “*In general, domestic barriers to competition tend to be higher in countries that have higher barriers to foreign trade and investment, and high levels of state control and barriers to competition tend to be associated with cumbersome administrative procedures and policies that reduce the adaptability of labour markets”*.

As already obtained above, the correlation analysis in Figure II.21 shows a non significant relation between this variable and adoption rates (correlation: -0.3637, p-value: 0.1259). **Countries with high levels of barriers to competition can have low adoption rates (France, Norway, Luxembourg and Greece) as well as high adoption rates (Hungary and specially Poland).** However, we should bear in mind that this indicator of barriers to competition should be understood as an explanatory variable of competition, as it is done in the regression analysis of Part III. The divergences between this indicator and the competition index presented on figure II.20 should also be noticed. This is due to the very different criteria entering into each of these indexes. This illustrates the subjectivity that arises in defining such variables and the necessary caution that is required for their interpretation.

Figure II.21. Adoption rate and barriers to competition index



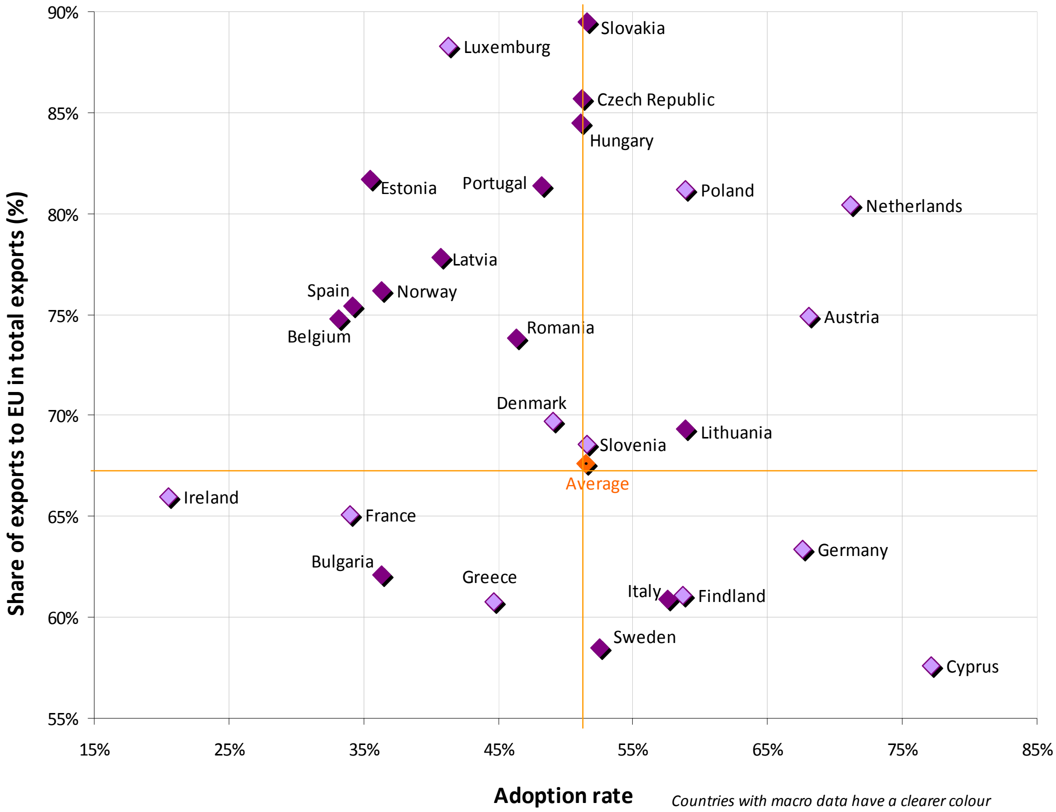
II.4.2.2. The innovation adoption rate seems not to be correlated neither with the level of trade nor with the barriers to trade

In this part, we assess to what extent the adoption rate in each country is associated with international trade and trade barriers. We wonder if the more opened countries record also the highest adoption rates. In CIS3 we had information on the total amount of exports, of each firm so that an indicator such as the share of export with respect to turnover could be used to proxy for trade. However, this information is not longer available in CIS4. This is way we will proxy trade through the information from EUROSTAT. Specifically, we consider the share that exports to EU countries represent on total exports of each country.

Is Trade in each EU member state related to Innovation Adoption and do barriers to trade have an impact on it?

1) **No, it seems that trade is not significantly related with innovation adoption**
2) **Barriers to trade do not seem to be correlated with the innovation adoption rates in the EU countries.**

Figure II.22. Export and international market in innovative firms and adoption rate



The relationship between trade and adoption will be explored more deeply in the econometric part. In particular, the absence of bilateral correlation may result from the impact of trade on overall innovation, which is the denominator of our adoption index. Therefore it is likely to lower the correlation observed between trade and adoption rate. However, once again this is not the case since trade is negatively (although not significantly) correlated with innovation (Pearson correlation: -0.2388; p-value: 0.2400). Therefore, it seems that higher trade is not related neither with higher innovation rates nor higher adoption of innovation.

Additionally, although not measuring trade but proxying for regulatory variables that may affect trade, we find an indicator named "Regulatory trade barriers" and more specifically "Non-tariff trade barriers" from the Economic Freedom World report. This variable is based on the Global Competitiveness Report's survey question: "*In your country, tariff and non-tariff barriers significantly reduce the ability of imported goods to compete in the domestic market.*" The index varies between 0 and 10. It is high if a country has low non-tariff trade barrier, that is to say, if the freedom of exchange across national boundaries is important.

Figure II.23. Adoption rate and non-tariff trade barriers index

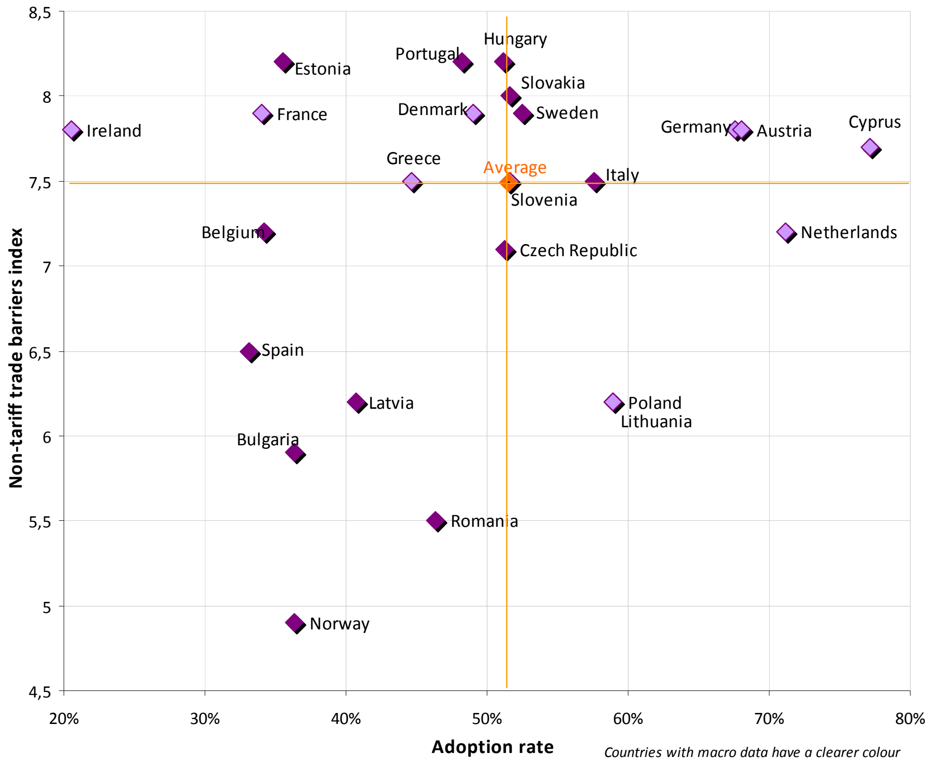


Figure II.23 shows a positive although not significant link between this variable and innovation adoption rates. The positive link would be expected if looking at the countries with low values for the index (so, with high non-tariff trade barriers) recording low adoption rates (Norway, Bulgaria, Latvia, Spain and Romania) which are more numerous than the ones with high adoption rates (but this is the case for Netherlands, Poland and Lithuania). However, countries with low non-tariff trade barriers (high values for the index) have equally low and high adoption rates, leading to the non-significance of the correlation.

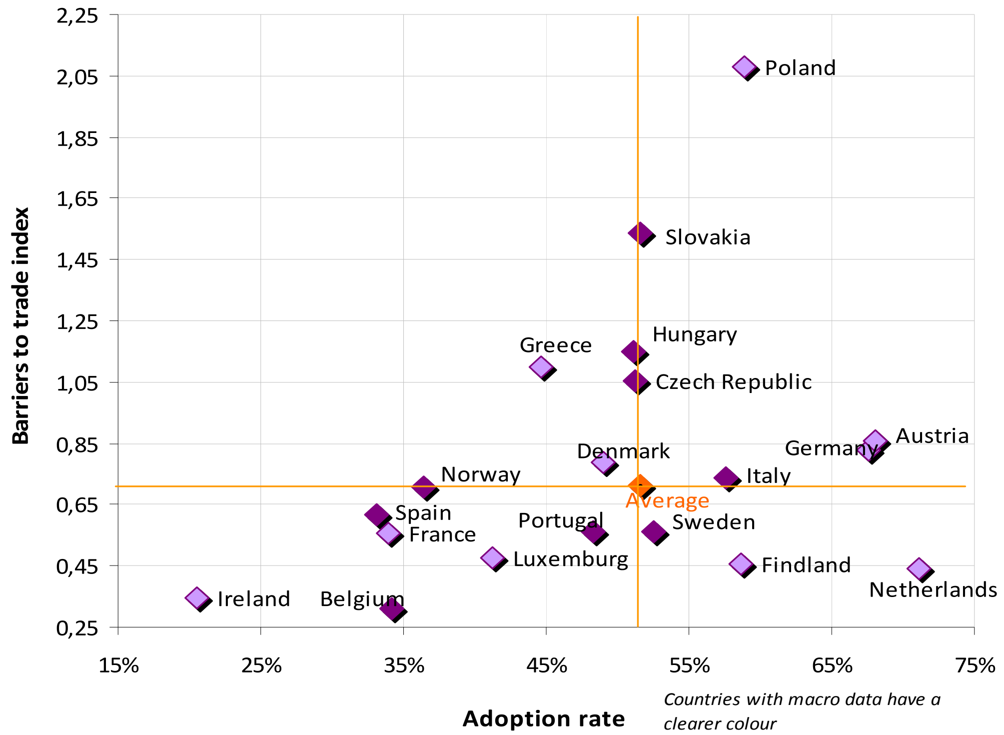
Finally, we cross with adoption rates a last variable that we find more general but missing for seven countries[24]. This variable named "Barriers to trade and investment" comes from the OECD Product Market Regulation indicators database. This synthesis variable contains information about ownership barriers, discriminatory procedures, regulatory barriers and tariffs[25] (higher value of the index indicating higher barriers to trade). Figure II.24 shows a positive but insignificant correlation between the two variables. We can see that in general terms countries with high barriers to trade record the highest adoption rates (Poland, Slovakia,

24 Bulgaria, Estonia, Lithuania, Latvia, Romania, Cyprus and Slovenia.

25 For more details, see P. Conway, V. Janod and G. Nicoletti, 2005, Product Market Regulation in OECD Countries: 1998 to 2003. Economics department working papers n° 419.

Hungary and Czech Republic) whereas the ones with lowest barriers exhibit lower adoption rates (Ireland, Belgium, Spain, France, Luxembourg, Portugal and Norway), a positive correlation that has little interpretation in economic terms. Although this positive correlation seems counterintuitive, this could be to the fact that barriers to trade could have a more clear positive relationship with innovation rates, pointing to the fact that higher barriers to trade would be related to more innovation (against theoretical arguments) increasing the denominator of our adoption index. And although not significant, this seems to be the case according to the positive value of this correlation, 0.1366 (p-value=0.577), with the conclusion that more trade barriers imply more innovation. All in all, these results would point to the fact that weaker barriers to trade would be related to less innovation mainly carried within the firms and also adopted with or from others. However, a completely different profile is found for Netherlands, Finland and Sweden which are countries with low barriers to trade and high innovation adoption levels.

Figure II.24. Adoption rate and barriers to trade index



MAIN INSIGHT: The correlation between the adoption rate and the export share is equal to -0.1574 (p-value = 0.442). **Therefore, the proxy for trade is negatively correlated to innovation adoption although not significantly**. Also non-significant is the correlation between the two variables used to proxy for barriers to trade.

We can therefore conclude that, **no matter which the indicator for the barriers to trade is, we do not obtain a significant correlation with the innovation adoption rates in the EU**. The insignificant correlation found for the overall innovation adoption indicators is shown also in the case of the disaggregated items product and process innovation adoption[26]. This result even contradicts the idea that especially product innovation adoption is affected by barriers to trade due to the fact that innovation in products is embodied in tradable goods and when trade is made more difficult (by any kind of barrier) then also innovation spills over less rapidly. This is not true for product neither for process innovation adoption.

II.4.3. Regulatory environment and adoption rate

As shown in the review of the literature (Part I), another important issue regarding the main drivers of innovation diffusion/adoption refers to the regulatory environment. In this sub-section we present how some of these regulations can be measured and make a descriptive analysis of the relation they maintain with innovation adoption. Specifically, we firstly consider patents and other protection methods and secondly we refer to several indicators about the functioning of the Internal Market.

II.4.3.1. Patents and other protection methods and adoption rate

Intellectual property rights (IPR) appear as an important issue for innovation diffusion/adoption, although without a consensus on the direction of the impact. On the one hand, the literature review on IPRs shows that they can improve diffusion. Innovators are obliged to reveal the content of their invention which increases the potential of related innovations. It also gives incentives to improve existing technologies, which is likely to facilitate their adoption. On the other hand, IPRs may prevent adoption by forbidding external agents to use the technology (except if they pay for a licence). In order to address which of these effects are preeminent, we aim at providing the correlation that IPRs maintain with innovation adoption. Several items of the CIS may be used to proxy for IPRs. We first consider the patenting activity through the consideration of the number of patent applications made by the firms in each country (A). Then, we make some comparisons with the

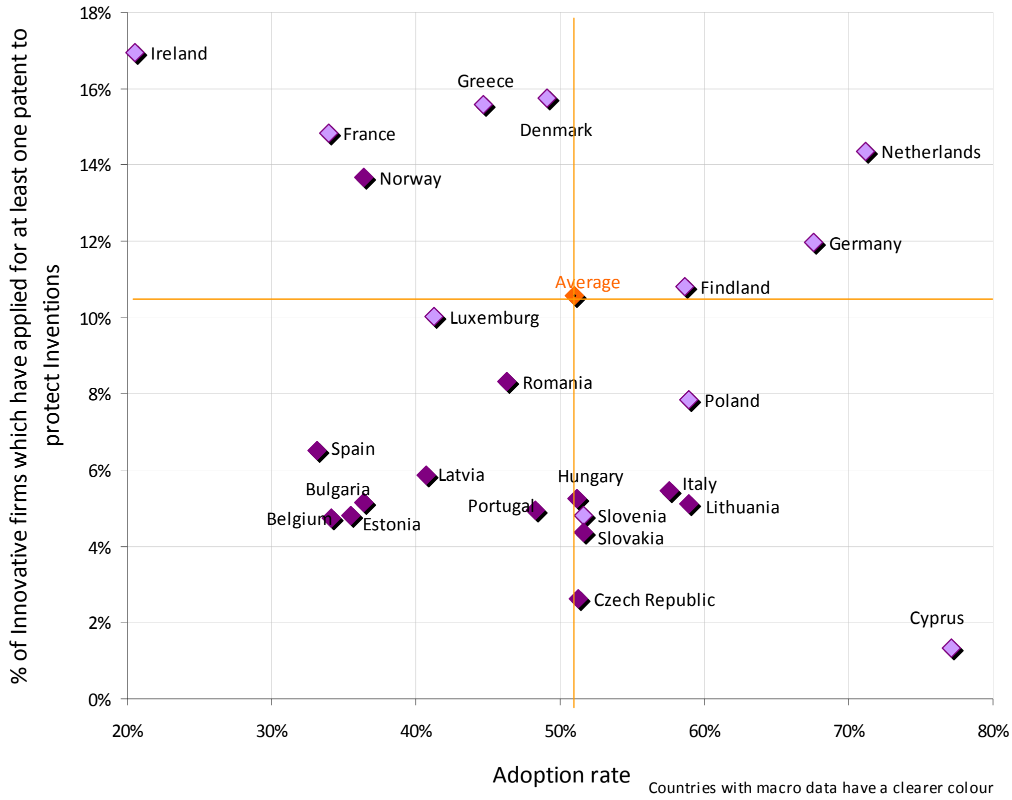
[26] Results are detailed in Appendix II.6 for both product and process innovation adoption separately.

information on other legal and informal protection methods also given in the CIS (B). Finally, we provide a different view about IPRs, using data on the index on "Security property rights" from the Economic Freedom of the World (C).

A. Patenting is one of the main legal protection mean for firms but not the most widely used. 8% of the innovative firms declare having applied for a patent. However, the number of patent applications can be very different according to the sector and the nature of inventions. By country, we can observe large differences in terms of percentage of innovative firms having applied for at least one patent. As shown in Figure II.25, this percentage varies between 2% (for Cyprus) and 17% (for Ireland).

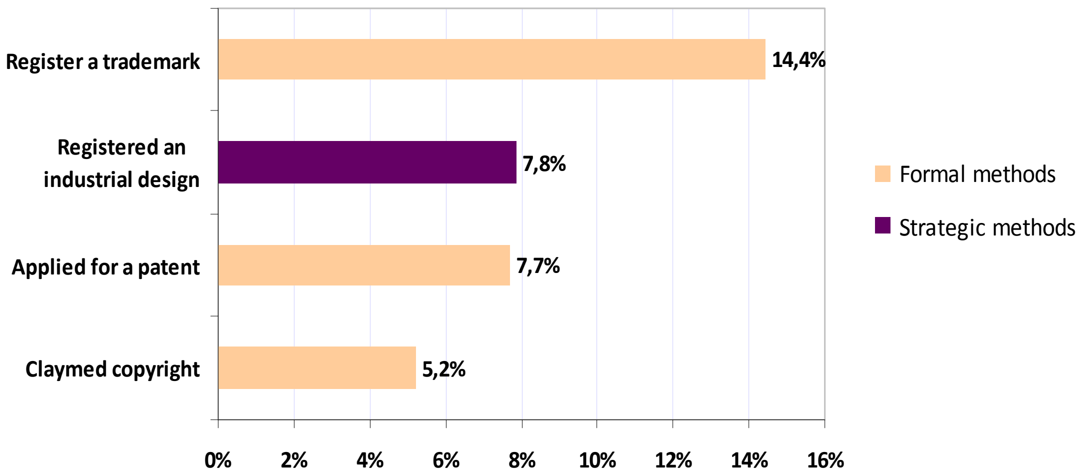
According to Figure II.25, we do not observe any clear pattern between patenting activity and adopting innovations. It is the case of some Eastern European countries (Hungary, Lithuania, Slovakia, Slovenia and Czech Republic) and Southern countries (Italy and Portugal to a lesser extent) of having low level of patenting activities with high adoption rates. However, other Eastern countries such as Bulgaria, Estonia and Latvia have little patenting activity together with little adoption rates. On the opposite side, we find the countries of the Netherlands, Finland and Germany with adoption rates over the average as well as high patenting activities. In line with such different profiles we obtain a negative although not significant Pearson correlation (Pearson correlation = -0.0743; p-value=0.7301). However, if we drop the extreme cases of Ireland and Cyprus, the correlation becomes positive (although not significant). We conclude therefore that **there is not a clear relationship between levels of patenting activities and the levels of innovation adoption.**

Figure II.25. Adoption and patents application to protect inventions



B. Other legal and informal protection methods. From the CIS database, we can observe that patent application is not the most used method to protect inventions (Figure II.26). Indeed, another formal method such as registering a trade mark and a more strategic than formal method such as registering an industrial design are respectively more (14%) and equally (almost 8%) used. On the opposite, copyright (5%) is the less used by EU firms.

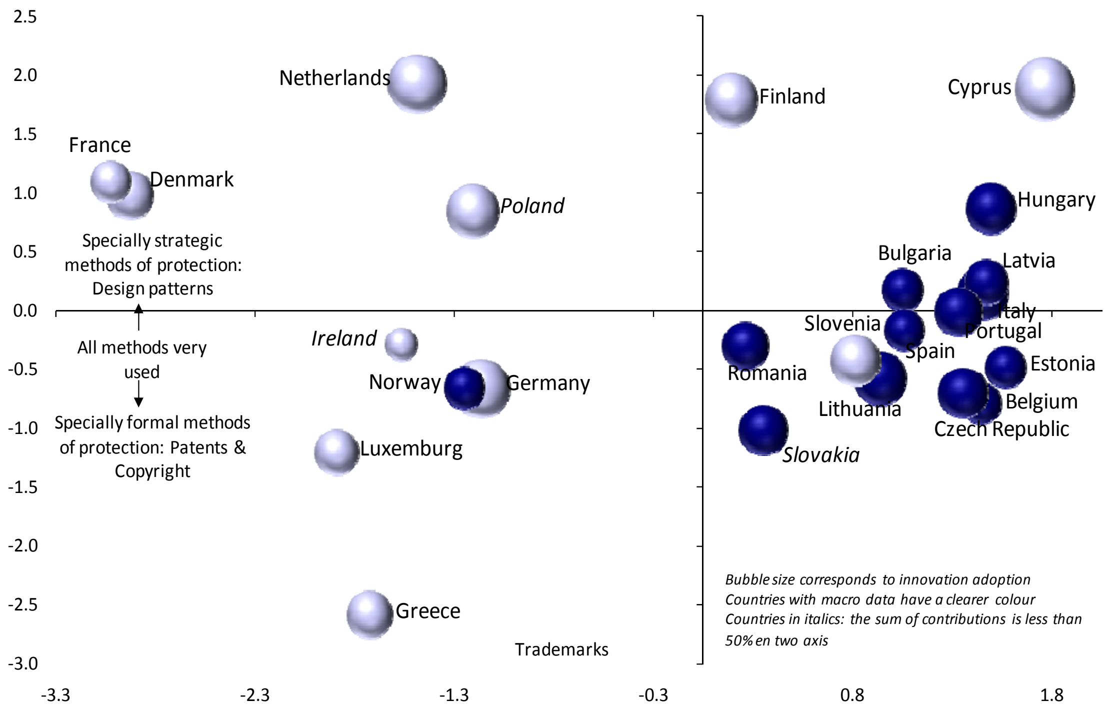
Figure II.26. Percentage of innovative firms using intellectual protection methods



Which is the relationship between the use of different innovation protection methods and innovation adoption in EU member states?

It seems that the highest adoption rates are shown in countries in which the recourse to protection of invention and more specifically strategic methods is frequent. Statistically we obtain that average adoption rates are significantly different according to the several groups of countries identified according to different profiles in the use of invention protection methods.

Figure II.27. Adoption and invention protection methods



MAIN INSIGHT: Different countries profiles can be distinguished in terms of the use of invention protection methods (Figure II.27, see appendix II.5 for more detail on the PCA):

- The first (Netherlands, France, Denmark and Poland) and second (Ireland, Norway, Germany, Luxembourg and Greece) groups are characterized by an important use of all methods. For the first group, the percentage of firms having recourse to strategic methods is particularly high, whereas for the second, it is the use of formal methods of protection.
- On the opposite, in the third group (that brings together most of Eastern countries plus the Southern ones) the use of protection methods is not very important and the recourse to strategic methods is particularly low.

If we cross these different groups with the adoption rate (bubble size), we can observe that countries with **highest adoption rates are either** in the first or in the second group, that is to say, **for countries in which the recourse to protection of invention is frequent. However, there is an exception, Cyprus, for which the use of protection methods is not very important and which exhibit high adoption rates, a result that would be in line with some other Eastern countries (Czech Republic, Slovakia, Slovenia and Hungary).** A one-way analysis variance shows that **average adoption rates are significantly different for the groups identified according to the different patterns in the use of invention protection methods** (F-statistic being equal to 3,427 and the significance value of the F-test being to 0,037).

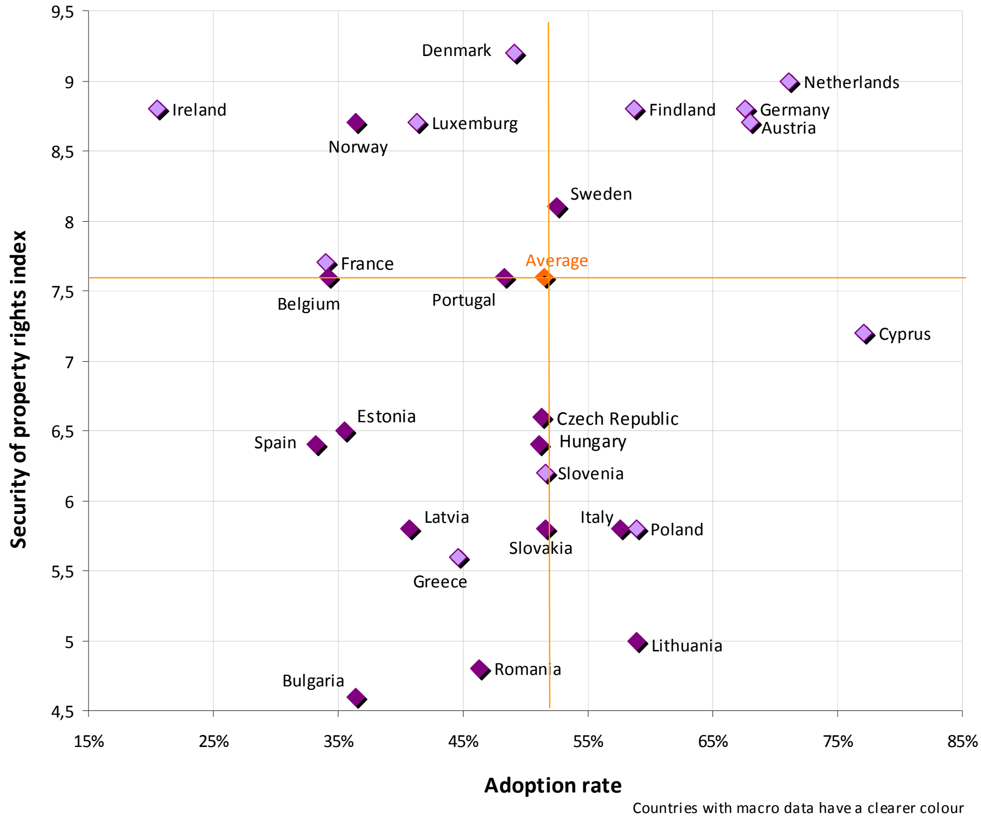
In the Appendix II.6 we obtain that among the different methods to protect inventions, only the one of registering a trademark is significantly correlated with adoption rates showing that registering an industrial design implies lower adoption of innovation. This negative and significant link is also observed for the disaggregated cases of process and product adoptions. Additionally, registering a trademark seems to be negatively associated with adoption of product innovations, but not in the case of processes.

C. Security of property rights. In order to examine more deeply the relationship between adoption rates and invention protection methods, we use now an indicator provided by the Economic Freedom of the World concerning the security of property rights.[27] This index is computed from the Global Competitiveness Report's question: "Property rights, including over financial assets are poorly defined and not protected by law (= 1) or are clearly defined and well protected by law (= 7)." This way, high values of the index indicate high protection levels.

Figure II.28 shows that there is not a clear pattern between the security of property rights and the adoption rates since we find countries equally distributed in the four quadrants. However, a specific profile seems to be that of Ireland (very high property rights with very low adoption rates). The Pearson correlation is not significant with all countries (coefficient= 0.3204, p-value= 0.1106) but it becomes significant at 10% level if we drop Ireland and Lithuania (coefficient= 0.3743; p-value = 0.0716).

[27] The Economic Freedom Network considers security of property rights, protected by the rule of law, as essential to economic freedom: "*Freedom to exchange, for example, is meaningless if individuals do not have secure rights to property, including the fruits of their labor. Failure of a country's legal system to provide for the security of property rights, enforcement of contracts, and the fair and peaceful settlement of disputes will undermine the operation of a market-exchange system. If individuals and businesses lack confidence that contracts will be enforced and the fruits of their productive efforts protected, their incentive to engage in productive activity will be eroded*" (page 11 of the 2007 Annual Report of Economic Freedom of the World).

Figure II.28. Adoption rate and security of property rights according to country



II.4.3.2. Internal Market and adoption rate

As detailed afterwards in Part III, it is not easy to account for the impact of IM on innovation adoption. Only indirect indicators can be used. A first set of indicators refer to **the Transposition Deficit Index,** which measures the percentage of Internal Market directives communicated as having been transposed (A). A second set of indicators can be extracted from the **Economic Freedom of the World** report and refer **to Product Market Regulations** (B). Finally, we will consider the indicator of **Product Market Regulation of OECD** (C). These indicators are presented below as well as their correlation with innovation adoption.

A. Transposition Deficit Indices (TDI). Two indicators of TDI are used in what follows: the global one that covers the 12 areas of EU directives (agriculture, environment, enterprise, innovation, competition, internal market, justice, energy, employment, taxes, education and health) and the specific low-level indicator that accounts for internal market directives in particular. This way, the first one is a more general one that, among other 11 subindicators, considers our second indicator. The higher the value of these indicators, the higher the transposition of EU directives.

Is the adoption of EU regulations and directives clearly associated to higher rates of Innovation Adoption across countries?

We can not conclude in general terms that those countries where more EU regulations and directives are enforced tend to display also higher rates of Innovation Adoption. However, we achieve such conclusion when analysing the specific relationship with Internal Market directives. Therefore, the transposition of EU directives seems to favour Innovation Adoption.

Figure II.29. Adoption rate and global transposition deficit indicator

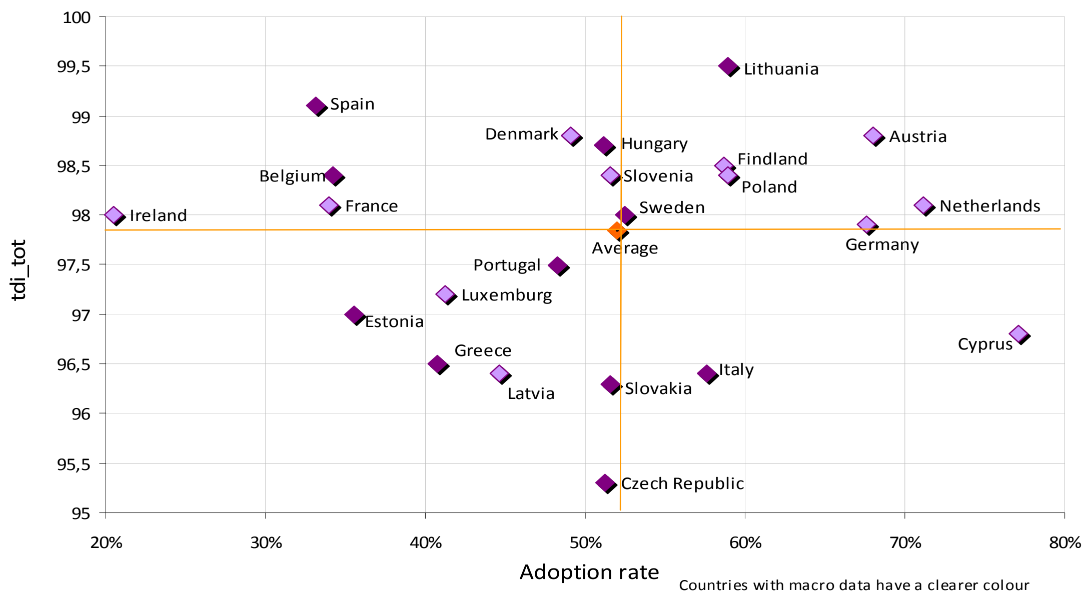
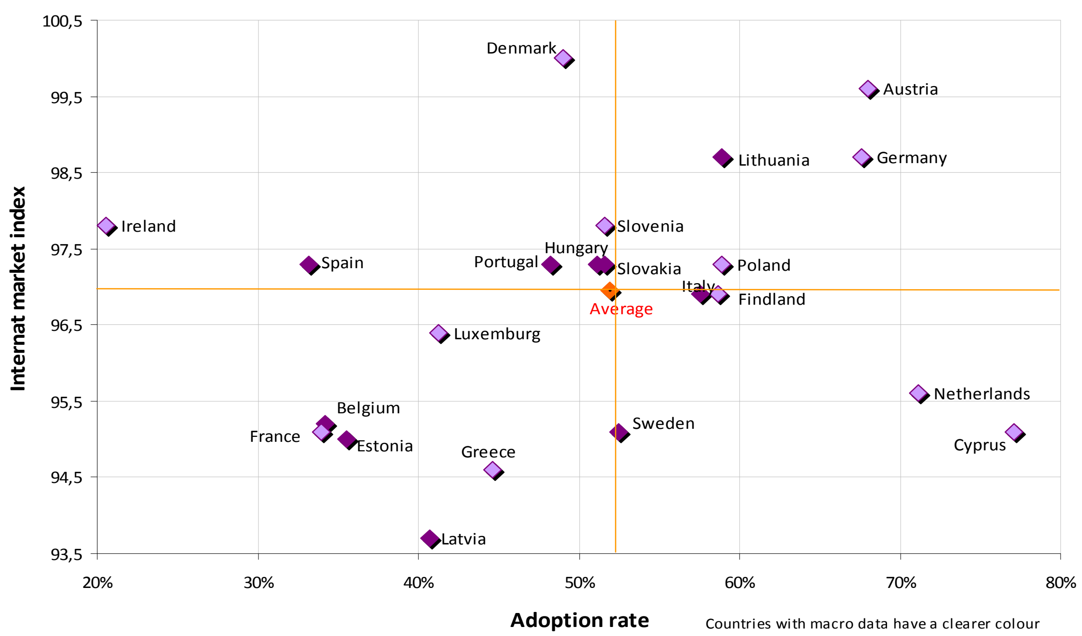


Figure II.30. Adoption rate and internal market transposition deficit indicator



MAIN INSIGHT: If we first consider the global TDI (Fig.II.29), a negative but non-significant correlation is observed (Pearson correlation of -0.2811, p-value: 0.1938)**.** We find countries distributed in the four quadrants. **It seems therefore that, in general terms, for most cases the lower the level of transposition of Community law, the higher the level of adoption of innovation and the other way around, although it is not statistically significant**.

However, the internal market TDI gives us a more accurate view of the correlation between Internal Market and innovation adoption activities. Except the two countries exhibiting extreme values for adoption rates (Cyprus and Ireland), **the countries that have transposed most of the EU internal market directives tend to present the highest adoption rates** (Austria, Germany, Slovenia, Slovakia, Poland, Hungary). Conversely, countries with the highest deficit of transposition (France, Belgium, Estonia, Greece and Latvia) are characterized with some of the lowest rates of adoption. The correlation coefficient is therefore positive and significant if we eliminate Cyprus and Ireland (correlation coefficient of 0.6088, p-value: 0.0034).

Also, when we focus on product and process innovation adoption separately we can observe how the Transposition Deficit Indicator in the Internal Market (where higher values correspond to higher transposition rates of EU regulations in the Internal Market area) are found to be statistically correlated to Innovation Adoption (product and processes)[28].

B. Product Market Regulation indicators by the EFW. In addition to the above measures of the IM, we can use another kind of proxy, accounting for product market regulations. A first set of variables come from the Economic Freedom of the World report, covering 5 areas:

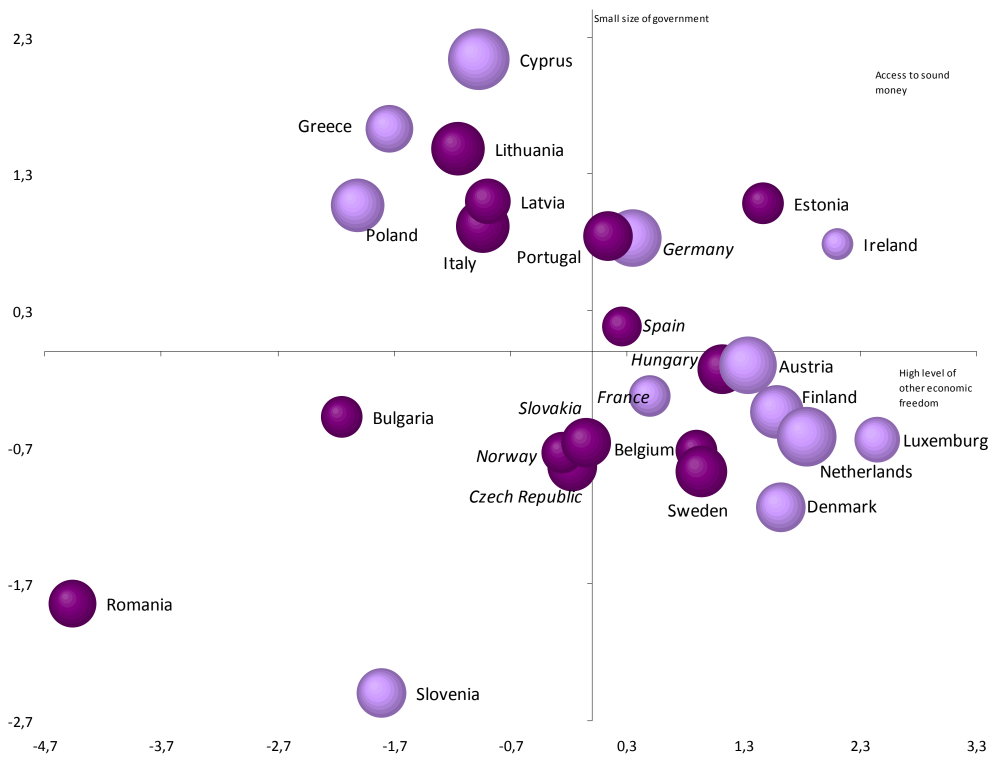
- Size of government: Countries with low levels of government spending as a share of total, a smaller government enterprise sector and lower marginal tax have the highest rates.
- Legal structure and security of property rights: The higher is the protection of property in the country, the higher the index rate.
- Access to sound money: The index shows high rates for countries that follow policies and adopt institutions that lead to low and stable rates of inflation and avoid regulations that limit the use of alternative currencies.
- Freedom to trade internationally: High rates of the index for countries that have low tariffs, a trade sector larger than expected, easy clearance and efficiency of administrations customs, a freely convertible currency and few controls on the movement of capital.

[28] Results are detailed in Appendix II.6 for both product and process innovation adoption separately.

- Regulation of credit, labor and business: The index displays high rates for countries allowing markets to determine prices and refrain from regulatory activities that retard entry into business and increase the cost of producing products.

Therefore, all the indices have the same interpretation: high values correspond to better performance of the regulations and therefore of the system. In the PCA below (Figure II.31)[29] on the same axis we represent the ones of Legal structure and security of property rights, Freedom to trade internationally and Regulation of credit, labour and business, under the label of Other Economic Freedom. The second axis represents the Size of the government expenditure. This PCA allows us to cross the information about economic freedom with the adoption rates (represented by the bubble size). **The largest bubbles, associated to higher innovation adoption rates tend to be in those countries that exhibit higher levels of economic freedom, specially related to legal structure, money and market regulation, and a small size of the government.**

Figure II.31. Economic freedom and adoption rate



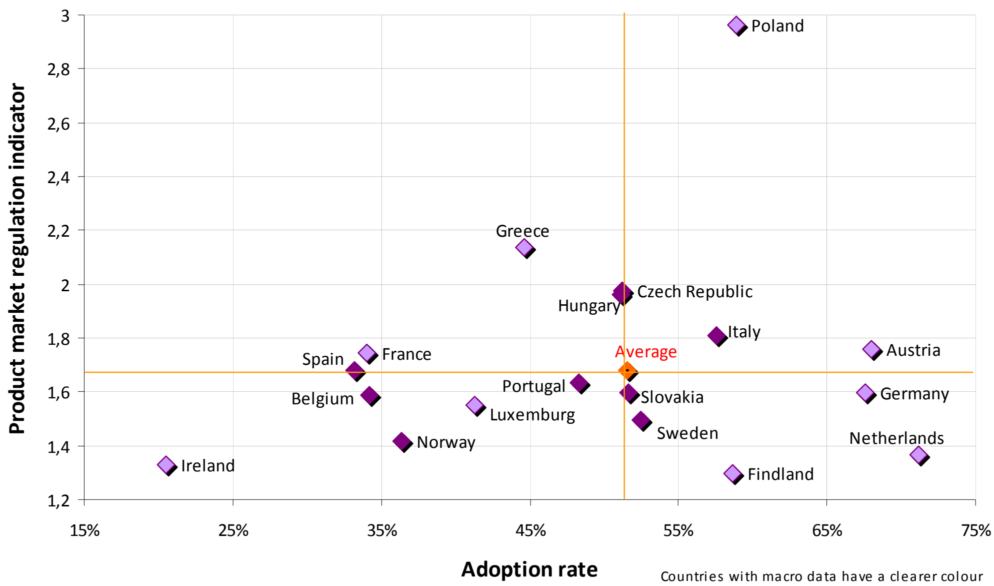
[29] See Appendix II.7 for more details on the PCA.

C. Product Market Regulation indicators by the OECD. Finally, we can use the Product Market Regulation indicator built by OECD, for which higher values imply tighter and burdensome regulation. In other words, the lower the value of the indicator, the better it is for the system since it implies that there is less burdensome product market regulation.

Does burdensome Product Market Regulation have a relationship with Innovation Adoption?

No, lower product market regulation does not seem to be significantly associated to higher rates of Innovation Adoption on a EU cross country basis.

Figure II.32. Adoption and product market regulation



MAIN INSIGHT: There is not a clear pattern of relationship between levels of regulation and those of adoption, as signalled by the negative but not significant correlation coefficient (Pearson correlation of -0.0707, p-value: 0.7737). Even if we drop Ireland and Poland (two countries with extreme values for product market regulation) we observe that the correlation between the two variables keeps being negative and non-significant (Pearson correlation of -0.2801, p-value: 0.2762). Therefore, with the exception of these two countries, we can conclude that c**ountries with high levels of regulation are characterized by low levels of adoption**. This result confirms the hypothesis of a positive effect of the IM objective of reducing barriers in the product market on the adoption of innovation.

There is not a clear correlation between total innovation adoption rates and Product Market Regulation, PMR (where higher values of the PMR index indicate burdensome and oppressive regulations), although once the extreme cases of Ireland and Poland are eliminated, it seems that countries with high regulation tend to present low innovation adoption. The same happens in the case of product and process innovation adoption[30] where a non-significant correlation is found. Results do not show significant coefficients of the correlation matrixes indicating the relationship between adoption of innovation and oppressive market regulations at the country level.

In Table II.6 we offer a summary of the determinants of innovation adoption for which we have analysed their correlation with adoption rates. The result of such relationship obtained through the descriptive analysis is specified not only for the case of CIS4 done in this report but also for the case of CIS3 as in the previous report (Suriñach et al, 2009). In bold you find the conclusions that are maintained across time, whereas in green colour those that have changed from being non-significant to being significant, and the ones that have gained significancy across time are given a yellow colour.[31]

All in all, it seems that there is not a clear correlation between most of the variables proxying the potential determinants of innovation adoption and itself. In fact, although not with all the indicators used to proxy for the functioning of the IM, for many of them the correlation they maintain with the adoption of innovation is significant or, at least, among the most significant of all the determinants. **Reducing the intrusiveness of the government and favoring free circulation of goods, people and fostering competition at all levels seems to be associated to higher rates of innovation adoption.** However, we must keep in mind that our IM proxies may be strongly correlated to other determinants of adoption. The clear impact/effect of IM must be addressed through econometric tools only, in order to control for the effect due to other variables. This is done in Part III of this project.

[30] Results are detailed in Appendix II.6 for both product and process innovation adoption separately.

[31] See Appendix II.8 for a summary of the variables used in this Part II.

Table II.6. Potential determinants of innovation adoption analysed in the descriptive

DETERMINANTS	CORRELATION OBTAINED WITH INNOV ADOPT RATES. CIS3	CORRELATION OBTAINED WITH INNOV ADOPT RATES. CIS4
A. Innovation inputs		
▪ Sources of information	Non-significant	Non-significant
▪ Innovation expenditure	**Positive although not always significant**	**Positive and significant**
▪ Human capital resources	Non-significant	Non-significant
▪ Organisational changes	**Positive and significant**	**Positive and significant**
▪ Cooperation in joint R&D	Non-significant	Non-significant
B. Market features		
▪ Competition	Non-significant	Non-significant
▪ Barriers to competition	Non-significant	Non-significant
▪ Trade	Non-significant	Non-significant
▪ Barriers to trade	Negative and significant	Non-significant
C. Regulatory environment		
➢**Protection methods**		
▪ Patenting	Positive and significant (without France and Sweden)	Non-significant
▪ Other legal/informal methods	Non-significant	Significant
▪ Security of property rights	Positive and significant (without Luxembourg)	Positive and significant (without Ireland and Lithuania)
➢**Internal Market regulations**		
▪ Transposition Deficit (high value: high transposition of EU directives)	**Positive and significant**	**Positive and significant (without Cyprus and Ireland)**
▪ Product Market Regulations by EFW (high value: better performance of regulations)	**Positive and significant**	**Positive and significant**
▪ Product Market Regulations by OECD (high value: tighter and burdensome regulation)	Negative and significant	Non-significant

II.5. Time profile of innovation adoption in EU countries

Although the descriptive analysis of adoption rates using CIS3 was made in the final report of the previous project and that with CIS4 has been done in section II.3 of this report, we turn not to shed some light on the time evolution of adoption in EU countries according to the data in these two waves of the survey. This is done therefore by comparing the adoption rates recorded in the CIS3 over the period 1998-2000 and the adoption rates recorded in the CIS4 over the period 2002-2004 for the countries for which such information is available in the two waves[32]. The two periods are not very distant but they may help us to observe some changes over time. In addition to a global evolution of adoption, these two waves of survey may provide some information about potential changes in the way adoption occurs, by confronting the evolution of cooperation-based adoption to the one of other organization-based adoption.

II.5.1. Towards a more process-oriented adoption

The two figures below (Fig II.33 and II.34) show that **the average product adoption decreases by 2 points of % and process adoption increases by 2 points of %.** Therefore, there is not a conclusive evolution for general adoption rates but they must be studied separately for product and process innovations.

When crossing this information with the change of innovation rates, it appears that **the behaviour in adoption is associated with the evolution in innovation**. Product adoption decrease does go together with a decrease in product innovation (-5.4 points of %) and process adoption increase is associated with a increase in process innovation (3.5 points of %). Therefore, we conclude that in general terms in Europe, innovation and innovation adoption present different evolutions according to the type of innovation: between the two periods under analysis product innovation has decreased whereas process innovation has augmented, both the one carried out internally and the one made in cooperation with others or outsourcing it from others.

[32] Although the sector of Financial Intermediation was not included in the descriptive analysis carried out with CIS3, it is now considered in order to make comparability feasible with that of CIS4. Therefore, it is included in the figures presented in this section.

Figure II.33. Change in product adoption and innovation rates by country (in percentage points)

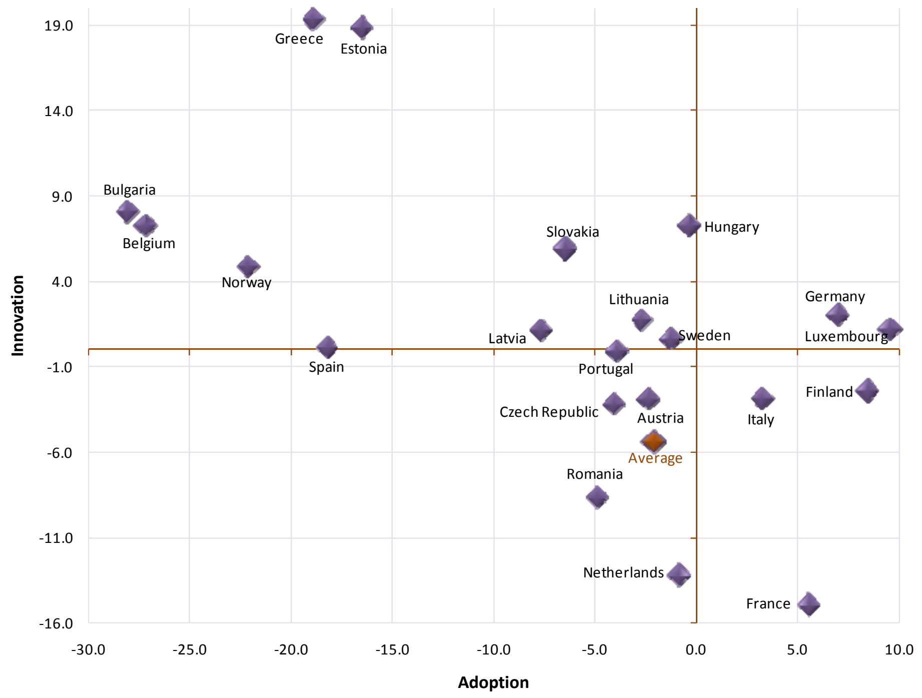
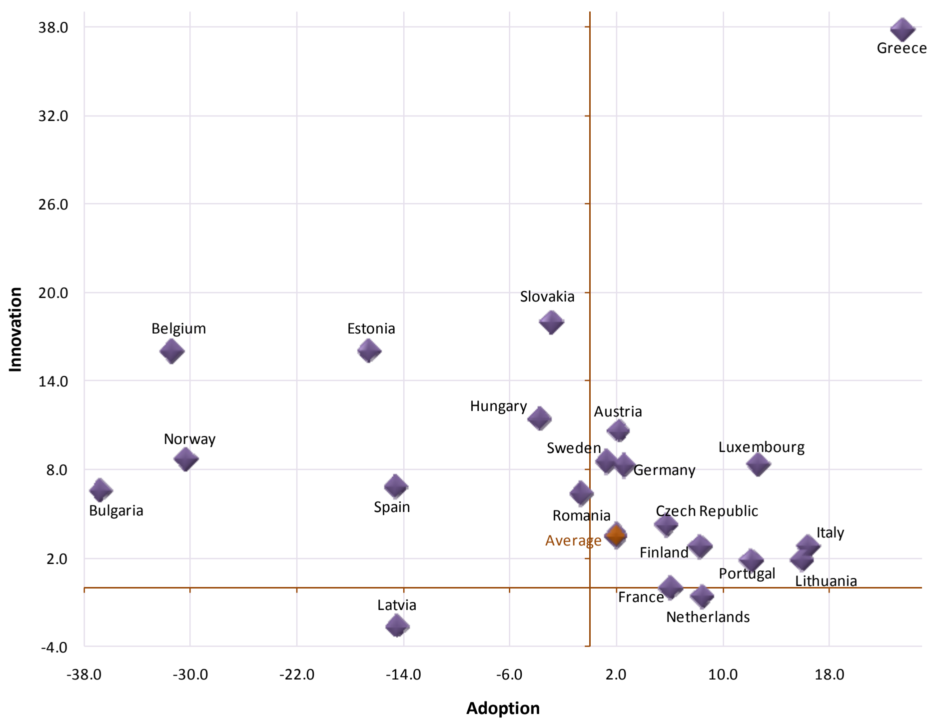


Figure II.34. Change in process adoption and innovation rates by country (in percentage points)



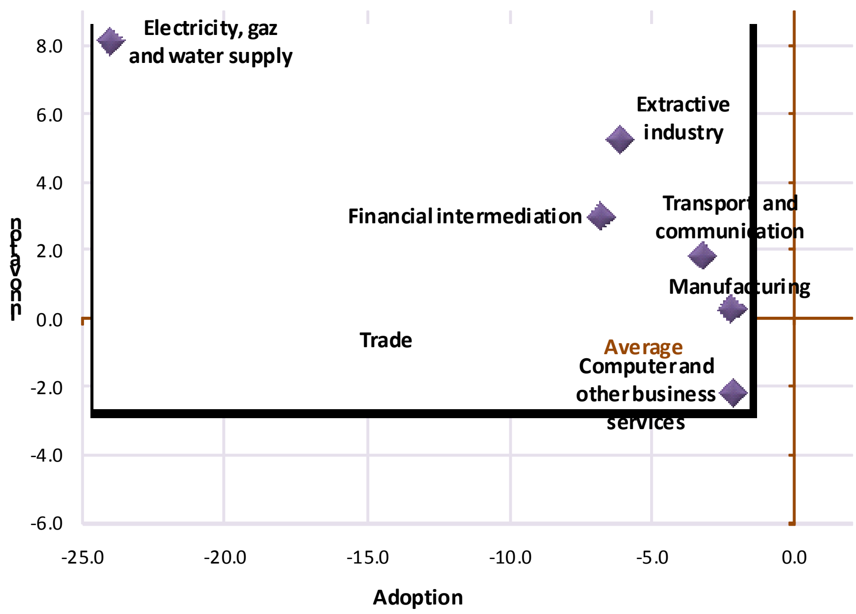
In the case of product innovations, this global trend is not shared by all countries. From the first graph above, we can distinguish four groups of countries, corresponding to each quadrant of the figure. In the bottom right quadrant, only three countries (France, Italy and Finland) record an increase of the adoption rate but a decrease of innovation: although less firms innovate, now they rely more on adopting it from/with others. In the bottom left quadrant, we can observe countries facing a reduction in both their product innovation and product adoption capability. This is particularly the case for Netherlands, Romania, Czech Republic and Austria. On the opposite, the top right quadrant has only Luxembourg and Germany as the only two countries that improve both its product innovation and product adoption capability. Finally, the rest of the countries exhibit innovation rate increases while their adoption rates decrease: they innovate more but tend to do it internally within the firm.

The picture is quite different **for process innovation.** In this case, **all countries except Latvia face a positive trend for innovation whereas their adoption rate can either increase or fall.** Belgium, Norway and Bulgaria are the ones experiencing higher falls in adoption rates: they innovate more but internally. Contrarily, Greece, Italy, Lithuania, Luxembourg and Portugal present the biggest increases in adoption rates (an increase of more than 10 percentual points) together with increases in innovation, implying that they innovate more but they rely more on adopting from/with others than in generating innovation within the firm.

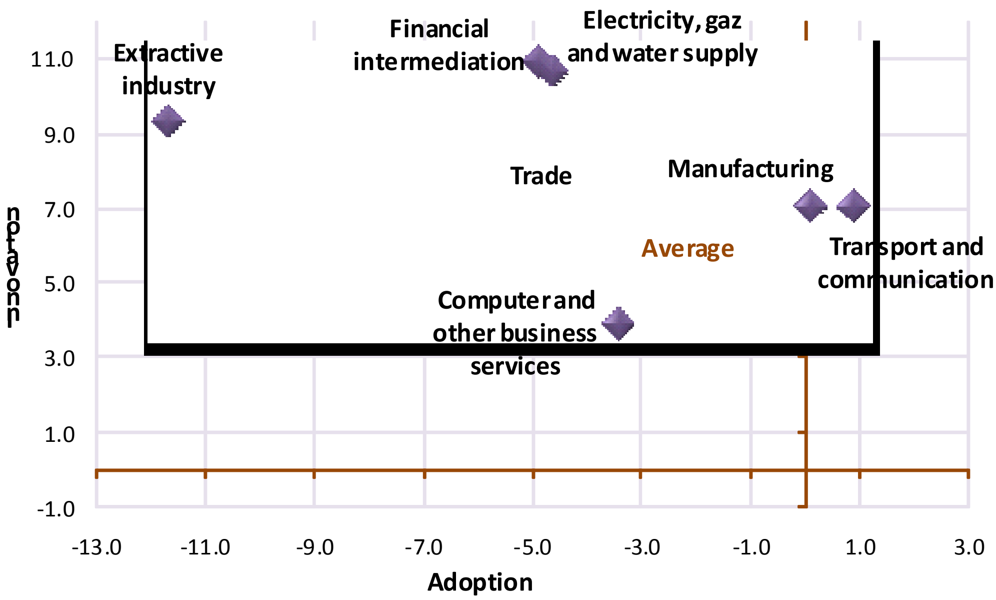
The analysis by sector confirms that we move towards a less innovative adopting economy for the case of product innovations; however, at the sectoral level, even process innovation decreases (Fig II.35 and II.36). Regarding product innovation, all sectors face decreases in their adoption rates. An evolution that goes together with decreases in their innovation rate in the sectors of Trade and Computer and other business services. On the opposite, the 5 remaining sectors are characterized by an increase in their innovation rates, meaning that firms in such sectors have innovated more to obtain new products but have carried out such innovation more internally than outsourcing.

Again, the picture for process innovation presents some important differences. Innovation increases in all sectors, together with decreases in adoption rates (except for the case of Transport and communication). Again, the percentage of firms generating innovation output in the form of new processes is superior now, but this is associated with an increase in the percentage of firms deciding to do it internally. The only exception, as commented above, is the sector of Transport and communication where there are more firms innovating new processes and the percentage of them that have decided to adopt this innovation, either in cooperation or outsourcing, is even higher, so that the adoption rate increases.

Figure II.35. Change in product adoption and innovation rates by sector (in percentage points)



FigureII.36. Change in process adoption and innovation rates by sector (in percentage points)



II.5.2. Divergence in the evolution of the nature of adoption for product and process innovation

Some changes in the way adoption occurred can also be observed. **Concerning product adoption** (figure II.37), **firms tend to rely more on cooperation-based and less in other organisation-based adoption activities**. The percentage of cooperation based adoption increases by 1 percentage point between CIS3 and CIS4 while the percentage of other organization-based adoption decreases by 2 percentage points. For the five countries that exhibited positive changes in product adoption rates (Germany, Italy, Luxembourg, Finland, and France), the three latter increase both cooperation and other organization-based adoptions. In contrast, Italy and specially Germany increase their adoption rate due to more cooperation agreements in innovation whereas they have trusted less in purchasing product innovations from others.

By sector (figure II.39), we arrive at the same conclusion that as far as product innovation is refered, firms tend now to decrease both their cooperation and their other organisation-based adoptions: the only two exceptions are Extractive industry that exhibit slight increases in other organisation-based adoption and Transport and Communication that increases the adoption rates coming from cooperation with other firms.

Process adoption is characterized by a different evolution: **we observe a general increase in other organization-based adoption**. This fact is observed for 16 countries among the 21 countries for which data is available in both time periods (fig II.38). However, in 5 out of these 16 countries increasing other organisation-based adoption we observe decreases in the cooperation rates (Hungary, Slovakia, Spain, Latvia and Austria). Therefore, product and process innovations do not face the same exact evolution in the way adoption is conducted. By sector (Fig II.40), the increase in both cooperation and other organisation based adoption is noticed for Manufacture and Transport and communication. For the other sectors, the cooperation tends to decrease while the other organisation-based adoption increases.

Figure II.37. Change in product cooperation-based adoption and other organisation-based adoption by country (in percentage points)

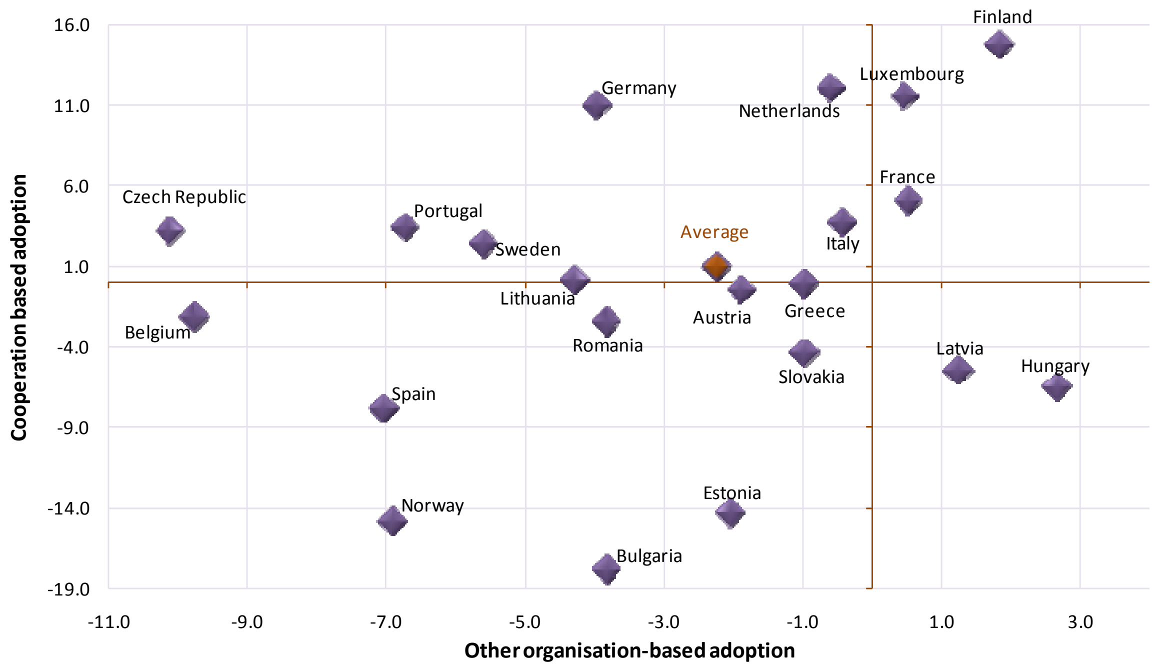


Figure II.38. Change in process cooperation-based adoption and other organisation-based adoption by country (in percentage points)

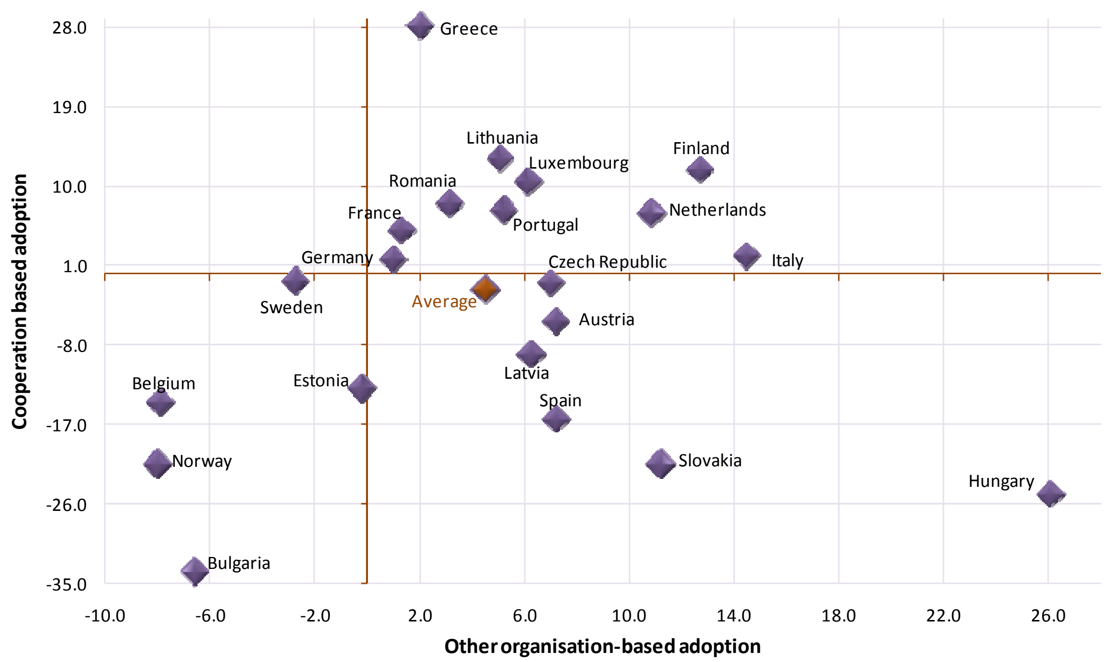


Figure II.39. Change in product cooperation-based adoption and other organisation-based adoption by sector (in percentage points)

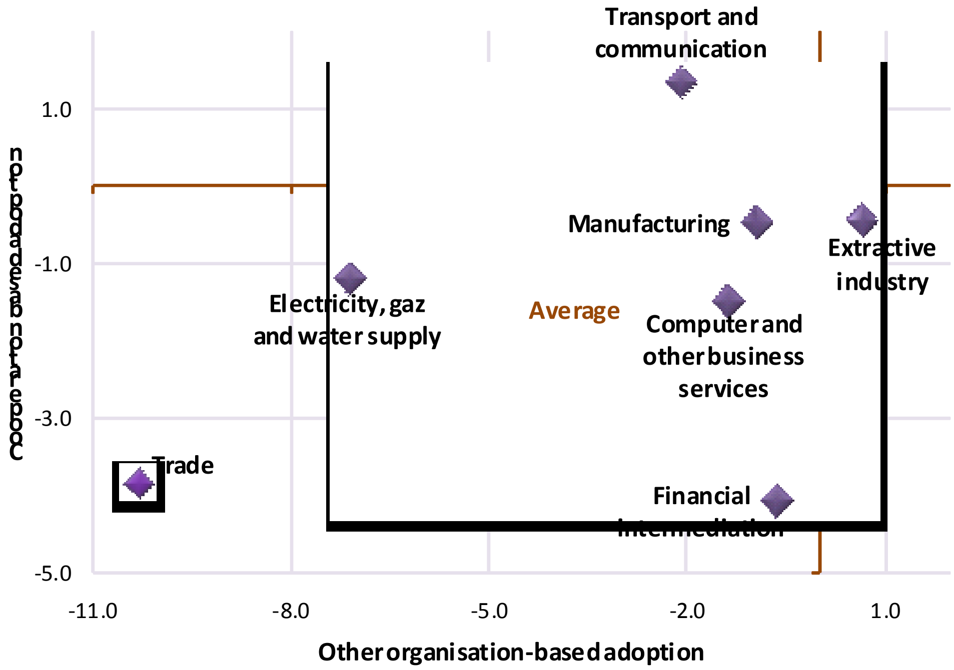
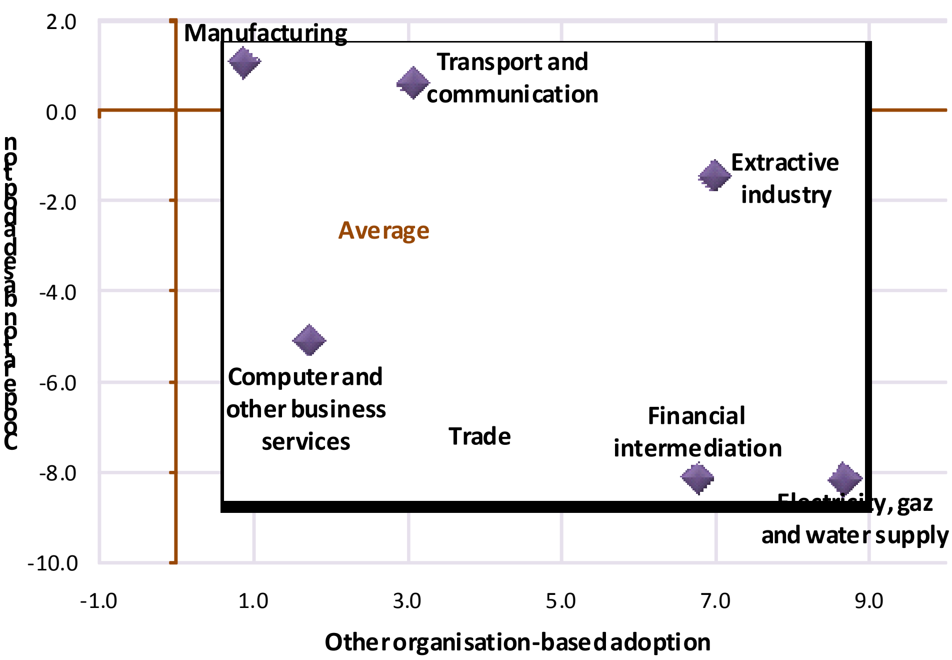


Figure II.40. Change in process cooperation-based adoption and other organisation-based adoption by sector (in percentage points)



To conclude, **the comparison between CIS3 and CIS4 highlight a decrease in product innovation adoption,** and an increase in process innovation adoption. However, although this is the case for almost all sectors, the countries present diverse behaviours, with more than half of them exhibiting increases in process innovation adoption rates. Therefore, strong heterogeneity is observed among nationalities. Also, a change in the nature of the adoption is observed: for product innovation, we observe increases in cooperation and decreases in other organisation-based adoption rates, whereas for process innovation it is the other way around.

Surely, among the several factors that are likely to explain this evolution, **one can think that the development of the Internal Market may at least partly have an influence**. Econometric investigations are made in Part III of this report to estimate the role played by the different determinants, and the specific role of IM.

II.5.3. Time evolution of the change in innovation adoption with respect to the evolution of the EU Internal Market

Since the analysis of the impact of EU Internal Market on innovation adoption is the core of this report, and given the availability of two waves of data for the CIS, we now address the relationship between the changes in innovation adoption rates in the European countries with respect to the time evolution of the Internal Market. Three main indicators measuring the regulations of the Internal Market are considered: the Transposition Deficit Indicator for the Internal Market, the Transposition Deficit Indicator in global, and the measure of Product Market Regulation according to the OECD database. This way, the scatter plots in Figure II.41 show in the X-axis the change in the adoption rate versus the corresponding measure of the Internal Market in the Y-axis. For each measure of the Internal Market, the plots are given for total innovation adoption rate as well as product and process innovation adoption rates, separately.[33]

We start by using the Total Transposition Deficit Indicator that covers the 12 areas of EU directives (agriculture, environment, enterprise, innovation, competition, internal market,

[33] It is worth noting that most of the Eastern countries do not appear in the plots. This is due to the fact that for some of them there is not information on the Internal Market variables at the beginning of the period under consideration, so that it is not possible to compute their change in the indicator.

justice, energy, employment, taxes, education and health). As can be observed in the first row of Figure II.41, the countries with higher decreases in adoption rates (Spain and Belgium) present an increase of the TDI_Total which is in the same line as the increase in the TDI indicator presented by countries such as Italy, Netherlands, Finland, and Luxembourg. In other words, the same evolution in the TDI indicator is shown in countries with very different profiles for the evolution of adoption rates. This is summarized in the lack of significance of the coefficient of correlation (Table II.7), not only for the case of adoption in general, but also for adoption in product and process separately. **Therefore, there is not a clear relationship between the evolution of the Transposition Deficit Indicator and the adoption of innovation no matter the type of innovation.**

We want to be sure that the conclusion on the lack of relationship between the evolution of the Internal Market and the adoption of innovation is not due to the choice of the indicator for measuring the Internal Market. We therefore use some other measures to analyse the sensitivity of the results to the choice of other indicators. The first one is a Transposition Deficit Indicator specific for the Internal Market (TDI_IM) which is a specific low-level indicator that accounts for internal market directives in particular. This way, the first one we have used (TDI_Total) is a more general one that, among other 11 subindicators, considers our second TDI indicator. As observed in the second row of Figure II.41 and in Table II.7, although not significant, we even obtain a negative correlation between the evolution of the TDI_IM and that of innovation adoption. For instance, Luxembourg and Germany present the highest increase in the adoption of innovation whereas the Internal Market indicator even decreases. Similar conclusions are obtained when disaggregating into product and process innovation adoption.

We also analyse the relationship when the Product Market Regulation indicator from the OECD is chosen. The indicator is 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 (OECD PMR indicators). In the third row of Figure II.41 we observe that there is a positive correlation that is even significant at 10% (Table II.7). However, Belgium, Spain and Norway again present the highest decreases in the rates of innovation adoption and have changes in the PMR indicator of similar magnitude of the ones for countries such as Portugal, Netherlands and Germany (which on the contrary present the highest increases in adoption rates). This is reproduced in the separate cases of the adoption of product and process innovations, which leads to non significant correlations in the evolution of both indicators and even negative for process innovations.

All in all, we can conclude that the evolution of the three indicators on the advance of the Internal Market does not seem to be correlated with the changes observed in the rates of innovation adoption irrespective of the type of innovation. This conclusion leads us to suggest the necessity of studying this relationship through a regression analysis where one can control for other variables that can also have a role in the evolution of the innovation adoption process.

Table II.7 Correlations between the evolution of innovation adoption and Internal Market measures

	TDI_Total	**TDI_IM**	**Product Market Regulation**
Adoption	-0.085	-0.4511	0.5253
	(0.7929)	(0.1411)	(0.097)*
Product adoption	0.3363	-0.3595	0.0319
	(0.2851)	(0.251)	(0.9257)
Process adoption	0.1722	0.3532	-0.3815
	(0.5926)	(0.2601)	(0.247)
P-values are given in parenthesis			

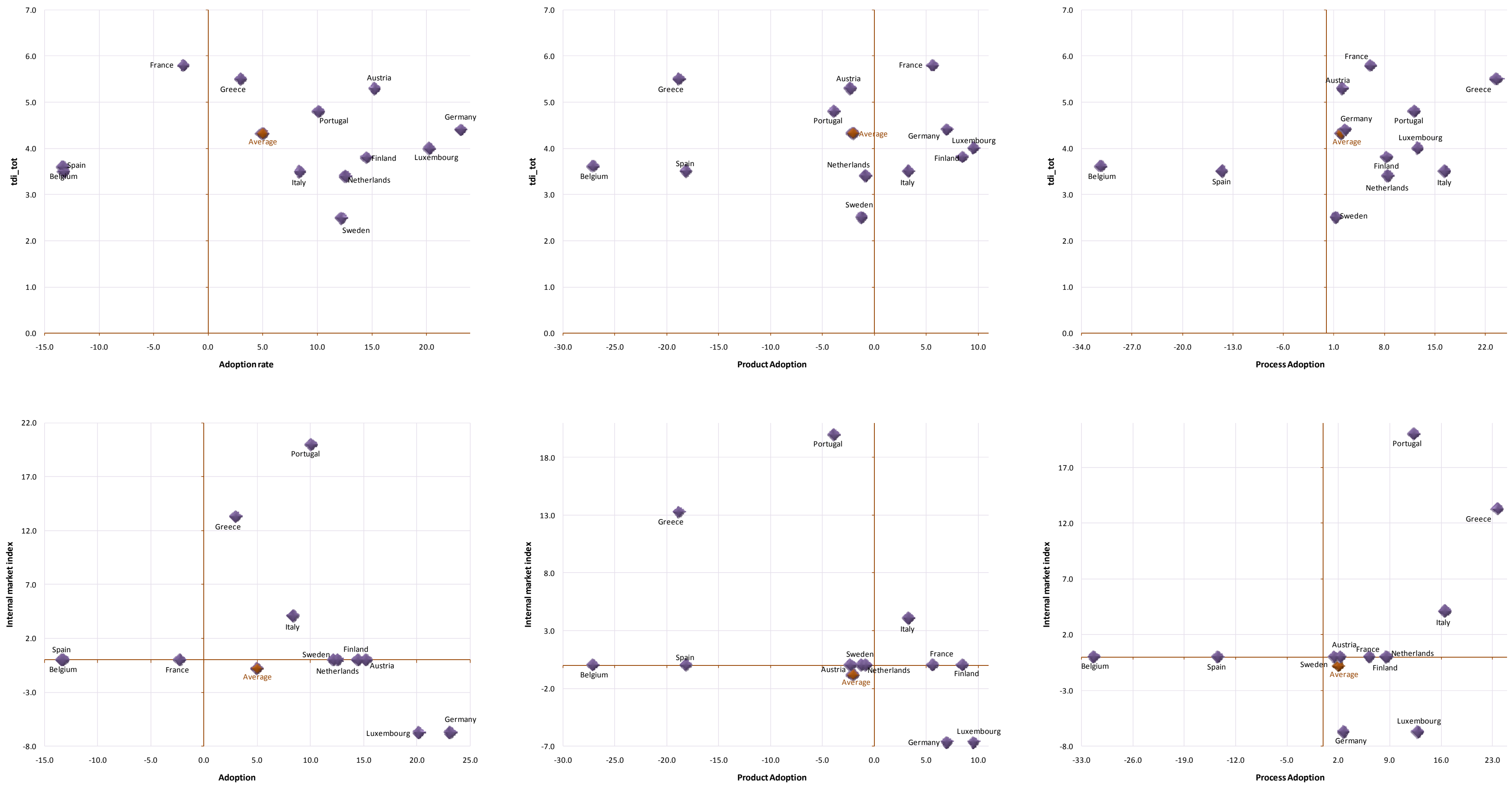


Figure II.41. Change in adoption rates and in the Internal Market measures at the country level

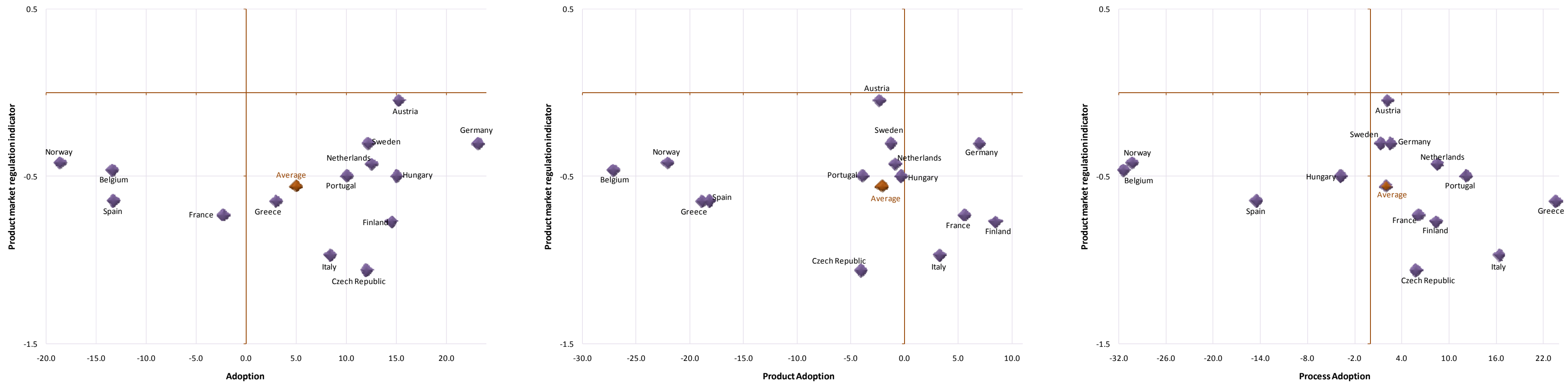


Figure II.41. Continuation.

II.6. Conclusion: Typology of countries according to their innovation adoption patterns

As a conclusion, this section summarizes the main points examined in Part II. Indeed, based on the level of adoption, but also in light of innovative activities, some country specificities can be identified.

To be more precise, a typology has been elaborated from the following four variables:

- The adoption rate
- The innovation rate
- Human resources in S&T (in the labour force)
- The cooperation rate.

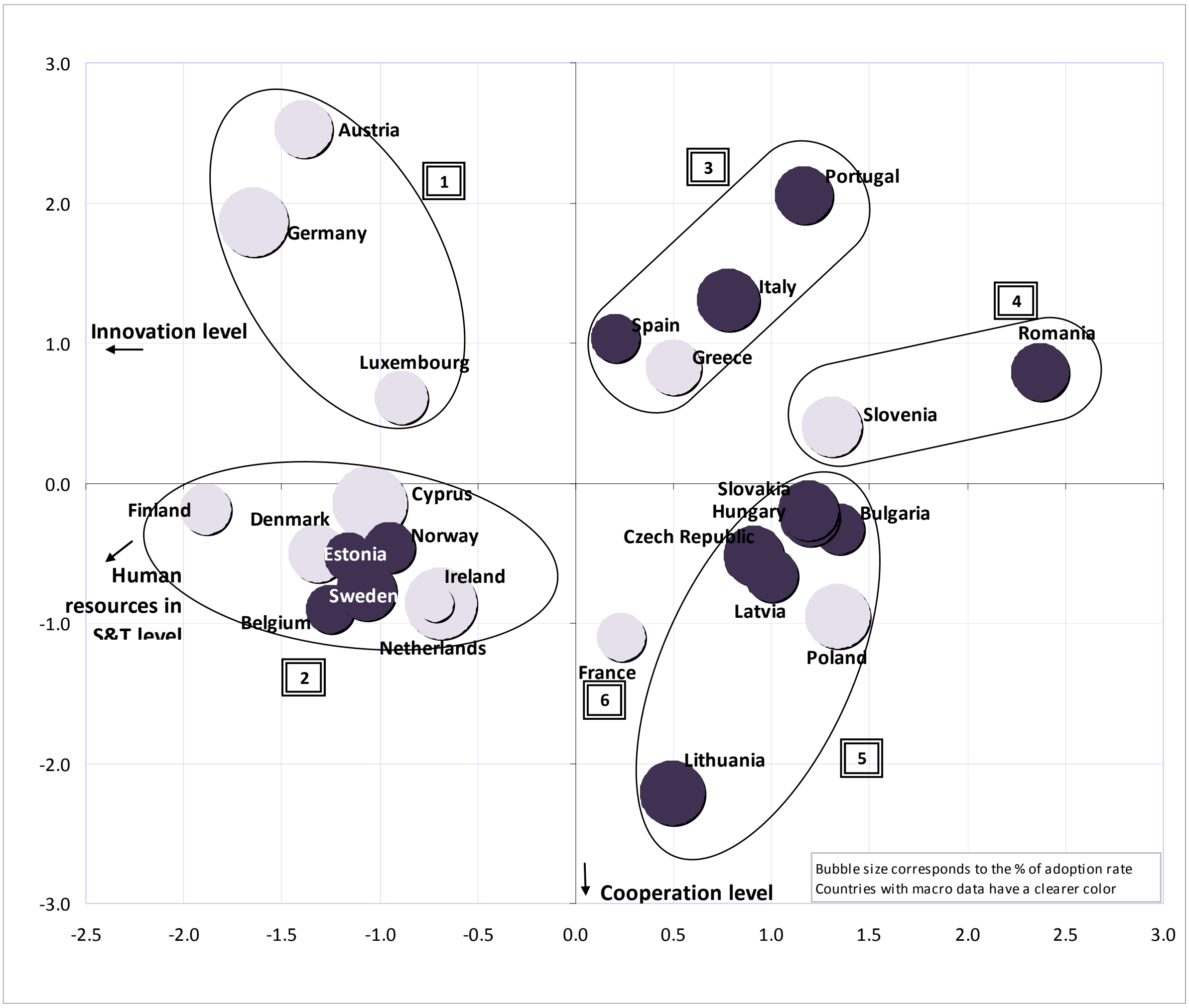
The factorial map obtained with a PCA (principal component analysis)[34] is given below. It clearly shows a strong heterogeneity in terms of country profiles since we can distinguish 5 different groups and a specific country. This mapping allows us to identify the main feature of each group of countries, regarding the four variables used to build the map.

Group 1: High innovation performance countries with high levels of human resources in S&T and low levels of cooperation: Austria, Germany and Luxembourg

This first group brings together countries with high rates of innovation, but also with high scores for human resources and a low level of cooperation. It concerns 3 countries in the core of Europe: Germany, Austria and Luxembourg, the former presenting a high adoption rate and the two latter being less adoption-oriented than Germany.

[34] The two first axes account for 72% of the variance. See Appendix II.9 for more detailed results.

Figure II.42. Typology of countries according to their adoption, innovation and cooperation level



Group 2: High innovation performance countries with high levels of human resources in S&T and high rates of cooperation: Finland, Denmark, Sweden, Belgium, Estonia, Cyprus, Norway, Ireland and Netherlands

The second group is geographically heterogeneous containing the Scandinavian countries (Finland, Sweden, Norway and Denmark) together with Belgium, Netherlands, Ireland, Estonia and Cyprus. It records relatively high level of innovation (less in the case of Norway) and an intensive use of human resources in S&T. Compared to the first group, these countries are characterized by a very high level of cooperation (again, less in the case of Norway). The interesting point is that despite this general pattern found in the other three variables (innovation, cooperation, use of HRST) adoption rates differs substantially among them:

Netherlands, Cyprus, Denmark and Sweden present adoption rates far above the average, whereas the rest of countries register among the weakest rates of adoption in Europe.

Group 3: Average innovation performance countries with weak cooperation activities and low use of HRST: Spain, Greece Italy and Portugal.

The third group (Spain, Greece, Italy and Portugal) registers relatively good level of innovation rates together with cooperation levels extremely low and also a low use of Human resources in S&T. The adoption rate in three of them is lower than the European average, with Italy being above the average.

Group 4: Weak innovation performance countries with low levels of cooperation and HRST: Slovenia and Romania

For the fourth group (Slovenia and Romania), all indicators are generally low except those of adoption rates which are in the average. Most of the characteristics of this group are opposed to the ones of group 2: innovation is very weak and in all cases, human capital and cooperation scores are low. Despite this general pattern the adoption rate is in line with the European average.

Group 5: Weak innovation performance countries with strong cooperation activities and low use of HRST: Lithuania, Latvia, Hungary, Slovakia, Czech Republic, Bulgaria and Poland.

The fifth group gathers countries with very high cooperation activities but the innovation is relatively low. It concerns Baltic countries (Lithuania, Latvia) and Central-East countries (Hungary, Slovakia, Czech Republic, Bulgaria and Poland). Another common feature of these countries is their low level of use of human resources in science and technology. With this general pattern, the adoption rates are among the European average for most of them (less in the case of Bulgaria and Latvia).

Group 6: A specific country close to group 5 but with high use of human resources in Science and Technology: France.

Close to the fifth group we find France which records low levels of innovation and adoption together with high cooperation and high use of human resources in S&T (the latter is the feature that distinguishes France from the countries in group 5).

PART III

Econometric Analysis of the Impact of Internal Market on Innovation Adoption across EU countries

III.1. Introduction

The aim of this third part of the report is to comment on the econometric results obtained by exploiting jointly the data coming from the CIS3 and CIS4 on which also the descriptive part is based on.

A main difference characterizes the present analysis from the one carried out in the previous report. In the present analysis we will make use of a much richer database by exploiting at the same time both micro and macro data coming from two waves of the Community Innovation Survey. This allows us to be much more precise and confident about the overall results also due to the fact that we have now more observations and that, for this reason, estimates should be more accurate. Hence, we analyze the same dynamics already analyzed for the CIS3 project but, this time, over 2 different time spans, 1998-2000 for the CIS3 and 2002-2004 for the CIS4. Our aim will be, then, to confirm whether some of the insights of the previous report are valid when we extend the analysis to more recent data or to point out whether the results obtained by the simpler CIS3 cross-country analysis (even though valid for that specific year) cannot be generalized to a longer time span and should be, therefore, revisited in the policy implications which had been drawn from them.

III.1.1. Some words on the data used in the econometric analysis and data constraints

As already stressed in Part II of this contribution, the micro data for both CIS3 and CIS4 have been merged with macro data coming from the Eurostat website and for which micro data were not available for our analysis. This, as it will be clear, has been done in order to increase as much as possible the sample size and in order to include the maximum number of countries in the econometric analysis. However, it is important to stress that the panel dimension of our sample (for the year 1998-2000 in the CIS3 case and 2002-2004 for the CIS4 one) will not ensure that all the countries for which descriptive statistics have been presented in part II will actually enter all the regressions presented in this part.

As it will be clear this is a data availability constraint that we face not only because of the availability of CIS data but also due to the availability of data on IM reforms and regulations which may (or may not) match the same number of countries for which CIS data are available. This data constraint has not a direct solution and we will have to cope with it throughout the whole report. Therefore, the final database contains a maximum number of observations of 364, due to the consideration of 26 countries, 7 sectors and 2 time periods. However, as it will be observed the number of observations in the regressions is by far lower than this maximum.

If any, this problem may be even more important in a setting, like ours, where the estimation is carried out in two steps (as in the IV estimation) for which, firstly, the effect of IM on the three different "diffusion channels" is studied and for which, then, the fitted values generated in the first stage are used in order to check the final effect of IM (through the channels) on the innovation adoption rates. Additionally, in Part IV of the report we estimate a third step regression where productivity growth is explained as a function of the fitted values of innovation adoption rates obtained in the second stage.

III.1.2. About the econometric approach

As we already argued in the previous report (and to which we send the interested reader for a more detailed discussion of the econometric methodology), the impact that IM regulations may have on the adoption of innovation is likely to be channelled through the direct impact that the Internal Market (IM) regulations have on some macroeconomic dimensions. The identifying assumption that we make here is, in fact, that the effect played by the IM directives on the adoption of innovation across countries is an indirect one and that this is channelled through the effect that these IM directives play in the first place on some macro magnitudes which we call "transmission channels".

It is important to notice, in fact, that the IM regulations designed by the European Commission are generally aimed at achieving specific goals which usually abstract from the direct objective of fostering innovation adoption or creation. Reaching higher levels of competition is, for example, one of the main objectives of major EU reforms and regulations. Similarly, the free movement of people, capital and goods are in the spirit of the Internal Market which usually finds its final goal in increasing the degree of cooperation in business activities among EU citizens or firms so as to reduce production fixed costs and increase scale economies and finally productivity levels. To this end, EU regulations have also aimed at increasing the degree of trade openness of all member states.

We believe (and this has been object of much economic literature) that all these macro-magnitudes have an effect on the possibility of firms to adopt technology and on their preferences over technology adoption versus technology creation. Innovation and adoption of innovation are, of course, going to be impacted by the level of competition experienced by each member state as well as by the degree of cooperation activities which are carried out in science and technology areas or by the degree of trade openness. Then, the relevant question (already asked in the previous report) is how the IM regulations aimed at achieving generic goals like fostering competition, cooperation or trade will finally impact also the rates of innovation adoption across countries.

We answer to this question by econometrically examining the two stages of this dynamics firstly looking at the impact played by the IM on the transmission channels (cooperation, competition and trade) and then looking at the impact that the IM play on innovation adoption through the above mentioned channels.

From an econometric point of view, hence, a two-stages 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 in 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 on the share of innovation adoption across countries in the second stage estimation. This second stage is estimated at the global level using 2SLS in order to define the effect of the channels on the overall adoption rate. However, we will also disaggregate the adoption rate into different sub-dimensions by analyzing the indirect effect of IM (channelled through the transmission channels) on (i) product innovation adoption and (ii) process innovation adoption as well as when this adoption has been made as a joint effort with other institutions (what we will call innovation adoption in cooperation) or as a result of the direct acquisition of the innovation from another institution (what we call "other firms based" adoption). Finally, hence, we will be able to analyze in the second stage of our study the following dimensions of EU innovation adoption:

1) Total innovation adoption
2) Product innovation adoption
3) Process innovation adoption
4) Product innovation adoption made in cooperation
5) Product innovation adoption "other firms based"
6) Process innovation adoption made in cooperation
7) Process innovation adoption "other firms based"

III.2. First Stage analysis: the impact of IM regulations on the transmission channels of Innovation Adoption

III.2.1. Introduction to the Instrumental Variable system of equations

As already argued before, the approach we are going to follow in order to disentangle the effect of IM regulations on innovation adoption will consist of a two stage estimation. In the first stage we estimate, by fixed effects, the role played by IM regulations on the transmission channels. The system of equations to be estimated in the first stage is as follows:

$$(3.1)\ \mathrm{Coop}_{c,i,t} = \beta_0 + \mathrm{IM}_{c,t}\beta_1 + \mathrm{Z\_Coop}_{c,t}\beta_2 + \mathrm{DUM}_i\beta_3 + \mathrm{DUM}_t\beta_4 + \varepsilon_{c,i,t}$$

$$(3.2)\ \mathrm{Comp}_{c,i,t} = \gamma_0 + \mathrm{IM}_{c,t}\gamma_1 + \mathrm{Z\_Comp}_{c,t}\gamma_2 + \mathrm{DUM}_i\gamma_3 + \mathrm{DUM}_t\gamma_4 + \xi_{c,i,t}$$

$$(3.3)\ \mathrm{Trade}_{c,i,t} = \alpha_0 + \mathrm{IM}_{c,t}\alpha_1 + \mathrm{Z\_Trade}_{c,t}\alpha_2 + \mathrm{DUM}_i\alpha_3 + \mathrm{DUM}_t\alpha_4 + \nu_{c,i,t}$$

where IM are the Internal Market proxies; Z_ are the control variables necessary to explain each dependent variable and DUM are the sectoral (i) and time (t) dummy variables.

In the second stage, hence, the fitted values of the eqs. (3.1), (3.2) and (3.3) will be used in order to explain the various dimensions of the EU innovation adoption. Hence, in a second stage, we are going to estimate the following general specification:

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

where InnoAdopt is the innovation adoption rate (or its disaggregated dimensions), Coop is the fitted value of the cooperation variable obtained from the first stage, Trade refers to the fitted value of trade obtained from the first stage, Comp is the fitted value of competition obtained from the first stage; Z_InnoAdopt are the different control variables of innovation adoption and DUM refer to either sectoral, country and time dummies.

III.2.2. Cooperation Channel

In the previous study based on CIS3 data, one of the main insights of the econometric analysis was highlighting the importance played by cooperation activities in the diffusion/adoption of innovation across countries. It is therefore, very important, to correctly analyze this channel again with the addition of the updated information coming from the CIS4.

As pointed out in the previous report, we are concerned on the analysis of the impact that cooperation activities have on the adoption of innovation across EU countries. For this reason, we mainly focus on a broad measure of "cooperation" which refers to the cross-country innovation activities carried out in cooperation and for which this cooperation is not constrained to be within the national boundaries. The dependent variable (Cooperation) is, then, expressed as the percentage of firms which have cooperated (within the EU territory) in any kind of activity related to innovation.[35]

This said, however, the CIS3 and CIS4 data allows us to analyze also the rate of cooperation activities which took place only across firms of the same country (what we call National Cooperation) or within the European boundaries (what we call European Cooperation). In the results below we will, then, propose the econometric estimation of the main drivers of the three of them: overall cooperation, national cooperation and European cooperation. We will see that the picture changes very little and that those regulations affecting overall cooperation are those which foster national cooperation.

[35] To be more specific we are going to propose as a baseline indicator of cooperation the total number of firms in each sector and country which participated in innovative cooperation activities divided by the total number of innovative firms.

As we already argued, the main assumption underlying our econometric model is that IM reforms will affect directly the macro magnitudes that we called “transmission channels”. For this reason, we regress cooperation on different IM regulations as well as on control variables in order to disentangle the effect played by the internal market directives on fostering cooperation across EU countries and over our time horizon (1998-2004). In order to correctly disentangle the partial effects of the different IM reforms on the rate of cooperation activities we have to control for different sources of heterogeneity across countries which may have specific effects at the sector and time level. Hence, for all the regressions we insert both time and sectoral dummies. Additionally, regressions make use of weighted observations. Not weighting would make the coefficients obtained in the regressions to be equally dependent on the structural relationship emerging in big and small economies. Given the very different size of the Member States within the EU, weighted estimates are important to provide a more representative picture of the EU economy. GDP is used as the weighting variable.

In table III.1 we propose the results. The fit of the overall first stage regression for cooperation is good (0.76). This result is important since the fitted values coming from this regression will be used in the second stage to explain innovation adoption rates. For the sake of completeness we compute the weighted correlation coefficients between fitted and real values on cooperation as a measure of the fitness of the regressions run in this first stage of the analysis. In this case, the correlation is significant with a value of 0.1965 with a p-value of 0.013.

A source of potential country heterogeneity is the level of **Trust** (as a proxy of social capital) experienced in each country under examination. The data we use to proxy for trust come from the European Social Survey (ESS) and refers to the variable “Most people can be trusted”. Differently from the previous report we could not use the data coming from the World Social Survey (WSS) due to its more restrictive time horizon for which no data for the 2004 were available. However, the variable provided by the EES is very similar to the one we used in the study carried out on the CIS3 data and, we believe, it allows a direct comparison with the previously obtained results.

The coefficient for **Trust**, as expected, is positive and significant meaning that those countries which had been able to build a good “social environment” and a good “stock” of social capital are those in which higher rates of cooperation in innovation is also carried out. Firms cooperate one another the more they trust this cooperation will not result in free-riding from their counterpart. This, as we will see in the second stage analysis, increases the rate of innovation adoption also. Not only that, we have (weak) indication that cooperation (and then also, trust) affect the rate of direct innovation creation due to the fact that the firms in countries where higher degree of trust is experienced have to spend less resources in the control of diversion and of free-riding (see Hall and Jones, 1999).

Related to the provision of social capital, also the stock of **Human capital** is found to be a significant explanatory variable for cooperation across countries. We proxy for the stock of human capital in each country by the share, over the total population, of those employed in Science and Technology activities/occupations. The idea here is that better trained workforce is usually more prone to cooperation. Hence, especially those workers graduated in scientific areas are going to participate in scientific cooperative projects which result is likely to be a new innovation or a modification of an existing one. More cooperation is achieved in those countries which have been able to produce the adequate human capital stock to work on science and technology projects such as, for example, the Framework Programmes by the European Commission. The better trained the workforce, the more the cooperation in Science, Technology and Innovation. The results we obtain here confirm those of the analysis based only on the CIS3 data.

As proxies of IM regulation, we may use the Transposition Deficit Indicator in its different areas. Specifically, we firstly inserted into the regression the **Transposition Deficit Indicator (TDI) for Employment and Social Affairs**. This is related, as it will be clear, to two dimensions which are likely to impact cooperation across firms and countries. On one hand, the transposition of EU directives oriented to the "employment" sphere is expected to increase cooperation by making easier and more uniform the legislation on firing and hiring procedures. This, indeed, is one of the main goals of EU policy makers in this area of policy action. Our results seem to show how adopting EU regulations in these matters is going to increase the possibility of workers to be employed across different countries and then their chances of participating in cooperative projects. Also, EU regulations related to "social affairs" have the important objective of creating, building or increasing the existent social capital in each country, which, as we have already pointed out, is likely to increase the "social framework" within which cooperation activities take place. We also insert the **Transposition Deficit Indicator (TDI) for Competition.** The idea behind is that the transposition of EU directives oriented to the increase of the competition levels in which European enterprises operate imply higher incentives for firms to cooperate among them in order to have an easier access to new innovations. The positive and significant sign obtained for the parameter of this variable confirms the theoretical arguments.

As a confirmation of the role played by IM regulations on cooperation activities across countries we are able to use the 2nd wave of data on Product Market Regulations (PMR) provided by the OECD and for which data are available for the year 1998 and 2003 fitting exactly the time horizon of our panel. The **Administrative and Regulation controls** are used to explain cooperation activities, with the idea that more burdensome regulations in all matters related to administrative and regulatory procedures seem to discourage cooperation activities. However this variable does not show up as statistically significant at standard confidence levels, so that we eliminate it in column (ii).

Table III.1. Cooperation channel equation

	(i)	*(ii)*	*(iii)*	*(iv)*
	Cooperation	***Cooperation***	***Cooperation National***	***Cooperation Europe (national included)***
Log Turnover	0.021	0.017	0.015	0.017
	(2.50)***	(2.49)***	(1.62)*	(1.25)
Trust	0.495	0.390	0.358	0.410
	(1.95)**	(1.80)*	(1.11)	(0.88)
Human Resource in S&T-Occupation as % total population	0.133	0.111	0.092	0.092
	(3.27)***	(3.46)***	(2.09)**	(1.45)
TDI Competition	0.006	0.005	0.003	0.004
	(2.72)***	(3.92)***	(1.86)*	(1.78)*
TDI Employment and Social Affairs	0.029	0.028	0.022	0.023
	(5.33)***	(5.73)***	(2.68)***	(2.04)
Administrative Regulations	0.024			
	(0.50)			
Constant	-8.205	-6.951	-5.680	-6.203
	(-3.49)***	(-3.70)***	(-2.02)**	(-1.52)
Observations	159	179	173	173
Number of id_country	17	19	19	19
R-squared	0.76	0.76	0.43	0.42

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4).

As we pointed out before, even if our main interest relies in the explanation of cross-country cooperation activities as a channel for the adoption, we propose a similar analysis for the case of within-country cooperation activities as well as of the within-Europe cooperation. In columns (iii) and (iv) of table III.1 we give the results. These confirm that similar variables seem to explain also the cooperation activity which takes place between firms in the same country or within the European boundaries. The fit of the overall regressions, however, is poorer than for the case of "overall cooperation", with a value of 0.428 and 0.422, respectively for the national and the European cooperation. Not as good was the result obtained for the case of cooperation across firms in other countries of Europe (without considering the national firms), since most of the variables turn out to be not statistically significant and a poorer fit of the regression is obtained.

III.2.3. Competition channel

One of the main channels through which innovation is fostered is that of increasing competition both across countries and firms. Economic literature has already pointed out the importance of relying on a competitive framework and market in order to foster innovation creation in theoretical models such as those of patent race[36.] It is more debated, instead, whether more competitive markets may also encourage the adoption of innovation especially in very competitive markets since this may imply sharing information with potential competitors. In any case, competition is very likely to be a fundamental driver of innovation adoption and, for this reason, we analyze its impact on it. Hence, in this first stage, as we did for cooperation, we look at the determinants of competition with special attention to the role played by EU IM directives.

As in the previous report, our proxy for competition makes use of a measure of the markup in the fashion of that proposed by Griffith and Harrison (2004)[37.] The higher the markup (above the value of 1), the less the competition achieved in the market under analysis since more

[36] See Aghion and Howitt (1996). The authors 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-and-neck is going to increase the incentives to produce and exploit innovation.

[37] The proxy is calculated as the ratio Value Added/(Labor costs+ Capital costs) for each country. Additionally, in order to obtain a different value for each sector in each country, we apply the combined information for the country itself with the sector differentials at the EU level in terms of mark-ups and at the sector composition of the economy. The sector differentials at the EU level are given in Christopoulou and Vermeulen (2008).

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.

In table III.2 we propose the results. The fit of the overall first stage regression for competition is very good (0.99). This result is important since the fitted values coming from this regression will be used in the second stage to explain innovation adoption rates. Additionally, when computing the weighted correlation coefficient between fitted and real value on competition as a measure of the fitness of the regressions run in this first stage of the analysis, we obtain a significant correlation (Correlation coefficient: 0.9282; p-value: 0.000), indicating the adequateness of this fitted value.

As for the analysis of the other transmission channels, also for competition we insert in the regression both time and sectoral dummies. Additionally, we control for the average size of the sector (proxied by the logarithm of the number of firms in the sector) that may influence the degree of competition experienced by firms, which in any case is not significant.

If we go more into the details of our econometric results, the degree of competition across EU firms is explained by different IM regulations. In the first place, an important dimension to explain the degree of competition of EU economies is the percentage of EU regulations devoted to increase competition (**TDI Competition**). This is supposed to have a clear direct impact on the level of competition achieved. Our econometric analysis seems to confirm this result with a negative and significant coefficient for the TDI proxy meaning that the reception of more EU directives in order to increase competition has actually led to a decrease in the experienced markup and an increase, then, of the degree of competition for the firms of the observed countries.

Business Regulations enter the regressions both in column (i) and (ii) with a strongly statistically significant coefficient. This variable comes from the data provided by the Fraser Institute in the Economic Freedom of the World (EFW) index and it has been built so as to assign lower values to countries providing less regulations. Therefore, the coefficient is negative as expected meaning that higher business regulations to competition are indeed increasing the markup of firms leading to the creation of unnecessary rents. Hence, the more the business regulations, which do not leave open way for competition, the less the degree of competition in the examined economy. This, finally, explains the level of markup which we use as potential transmission channel for the adoption of innovation in the analysis in the second stage.

Additionally to that, we are able to explain the degree of competition by the percentage of **Transfers and Subsidies**. Obviously, the more the conceded transfers and subsidies, the less will be the degree of competition since this would be actually proxying for State subsidies to inefficient firms or sectors which eventually reduce the degree of competition maintaining unproductive firms in the market. This proxy comes from the data provided by the Fraser Institute in the Economic Freedom of the World (EFW) index and it has been built so as to assign lower values to countries providing less subsidies and direct transfers. Therefore, the expected sign for this IM proxy is negative as, indeed, in the proposed results of table III.2.

As a confirmation of the fact that subsidies decrease the degree of competition in our observed sample of EU member states, also the **State Aid** as a percentage of the total GDP of the country enter our regression. Although the coefficient for this explanatory variable is not statistically significant at common percent confidence level, it presents a positive sign meaning a positive partial effect of public aids and subsidies on the level of experienced rents across countries. As a robustness check, we have also inserted the State Aid Scoreboard indicator (Total State Aid by Member States as a % of GDP) in column (iii). The same conclusions are obtained.

As a sensitivity analysis, we analyse whether the general rules to increase the European Internal Market, and specifically the ones actually implemented by each member state in the two years of our panel have a clear impact on competition. These are proxied by the **TDI for Internal Market**. The idea, again, is that the more EU regulations are adopted by each member state and the higher the degree of competition since the regulations made at the EU level have indeed this objective. Our econometric analysis seems to confirm this result with a negative coefficient for the TDI proxy meaning that the reception of more EU directives for deepening the Internal Market has actually led to a decrease in the experienced markup and an increase, then, of the degree of competition for the firms of the observed countries.[38]

[38] We have re-run the same regressions with a dependent variable in which the Eastern countries also had information on markups. This was computed combining the EU differentials in markups with their sectoral composition. However, the goodness of fit of such regressions were of less quality than the ones presented in Table III.2 in which the dependent variable did not consider the Eastern countries.

Table III.2. Competition channel equation

	(i) *Competition*	*(ii)* *Competition*	*(iii)* *Competition*
Business Regulations	-0.019 (-3.60)***	-0.014 (-2.39)***	-0.013 (-1.89)*
TDI Internal Market		-0.001 (-1.45)	
TDI Competition	-0.0004 (-1.70)*	-0.0007 (-2.36)**	-0.003 (-1.12)
Total State Aid (% GDP)	0.037 (0.84)		0.051 (1.25)
Transfer and Subsidies (% GDP)	-0.007 (-2.66)***	-0.006 (-1.92)**	-0.009 (-2.93)***
Size (log of # firms)	-0.002 (-0.81)	-0.002 (-0.82)	-0.003 (-1.09)
Constant	0.814 (15.91)***	0.953 (11.36)***	0.767 (10.66)***
Observations	160	160	160
Number of id_country	13	13	13
R-squared	0.99	0.99	0.99

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4).

III.2.4 Trade Channel

The economic literature points to Trade openness as one of the most likely important channels of knowledge and technology spillovers. This is mainly because different agents can easily access the embodied technological content present in commercialized goods once this good is known in the national market. The idea is, therefore, that those countries that are more open to trade are also those receiving more differentiated goods and that can get in touch with the latest technology and innovations and, in the end, decide to adopt them.

Differently from the previous report based on the CIS3 data only, in the present one we use a proxy for trade that is the volume of exports and imports as a share of Value Added. The reason is that the CIS4 does not provide the same series for trade that we used in the previous report such that, in order to maintain coherence in our panel and to be able to compare the same trade series across time we had to opt for a different **Trade proxy**. To be more specific, we proxy for trade openness by building the sum of import and export volumes and express it in relative terms as a share of total Value Added. In the case of the service sectors, this information comes from the Balance of Payments in EUROSTAT (with the exception of the sector of Wholesale and Retail trade for which the data are not available). In the case of the non-service sectors (Manufacturing, Mining and quarrying, Energy) the information comes from COMEXT database.

Also, similarly to what we have done with the cooperation channel we run a robustness check on the results by restricting the definition of trade to the trade intra-EU 27 only. Indeed, what we are interested in is the propensity of each country to be open to trade (and then in the second stage how this openness affects the adoption of innovation). In fact, the definition of innovation adoption does not restrict to only innovation adopted from EU partners, then we are well interested in the larger definition of trade that we actually used in the regressions. However, we will also analyse what happens if we consider only intra EU 27 trade.

In order to fully capture the size effects that may affect the openness to trade proxy apart from controlling for time and sectoral fixed effect we also control for the logarithm of the total turnover produced in each sector as a measure of the magnitude of their economic activity, although it does not show up to be statistically significant in all the specifications. Specification in column (ii) is the one we will finally use as preferred specification in the second stage analysis, given that the correlation of the fitted value of the endogenous is higher in this specification than in the others (correlation of 0.4359; p-value: 0.000). Despite this high correlation, it must be pointed out that the goodness of the fit is much lower in this channel than in the other two cases, with a R-square of 0.324, given to the fact that many of the variables introduced in the specification are not significant.

As for the IM regulations that explain the Trade channel, an increase in the **Regulatory Trade Barriers** (data provided by the OECD, PMR) shows to impact negatively the degree of openness to trade in our panel, although the parameter is not statistically significant. To be slightly more precise, the Regulatory Barriers variable reflects barriers to international trade such as international harmonization or mutual recognition agreements. The more burdensome these barriers, the more difficult will be to trade. Although the sign is maintained in all the specifications, it does not show up to be statistically significant neither for the main trade proxy nor in the robustness check using only trade intra-EU 27.

Along with these barriers, other regulations may affect the degree of trade openness. The proxy on **Regulatory Trade Barriers** coming from the EFW index is not significant but has a positive sign as expected (remind that high scores of this index imply low barriers). This proxy is built as the average of two different sub-indicators: (i) Non-Tariff Trade Barriers and (ii) the Compliance cost of importing and exporting.[39]

Another aspect that is of relevance in the definition of the patterns of trade is the **Comparative prices level** and the direct **Control over prices** by the national governments. In the first case, the proxy measures the comparative price levels of each examined member state in comparison with the average for the EU when this equals 100 (source: EUROSTAT). This proxy should be regarded as a control variable for the experienced differences in prices across different member states which may affect the trade volumes. Due to the way we built the trade proxy (as the share of imports and exports over GDP), the interpretation of the coefficient is hence, not straightforward. In fact, different arguments could be used in our setting to justify either a positive or a negative coefficient for this variable. What matters instead, from our point of view, is not the sign of the coefficient per se but the fact that we are "controlling" for price level differences in the regression and that part of the variability of the data is actually accounted for by these price differentials across countries. As observed, this variable is not significant in any case.

Of more direct interpretation is, instead, the proxy for **Price Controls** (source EFW) that accounts for the extent of price controls in specific sectors. The more widespread the use of price controls, the lower the rating of this proxy. The survey data of the International Institute for Management Development's (IMD) World Competitiveness Yearbook (various editions) were used to rate the countries (mostly developed economies). To more controls correspond lower degrees of trade openness. The index scores higher values the less restrictive the price controls in each examined member state such that the expected coefficient is, as obtained in the empirical results, positive. However, it is does not appear to be significant in none of the specifications.

[39] This latter, for example, proxies for the average cost and time needed in each member state of the procedures to import a 20-foot container.

Finally, we introduce the Transposition Deficit Indicator in the Area of Taxation and Customs, that is, the number of implemented EU regulations (over the total promulgated) in the matters of Taxation and Customs to explain the dependent variable Trade. One would expect that all those regulations which reduce trade barriers, taxes on trade and international capital market controls have the ultimate effect of increasing trade across member states. However, contrarily to what was expected, results show how the **TDI Taxation and Customs** seems not to impact significatively the extent by which EU countries are open to trade. This is the case in all the different specifications and even considering the trade intra EU27.

In column (iii) we reproduce the same estimations as in the first column for the case of trade only among the EU27 countries. Main conclusions are maintained.

Table III.3. Trade channel equation

	(i)	*(ii)*	*(iii)*
	Trade	***Trade***	***Trade Intra EU27***
Log Turnover	-1.996	-1.131	-0.904
	(-1.79)*	(-1.60)	(-1.64)*
Regulatory barriers	-6.044		-2.967
	(-1.01)		(-0.97)
TDI Taxation and Customs	-1.257	-0.706	-0.540
	(-1.51)	(-1.29)	(-1.27)
Comparative Price Levels	0.143		0.060
	(0.15)		(0.12)
Regulatory Trade Barriers	10.675	6.372	4.684
	(1.24)	(1.04)	(1.05)
Price Controls	0.134		-0.046
	(0.08)		(-0.05)
Constant	64.470	41.142	28.802
	(0.53)	(0.55)	(0.46)
Observations	110	138	115
Number of id_country	17	22	17
R-squared	0.32	0.32	0.16

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4).

III.3. Second stage analysis: the impact of transmission channels on innovation adoption

In this section we will analyze the results coming from the econometric estimation of the second stage regression (see Annex III.1 for a review of the main variables used in this Part III). Few things are worth to be noticed. As in the first stage regression, also in the second stage we will make use of a panel structure. This has the evident advantage of exploiting a considerable higher number of observations. In the present analysis we have more than the double of the observations than in the cross-section for CIS3. This is mainly due to the fact that two time spans are here considered and that more countries are now available in principle for the analysis. The panel structure of the analysis surely allows us to be more precise on the effect played by the IM and by the transmission channels on the adoption of innovation. Also, and probably more important, we are able to control for differences in time (in between the years 1998-2004) and to check whether the static results we obtained in the simpler cross-section analysis are confirmed when we look at the dynamics of the innovation adoption process. This is a non-trivial issue since, the insights that one can obtain in a static framework may have masked the actual dynamics which can only be detected when more time spans are analyzed. This is to say that the results we are going to present in this report should be carefully compared with the ones we obtained in the previous report, taking into consideration that this time we are able to analyze, in a more appropriate framework, the dynamics (rather than the static picture) of innovation adoption.

III.3.1 The endogeneity problem and the two stage estimation

As we already pointed out in previous sections, IM regulations are put in place by the European Commission in order to build and foster the Internal Market whose aim is to enable citizens, goods and capital to freely move within the EU boundaries as well as to foster competition across economic agents so as to increase productivity levels and welfare at the European level.

The above mentioned IM regulations (and those that entered the equations in the first stage also) we showed have a statistical significant impact on three different macro-dimensions, namely cooperation, competition and trade, the latter not so clearly in the regressions. The objective of this section (and the ultimate goal of this report) is to study the impact that these IM regulations have on innovation adoption rates through the above mentioned transmission channels, that is, through the indirect effect that EU regulations have on the degree of competition, cooperation and on the propensity to trade of EU member states.

The econometric specification we will exploit is detailed in eq. (3.4) where the fitted values of the dependent variables in eqs. (3.1), (3.2) and (3.3) are inserted as regressors in eq. (3.4). This amounts to run a two-stage least square estimation (2SLS) by making use of the IM as instruments for the cooperation, competition and trade. In fact, by using this kind of estimation we are solving at once also the likely problem of endogeneity that may affect innovation adoption and the three above mentioned macro-dimensions. In fact, either cooperation, competition and trade may have a direct effect explaining innovation adoption rates but, at the same time, innovation adoption rates through their effect on GDP may cause the cooperation, competition and trade to increase or decrease. By estimating in two stages we solve the endogeneity problem and get consistent estimates of the partial effects of the three transmission channels, then, being able to infer the effect of IM on innovation adoption rates.

III.3.2. Total innovation rates and the relation with adoption

As in the previous report, innovation adoption is computed as the share of innovative firms which have introduced an innovation in product or process either in cooperation or purchased from other firms (hereinafter also referred to as "other organizations-based innovation adoption"). This variable, therefore, is aimed at measuring the degree of innovation adoption at the country and sectoral level. It is, however, a general definition since it does not distinguish between the innovation adoption which is done mainly through cooperation among firms ("made in cooperation") from that which is mainly direct adoption of blueprints or innovation developed elsewhere ("other organizations-based"). Also, it does not distinguish between product and process innovation. These two types of innovation (product and process) may require different channels to be adopted or transmitted. Also, therefore, the same IM regulation may impact a specific type of innovation adoption (i.e. product made in cooperation) in a different way that it impacts another type of innovation adoption (i.e. process innovation adoption other organisation-based).

The results on overall innovation adoption will be analyzed in Table III.4 while the ones for which we disaggregate innovation adoption in its main dimensions (product vs process as well as made in cooperation vs "other organizations based") will be analyzed in Table III.5.

As for the results on overall innovation adoption, the regressions display a R-square around 0.60, and in the case of specification in column (ii), which is the one we will finally use as preferred specification in the third stage analysis, where productivity growth is explained by the fitted values of innovation adoption, we must say that the correlation of the fitted and real values of the endogenous is 0.1933 and highly significant (p-value: 0.019). In the next paragraphs we firstly explain the rate of country innovation adoption by the fitted values of cooperation, competition and trade coming from the best specifications analyzed in the first stage analysis.

Cooperation shows up to be a driver of innovation adoption in most of the regressions. This result is not surprising and it is in line with the one we obtained from the cross section analysis for the CIS3 alone. This time, the use of more observations, and the analysis of the dynamics of both cooperation activities and of innovation adoption seems again to point to the importance that cooperation in innovation activities has on the degree of innovation which is finally adopted across EU firms. The more the cooperation, the more will be the rate of innovation which is finally adopted. The coefficient is statistically significant in the specification proposed in column (i) although it looses its significance in some of the robustness checks that we propose in the following columns.

Behind the result on the positive effect of cooperation relies a more complex consideration on the actual determinants of cooperative activities and on their (indirect) effect on innovation adoption. As we argued in the first stage analysis, cooperation activities are explained by different IM regulations. Hence, their effect is transposed to innovation adoption. Higher levels of **Trust** as well as of **Human Capital** are going to foster cooperation activities which, at the end, are shown to increase the rate of innovation adoption across countries. Also, **less burdensome administrative regulations** and a better overall implementation and **reception of EU regulations in the matters of Employment and Social affairs and in Competition** are statistically shown to increase the rate of cooperation and eventually of innovation adoption rate.

Also **Trade** openness is shown to be positively affecting the rate of innovation adoption. This result is different, indeed, to the one we obtained in the cross-section analysis based on CIS3 data. In the previous report, Trade was never statistically significant and also the sign of the coefficient was mixed depending on the different specifications analyzed. This time, the use of a larger database, and the possibility of examining also the dynamics over different time spans gives us the possibility of being more specific about the impact of trade. The economic literature has already discussed the role of trade openness in the diffusion of innovation and economic growth (see Kaufmann and Kraay, 2002 or Manca, 2009).

Trade openness allows firms operating in different countries to get in touch with technologies and innovations developed elsewhere. The easier is to trade, the more technology will freely flow from a country to the other such that innovation adoption rates will finally increase. This is indeed the econometric result that we obtain in Table III.4 in all the specifications. If any, it is the embodied technology in the traded goods which more than other spills over through trade. If a new process innovation is invented for producing cereals in one country, then similar firms will get to know it especially if the result of this innovation is actually traded and commercialized in their market. This way, they will be able to decide whether to adopt this new process innovation and use it in their productive processes if they believe it to be profitable. This mechanism does not work if the embodied technology is not actually traded across countries.

Again, as for the case of cooperation, the impact of trade on innovation adoption is masking the deeper impact of those IM regulations which determine how much a country is open to trade, although this was not so clear in the case of trade. Hence, **decreasing regulatory trade barriers**, as well as fostering international trade harmonization through univoque trade rules is going to affect positively the volumes of trade over GDP (although not all of them appeared to be significant) and, at the end, also foster the rates of innovation adoption. The same applies to those countries which more than others do not exert price controls and let the market freely determine price levels for traded goods. These countries are going to be more open to trade and eventually adopt innovation at higher rates.

As for the three transmission channels, also **competition** exert a significant impact on innovation adoption. In the present analysis, the coefficient for competition is statistically significant and positive while in the previous report, the coefficient associated to “markup” was almost never significant and, if any, it was negative. At a first sight this may seem an odd result.

Higher levels of competition seem to affect negatively the adoption of innovation. The economic intuition of this result, however, could be much clearer when we also take into account that firms face usually two options. The first is to innovate directly within the firm. The second is to adopt existing innovation or to develop it jointly with other firms (which however do not stop being, usually, direct or indirect competitors in the market). We know that higher levels of competition strongly push firms to remain at the edge of their technology frontier. In order to do so, and so to maintain their share of the market, innovation creation is possibly the best option. Due to our definition of innovation adoption, an increase in the creation of innovation decreases the observed rates of innovation adoption since firms are put in front at the decision of whether to innovate or imitate. Hence, it not surprise that in more competitive environments firms prefer to innovate rather than adopt or share knowledge with possible competitors. This would justify the observed positive coefficient on "markup" for which in those countries where the competitive pressure is higher (low levels of the mark-up index) the rates of adoption (everything else constant) are below the average.

An indirect confirmation of the goodness of this point of view comes from the estimation of two additional regressions as in column (ii) but changing the dependent variable. In the first one, we use as a dependent variable the innovation rate, instead of the innovation adoption rate. This is presented in column (iii) of Table 4. In the second regression, we use as a dependent variable the rate of adopting firms over total firms (column iv in Table 4). In these two regressions the coefficient for mark-up should be negative if our intuition that in more competitive environments firms prefer to innovate rather than to adopt. However, the intuition is not confirmed, with a positive sign of the mark-up variable indicating that in environments with higher mark-ups (lower competition) firms have more incentives not only to adopt innovations but also to innovate in general terms.

Another way of studying the veracity of the argument that in those countries where the competitive pressure seems to be less, the adoption of innovation, rather than its creation could be a plausible productive model for economic growth could be through the consideration of the variable Integrity of the legal system. This variable shows a positive and significant coefficient in the case of the regression of innovation adoption leading to think that more innovation adoption is carried out when firms can trust their competitors not to free-ride on the shared knowledge produced by the adoption of innovation (especially when this is made in cooperation). To say it in different words, when the legal system of a country does not ensure that the knowledge that firms share when they adopt an innovation in cooperation cannot be freely appropriated by the partner, then, innovation creation rather than innovation adoption is preferred. The complementarities of these two strategies can be easily seen in the opposite signs shown by the "integrity of the legal system proxy" over adoption rates and innovation rates, positive in the first case and negative in the second, and significant in both cases.

In order to analyse a bit deeper the reasoning behind the positive sign of the coefficient of mark-up, we may also think that between product market competition and innovation there exists an inverted-U relationship. This is suggested and empirically tested in the paper by Aghion, Bloom, Blundell, Griffith and Howitt (2005). They re-examine this relationship using panel data and find clear nonlinearities in the form of an inverted-U shape. Following their strategy, we have also estimated our model but now including a squared term of the mark-up variable. As it can be observed in Appendix III.2, the results are maintained on the positive sign of the competition proxy. The squared term is also positive although not significant. Therefore, the positive influence of the mark-up on adoption rates does not seem to be explained by the lack of consideration of a non-linear form.

Going back to the determinants of innovation adoption, apart from the integrity of the legal system also transposition of the European Union rules, and specifically the ones related to the Internal Market (**TDI Internal Market**) seem to be important in defining the rate of adoption. Increasing in the number of regulations are adopted by each member state to approach a real Internal Market within the European Union has a clear positive impact in the adoption of innovation. The coefficient is statistically significant and with the expected positive coefficient in all the regressions run.

Additionally, **Administrative regulations** seem to be important in defining the rate of adoption. A decrease in the time spent to deal with bureaucracy is one of the main goals of the EU regulations for which the standardization at the European level of bureaucratic procedures has the aim of increasing productivity and homogenise standards. Here, we find a statistical confirmation that burdensome administrative regulations reduce the rates of innovation adoption by making this comparatively more difficult to be carried out. The coefficient is statistically significant and with the expected negative coefficient.

Table III.4. Determinants of innovation adoption

	(i)	*(ii)*	*(iii)*	*(iv)*	*(v)*
	Adoption rate	***Adoption rate***	***Innovation rate***	***Adoption rate over total firms***	***Adoption rate***
Cooperation	1.920	0.624	0.746	0.474	0.335
	(3.03)***	(1.48)	(2.40)**	(1.89)*	(0.69)
Markup (low competition)	18.320	7.343	5.822	4.891	0.682
	(4.02)***	(3.60)***	(4.09)***	(4.03)***	(0.18)
Trade	0.018	0.019	0.011	0.010	0.028
	(2.68)***	(2.80)***	(2.18)**	(2.39)**	(3.19)***
TDI Internal Market	0.030	0.009	0.012	0.005	0.006
	(3.24)***	(1.78)*	(3.42)***	(1.75)*	(1.00)
Integrity of the Legal System	0.111	0.043	-0.032	-0.013	0.165
	(3.14)***	(1.69)*	(-1.77)*	(-0.88)	(2.42)**
Administrative Regulations	-0.270				
	(-2.68)***				
Belonging to a Group					-0.000
					(-1.18)
R&D Expenditures, Total					0.028
					(2.16)*
Organizational changes					-0.000
					(-0.51)
Constant	-15.003	-5.629	-4.292	-3.402	-2.556
	(-3.86)***	(-3.23)***	(-3.60)***	(-3.28)***	(-1.12)
Observations	147	147	183	147	122
Number of id_country	17	17	19	17	15
R-squared	0.62	0.59	0.67	0.63	0.62

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4).

As a robustness check of the results, and similarly to what we did in the previous report, we insert in the main regression other possible controls (apart from the time and sectoral dummies that are inserted in all regressions). Hence, we control for the rate of firms belonging to a group, the total expenditure in R&D by sector and the rate of firms that have introduced organizational changes. As in the previous report these variables do not show up to be statistically significant (only Total R&D expenditure is significant at 10% level) but, at the same time, some of the overall significance of the other coefficient is lost (especially for cooperation and competition). We also propose some tries with only one of the control variables at once. The picture does not change and the three transmission channels re-gain their statistical significance.

We have also re-estimated the same equations as in (v) but this time changing the total expenditure in R&D into their different categories: intramural R&D, extramural R&D, acquisition of machinery, equipment and software, training, and finally market introduction of innovation. Reproducing the specification in (v) with these different categories, and also eliminating the control variables of group of enterprises and the introduction of changes to work organisation, the conclusion is consistent: the fact of the firm being engaged in market introduction of innovation implies having a higher adoption of innovation. In general, it is also obtained that increases in expenditure in both intramural and extramural R&D supposes increases in adoption rates.

III.3.3. Disaggregating Innovation Adoption

As we have already argued, due to the convenient way the CIS data are built, we are able to disentangle the different dimensions of innovation adoption. The adoption of innovation, in fact, can be of product or processes and, at an even deeper level of disaggregation, both product and process innovation adoption can been disaggregated in adoption made in cooperation and that which is the result of the direct acquisition from another firm (other organization-based innovation adoption).

Significant differences seem to arise from the analysis of these different dimensions. **Cooperation seems to be a statistical significant driver of innovation adoption based in cooperation activities. On the contrary, it seems to affect negatively the innovation based on purchasing from others.** This result seems itself to be driven by the fact that innovation adoption in cooperation is, as expected, more positively related to overall cooperation across firms, which implies a joint effort between firms in innovation activities. Instead the effect of cooperation is show to be modest (or null) for the adoption of both processes or products when this adoption is the result of direct acquisition of the innovations from other organizations or firms.

Trade is shown to be statistically significant in explaining overall process adoption rate. This said, at a deeper disaggregation level, it seems that it is specially adoption rates made in cooperation with other firms to innovate in process that get more affected by trade.

Markup (as a proxy of competition levels) is not such a significant variable explaining the decisions of innovation adoption when the analysis is disaggregated into product and processes innovation adoption than in general terms. The coefficient for this explanatory variable is positive and significant for product innovation made in cooperation pointing to the fact that the more the competition, the fewer firms will decide to adopt product innovation in cooperation when they can also, instead, directly be the creator of innovation. On the contrary, the coefficient is negative and significant for process innovation purchased from other firms meaning that the higher the competition, the more firms will decide to buy process innovations from other firms.

Table III.5. Determinants of dissagregated innovation adoption

	Adoption rate in PDT	*Adoption rate in PCS*	*Adoption rate in Cooperation, PDT*	*Adoption rate other organization based, PDT*	*Adoption rate in Cooperation, PCS*	*Adoption rate other organization based, PCS*
Cooperation	-0.135	-1.169	0.742	-0.023	0.888	-0.966
	(-0.25)	(-0.33)	(1.68)*	(-0.06)	(1.95)**	(-2.16)**
Markup (low competition)	-0.357	-0.567	4.372	-0.489	3.109	-3.889
	(-0.14)	(-0.23)	(2.10)**	(-0.26)	(1.45)	(-1.85)*
Trade	0.007	0.035	0.003	0.001	0.033	0.006
	(0.79)	(4.08)***	(0.40)	(0.21)	(4.34)***	(0.86)
TDI Internal Market	-0.008	0.008	0.002	-0.003	0.010	-0.001
	(-1.26)	(1.29)	(0.32)	(-0.55)	(1.92)**	(-0.27)
Integrity of the Legal System	0.017	0.019	0.010	-0.005	-0.001	0.025
	(0.53)	(0.61)	(0.40)	(-0.20)	(-0.04)	(0.95)
Constant	1.111	-0.141	-3.014	0.642	-2.938	2.805
	(0.51)	(-0.07)	(-1.71)*	(0.40)	(-1.62)*	(1.58)
Observations	146	153	142	139	147	147
Number of id_country	17	17	17	17	17	17
R-squared	0.35	0.34	0.19	0.28	0.22	0.24

Absolute value of t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%. Time and Sectoral dummies have been inserted in all regressions. The time dimension refers to 2000 and 2004 (CIS3 and CIS4).

Finally, not so clear is the effect of the Internal Market. With respect to **the integrity of the legal system, we do not obtain a significant impact in any of the cases of innovation adoption under consideration. Similarly happens with the TDI for the Internal Market,** except in the case of process innovation adoption made in cooperation, that seems to be positively and significantly affected by the number of EU directives in the field of the deepening of the Internal Market.

PART IV

Analysis of the effects of innovation diffusion/adoption on productivity growth

IV.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, 1991, Coe and Helpman, 1995).

The idea in this Part IV 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 (section IV.2) and subsequently, we will study the real impact that innovation adoption may have on productivity growth through a regression analysis (section IV.3).

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

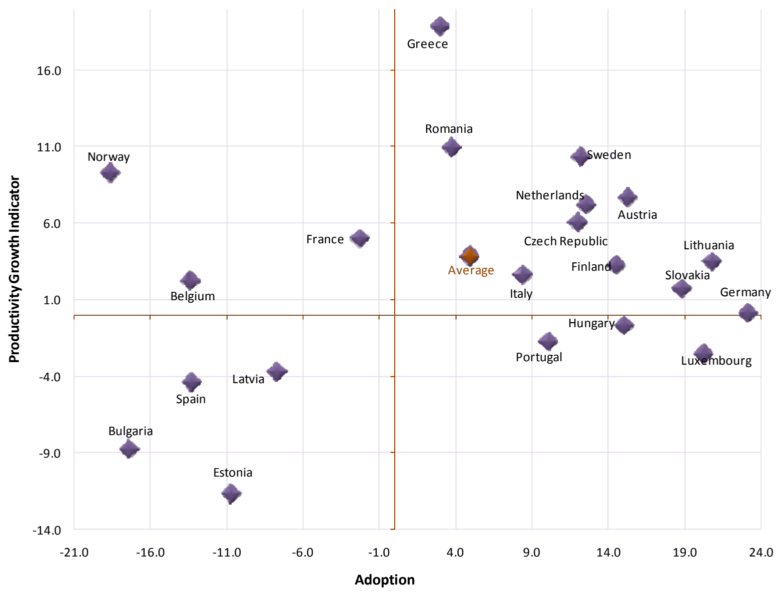
The expected relationship between innovation diffusion/adoption and productivity growth is positive as highlighted in previous empirical and theoretical literature. For instance, the Nelson-Phelps (1996) model of technology diffusion/adoption is based on the idea that changes in productivity and in total 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. 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. At a first stage the plots are given for national averages whereas afterwards we will turn to a sectoral disaggregated analysis.

IV.2.1. Descriptive statistics of the relationship between innovation adoption and productivity growth at the national level

Figure IV.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 IV.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 IV.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.[40]

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 IV.3), once we delete Greece and Norway, the correlation becomes clearly significant (coefficient of correlation of 0.426;

[40] 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.

p-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 IV.2. Scatterplot of changes in product adoption and productivity growth

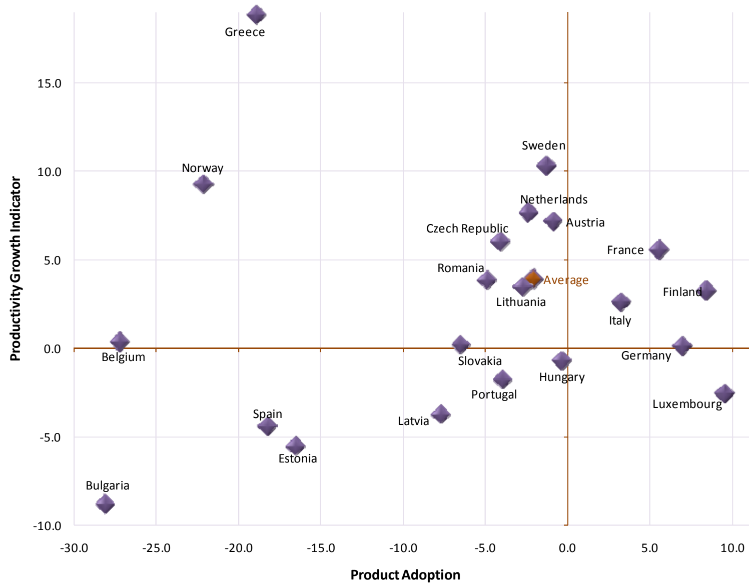
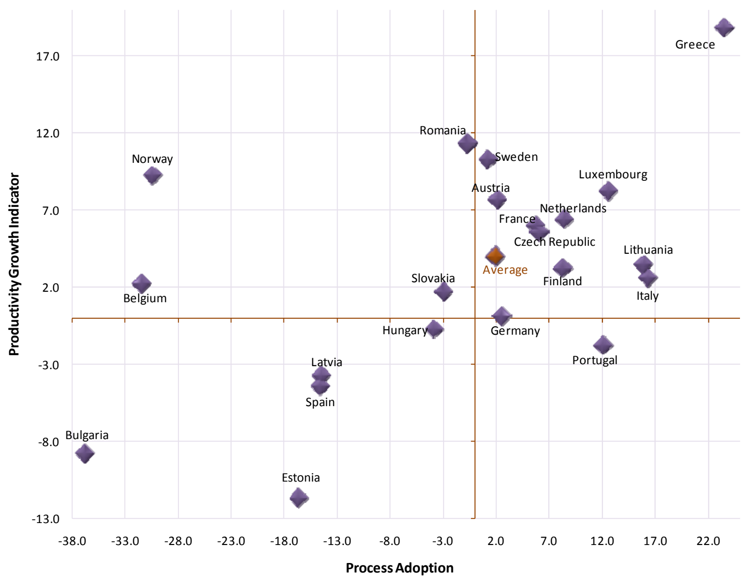


Figure IV.3. Scatterplot of changes in process adoption and productivity growth



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.

Figure IV.4. Scatterplot of changes in product innovation coopearation-based and productivity growth

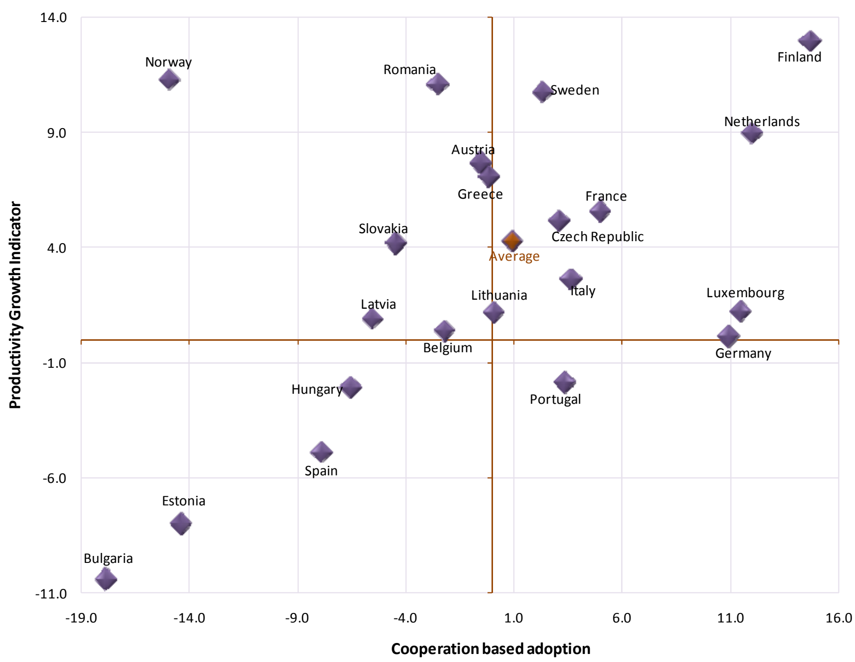
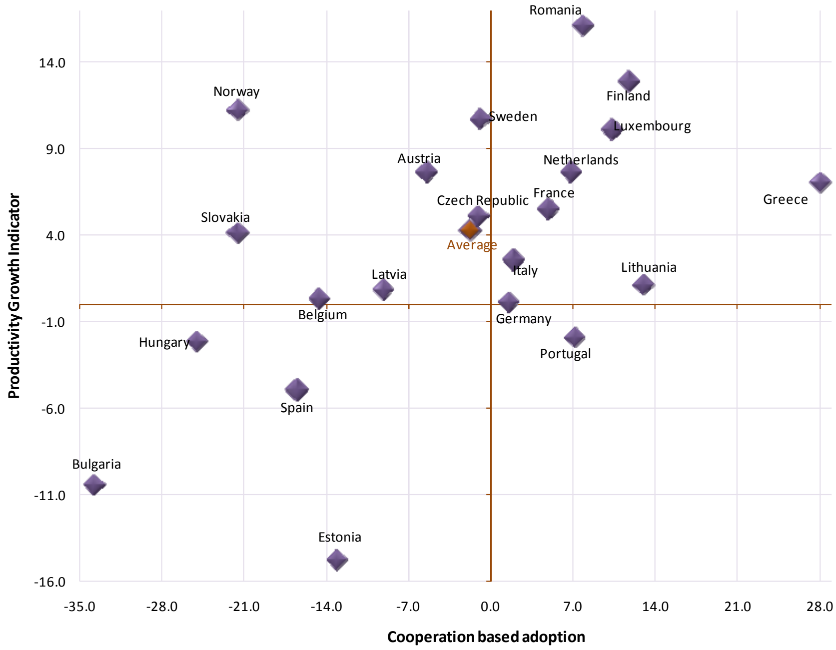


Figure IV.5. Scatterplot of changes in process innovation coopearation-based and productivity growth



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 IV.6 and IV.7). Again **the relationship is positive** for product adoption (46%, being significant at a 3% level), but it is not 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.**

Figure IV.6. Scatterplot of changes in product innovation other organisation-based and productivity growth

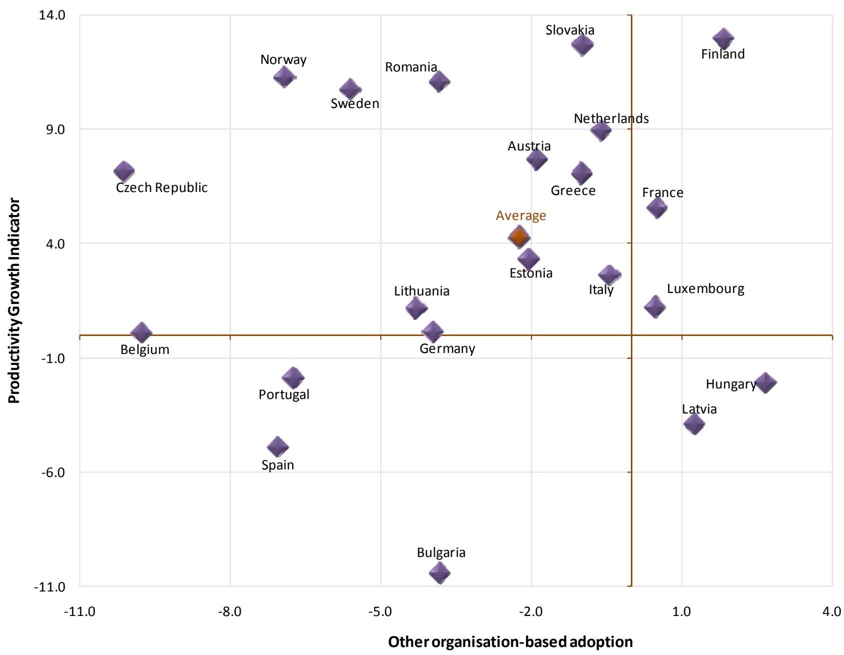
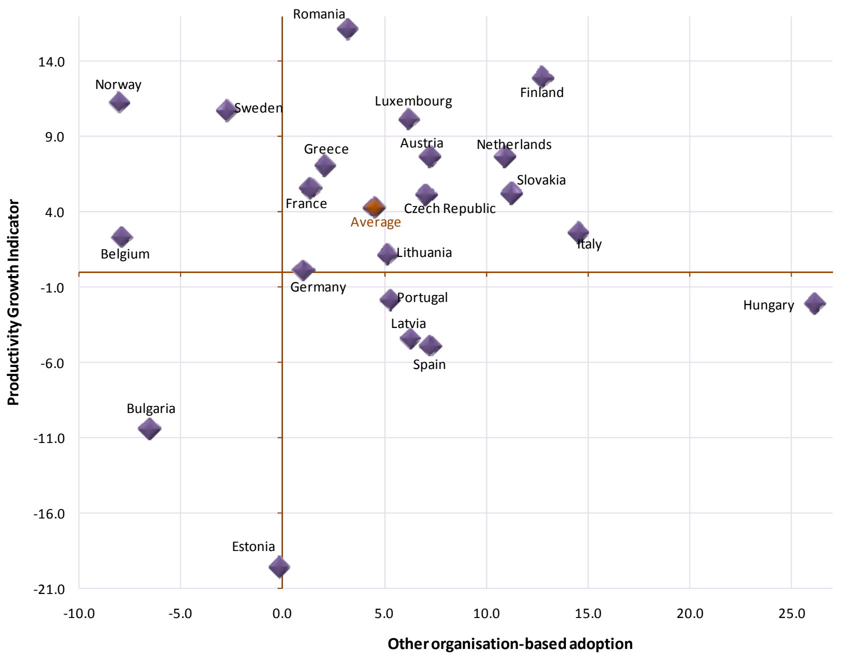


Figure IV.7. Scatterplot of changes in process innovation other organisation-based and productivity growth



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

	Correlation	Correlation without some countries
Adoption	-0.0285	0.0975 (Norway and Greece dropped)
	(0.9023)	(0.691)
Product adoption	0.0754	0.4145 (Norway and Greece dropped)
	(0.7453)	(0.077)*
Process adoption	0.3367	0.4258 (Norway and Greece dropped)
	(0.1356)	(0.069)*
Product adoption in cooperation	0.1866	0.3700 (Norway dropped)
	(0.418)	(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		

IV.2.2. Descriptive statistics of the relationship between innovation adoption and productivity growth at the sectoral level

We turn now to investigate whether the positive relationship between changes in innovation adoption and productivity that has been observed at the national level is also displayed with the information at the sectoral level. A summary of the correlations obtained for both variables is shown in Table IV.2.

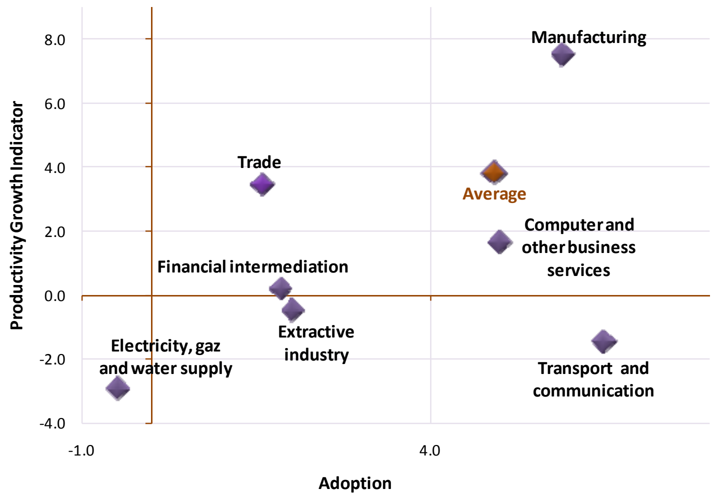
Table IV.2. Coefficients of correlations between productivity growth and changes in innovation adoption. Sectoral level

	Correlation
Adoption	0.3127
	(0.494)
Product adoption	0.198
	(0.670)
Process adoption	0.447
	(0.314)
Product adoption in cooperation	0.0216
	(0.963)
Process adoption in cooperation	0.4656
	(0.292)
Product adoption other organisation-based	0.2014
	(0.665)
Process adoption other organisation-based	-0.5071
	(0.245)
P-values are given in parenthesis	

A general conclusion **is that the correlation between productivity growth and changes in innovation adoption is not significant**. It is probably due to the small number of observations under consideration, only 7 sectors. However, the sign of the correlation is positive except in one case, leading to the conclusion that higher growth rates of productivity tend to be associated to higher changes in innovation adoption. This is more the case for the adoption of process innovations made in cooperation and in the case of product innovations adopted from other firms or organisations. It seems therefore that sectors that have increased their number of firms making process innovations and do this kind of innovation in a cooperated way tend to have increased their productivity. The same would occur in the case of the number of firms wanting to innovate in product through the purchase from another institution. These two practices seem to be related to a more clear positive relationship with productivity growth.

The scatterplots are shown in Figures IV.8 and subsequents. As observed in Figure IV.8, in general terms, the sectors with higher productivity growth rates are also developing strategies of increases in adoption rates. This is the case of Manufacturing, Trade, Computer and other business services and Financial intermediation. On the contrary, the sector of Electricity, gaz and water supply present very low growth rates of both innovation adoption and productivity. However, breaking this general rule we find the sector of Transport and communication, which is also increasing its innovation adoption at a rate over the average whereas its productivity growth is far below.

Figure IV.8. Scatterplot of changes in innovation adoption and productivity growth



When the innovation adoption is made in cooperation, the sector of Electricity, gaz and water supply is the one with negative productivity growth rates together with changes in adoption which are in the range of other sectors, these ones obtaining positive productivity growth rates. Similarly, among the sectors with positive productivity changes one can find some that also have positive changes in adoption rates in cooperation with other firms (Manufacturing and Transport and communication) whereas others present clear negative changes in adoption rates (Trade, Financial intermediation and Computer and other business services). This points out to the coexistence of sectors with the similar growth rate and presenting completely different patterns of behaviour in relation to innovation adoption

Figure IV.9. Scatterplot of changes in product innovation adoption made in cooperation and productivity growth

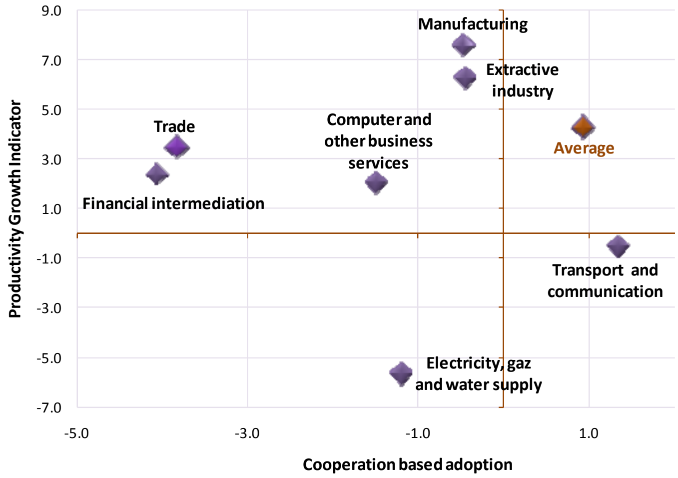
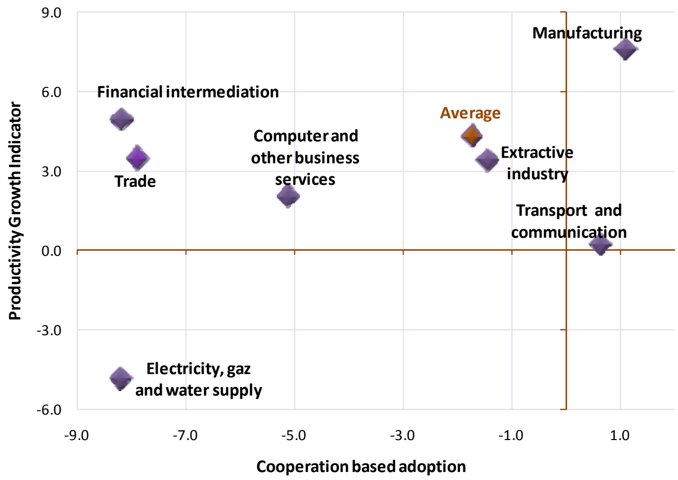


Figure IV.10. Scatterplot of changes in process innovation adoption made in cooperation and productivity growth



Finally, as observed in Figures IV.11 and IV.12, again, for the case in which firms purchase innovation from other firms or organisations, no clear pattern is observed, with some sectors having similar changes in adoption rates and very different profiles of productivity growth rates. Therefore, it is necessary to carry out a regression analysis where the real impact of innovation adoption on productivity growth can be studied. This is done in the next section.

Figure IV.11. Scatterplot of changes in product innovation adoption other organisation-based and productivity growth

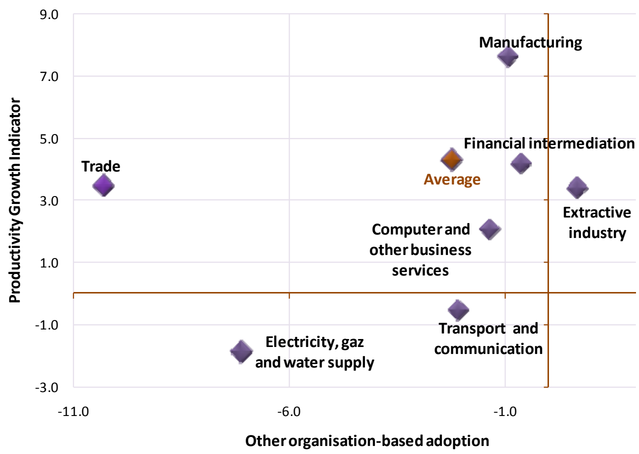
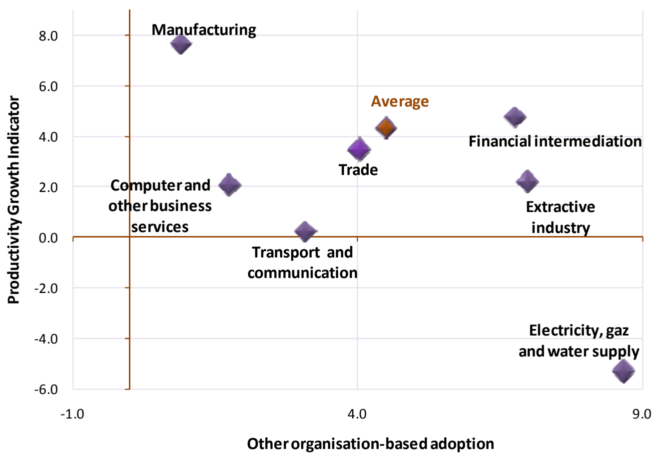


Figure IV.12. Scatterplot of changes in process innovation adoption other organisation-based and productivity growth



IV.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):

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

(4.1)

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:

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

(4.2)

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 Part III of this report, and 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. Once again, 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. (4.2) where the fitted value of the dependent variable in eq. (3.4) is inserted as a regressor in eq. (4.2). 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 IV.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 IV.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.[41] 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.

As a concluding remark of this Part IV of the report, it seems that an effort in line of making enterprises increasing innovation adoption, either in the form of cooperating with other enterprises of 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

[41] 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.

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.

PART V

Conclusions and Policy recommendations

At this stage of the work we have been able to disentangle the effect of the Internal Market on innovation adoption across major EU countries. We analyzed how this impact actually works through three channels which are identified in trade, competition and cooperation.

We have been able to disentangle specific policies and regulations which may statistically affect each one of these channels. These results are of particular interest from a policy making point of view since they allow us to directly identify both channels of transmission of innovation adoption across EU firms and countries as well as the IM regulations which boost these channels and ultimately promote innovation adoption. It should be noted however that the results have been obtained thanks to a statistical analysis which includes some limitations. Firstly, our measure of diffusion focuses on adoption, and therefore does not allow us to cover the whole diffusion process. Secondly, the database used is of weak quality (due to double counting problems and missing observations). Therefore the policy recommendations drawn below should be taken when keeping this in mind. We first detail, here below, the main transmission channels of innovation adoption that we have been able to identify (Trade, Competition and Cooperation). Given our definition of innovation diffusion using CIS, we highlight how differently the determinants of diffusion can impact the different forms of adoption, being they cooperation-based adoption or adoption of technologies mainly developed by other enterprises. Indeed, this distinction may have policy implications. Then we present the IM policies which are found to statistically affect both the transmission channels and their indirect effect (being this positive or negative) on innovation adoption. We are also able to say something on the impact that some specific regulations may have on different kinds of innovation adoption. In particular, the distinction between product and process innovation adoption is worth noting and confirms somehow the necessity of considering them separately when defining public policies. Some useful elements concerning the relation between innovation adoption and productivity growth are also provided (as detailed in Part IV). Finally, beyond the global regularities identified above, we underline the potential impact of the diversity of the countries and sectoral contexts as revealed by the descriptive statistics of Part II. Indeed, results of global policies applied to highly diversified contexts are not always easy to anticipate.

V.1. Identifying the determinants of innovation adoption. The impact of the transmission channels

Using country and sectoral aggregated data, our econometric analysis of the role of Cooperation, Competition and Trade as channels for innovation adoption within the EU has gone deep into the determinants of innovation adoption not only by focusing on the total innovation adoption scores but also by disaggregating innovation adoption into different categories related to “product” and “process” and to additional sub-categories linked to the way the innovation has been adopted (mainly as a result of some kind of inter-firm cooperation or as a direct acquisition of the product or process developed externally from the acquiring firm). Summarizing the results we may highlight that:

i. **Cooperation** appears as one factor likely to enhance the rate of innovation adoption.

   a. **<u>Total innovation adoption</u>** (product + process innovation adoption) **is statistically correlated with cooperation activities** (being these carried out across countries or within the same country)
   b. **Cooperation is found to be especially important in the diffusion and adoption of inventions, no matter whether they are products or processes, which are obtained jointly with other enterprises or institutions.** This is to say that **making cooperation easier will incentivize innovation adoption resulting from actual cooperation across firms, irrespective of the type of innovation, product or process innovations.** Thereby this may contribute to an improvement of the efficiency of adoption which generally necessitates direct interactions in order to transmit tacit knowledge and know-how.
   c. **Cooperation is also found to be statistically related to innovation creation.** In other words, as a result of the work of different firms on the same R&D projects, not only joint innovations appear but also firms are more prone to made innovations carried out within the firm.

Cooperation is one of the determinants of the innovation spillover observed across firms/countries and **should be strengthened** even more in order to achieve **higher levels of diffusion/adoption**. Facilitating cooperation could also lead to a better **efficiency especially in innovation adoption made jointly with other firms or institutions**, by giving incentives to firms to preferably choose the adoption through cooperation.

ii. **Competition** surprisingly shows to be always a strong **determinant of total innovation adoption**. However, the sign of this effect is contrary to what was initially expected. High levels of competition seem to affect negatively the adoption of innovation. One possible explanation for this result would be that in more competitive environments firms prefer to innovate themselves rather than adopt or share knowledge with possible competitors. However, our results point to the fact that **environments with high competition imply fewer incentives not only to adopt innovation but also to innovate within the firm.**

However, results are dependent of the nature of innovation adoption. Particularly, when considering more precisely the nature of innovation adoption, the conclusion above is especially true for product innovation adoption made in cooperation. A probable explanation is that the higher the competition, the fewer firms will decide to adopt product innovation in cooperation since it the competitive environment makes the firm not to rely other possible competitors. On the contrary, **process adoption acquired from outside the firm is positively and significantly impacted by the level of competition**. Such a result may be interpreted as follows. Competitive pressures often lead to innovation race which implies the shortening of the product life cycle and the strengthening of innovation protection, being they new products opening new market opportunities or new processes allowing a reduction of production costs. In such a context, appropriability matters are extremely sensitive implying that direct adoption is preferred to adoption through cooperation. Another interpretation is that in fact a more developed competition allows firms to merge (and therefore acquire production processes) or to simply buy and exchange production processes in a much easier way.

Competition does not seem to foster innovation and it is neither a **determinant of innovation adoption in general terms**. However, as it eases the market for technology and at the same time contributes to the reinforcement of knowledge appropriability constraints within cooperation, **competition is a significant incentive only for direct acquisition of external new processes innovation** and not for innovation made in cooperation.

iii. **The Trade channel has a significant effect on the total adoption rate of innovation.** This way, trade openness would allow firms operating in different countries to get in touch with technologies and innovations developed elsewhere. The easier it is to trade, the more technology will freely flow from a country to the other such that innovation adoption will finally increase. When considering more specifically the nature of innovation adoption, we obtain that trade is shown to be more statistically significant in explaining overall process adoption, and more precisely the ones made in cooperation with other firms. It seems therefore that if a new process innovation is invented for producing a product, then similar firms will get to know it especially if the result of this innovation is actually traded and commercialized in their markets.

From a more general perspective, we would like to stress that in various specification the estimated coefficients for some transmission channels do not show the usual statistical significance, but are instead, only "marginally" significant. This leads to think that extra-care is needed when interpreting these coefficients. Also, we believe that further research may be needed (especially improving the data in the sense of having less missing values) in order to fully test the hypothesis of the current work on a larger number of observations which would allow a more robust empirical and statistical analysis.

V.2. Identifying the IM regulations likely to boost the channels of innovation adoption

We turn, here below, to our analysis concerning the IM regulations affecting the transmission channels. Thus, we present the main conclusions related to the indirect impacts that the IM regulations may have on the adoption of innovation.

i. **Cooperation** (intended as the propensity of carrying out firm innovative activities together with other firms) is shown to be positively correlated to the degree of **social trust** in each country. Policies aiming at ensuring a higher level of generalized trust may be helpful therefore in boosting cooperation.

   a. From a more IM regulation point of view, we have been able to detect a statistical significant correlation of cooperation activities with the transposition of EU directives in the fields of employment and social affairs. On the one hand, the transposition of EU directives oriented to the employment sphere is expected to increase cooperation by making easier and more uniform the legislation on firing and hiring procedures. This would increase the possibility of workers to be employed across different countries and then their changes of participating in cooperative projects. Also, EU regulations related to "social affairs" have the important objective of creating, building or increasing the existent social capital in each country, which is likely to increase the social framework within which cooperation activities take place.
   b. Also, strengthening **Human Capital** is shown to be statistically significant when explaining the degree of cooperation (especially in innovative projects). The use of framework programmes (such as the last EU 7FP) may therefore be seen as a way of efficiently exploiting the existing human capital and to foster additional cooperation at the EU level which, ultimately, will be conductive to innovation adoption and diffusion.

Therefore, policies contributing to reinforce social trust within countries especially through the transposition of EU **directives ensuring an homogenous labour market as well as those related to social affairs** are likely to develop cooperation among firms and consequently to achieve **higher levels of diffusion/adoption. Strengthening Human Capital also appears as an efficient way to enhance cooperation and consequently innovation adoption**.

ii. **<u>Competition</u>** has been one of the main priorities for the EU Commission and its various DGs. We have been able to detect how the work of the EU Commission started producing its results by increasing the competition level of the member states' economies. The level of competition is shown to be highly correlated with the adoption of the "competition regulations" proposed by the EU. In fact we are able to show how for those countries which are still lacking the full adoption of the EU regulations the markup levels are on average higher. **The Transposition of the EU-Competition regulations is shown to robustly provoke higher competition levels across the countries in our sample**.

a. From a more specific regulatory point of view, we detected how the **intrusiveness of national government** (when "national, state or provincial government controls at least one firm in one basic sector") is going to reduce competition so these kinds of behaviours should be strongly opposed.
b. At the same time we detected how the **size of the public enterprise sector should diminish** so as to foster more competition.
c. Finally, we find a **negative relation** between competition and the use by national governments of the **golden rule option**, or the presence of any **constitutional constraint to the sale of the stakes** held by national governments **in publicly controlled firms**.

Policies reducing rents, administrative burdens and national government controls should be therefore strongly implemented at the EU level in order **to achieve higher levels of competition and eventually higher shares of adoption of external processes and productivity growth.**

iii. **<u>Trade</u>** is not significantly affected by the kind of regulations on the Internal Market that we are considering in our estimations. Although the sign of these regulations is as expected, they do not appear to be statistically significant. This is the case not only for trade from/to around the world but also the intra EU27. We think that the statistical information we have for trade at the sectoral level in the different countries, coming from two different databases, may be the reason behind this poor estimation.

Although not significant, our results show that regulations which imply heavy "**price controls**", especially those on air travel, road freight, retail distribution and telecommunications are going to decrease the amount of trade. The intuition is that companies will trade more where they can freely decide prices or where the transportation sector (crucial for the export industry) is not heavily regulated by national governments. **Trade** is also positively affected by **less restrictive trade barriers** and, in general, we showed how trade is positively associated with well known indexes of trade openness which suggest how, among other things, providing an **easier access of citizens to international capital markets** and *viceversa* for **foreign investor the access to national capital markets** is going to foster international exchange also in tradable goods.

We therefore showed how **the indirect effect of policies reducing prices controls or the national government controls on the transportation sector are going to foster international trade, although not significantly, and eventually affect the extent by which innovation can freely move within the EU borders and eventually been adopted**. The result on the lack of significance of most of the EU regulations on trade is puzzling and it seems to need further research.

All in all, we get the general picture that IM regulations undertaken by the European Commission are having their impact on the level of adoption of innovation in EU firms. It should be highlighted that this influence goes through changes in the three channels under consideration in this study, namely cooperation, competition and change. However, the importance of the channels identified varies according to the type of innovation adoption we have considered. In particular, diffusion through cooperation will particularly be enhanced by policies aiming at facilitating cooperation whereas diffusion through direct purchases from other firms will be enhanced by policies aiming at augmenting competitive pressure. Results obtained by the comparison between CIS3 and CIS4 certainly show that the development of the Internal Market may already have had an influence. As countries have historically constructed themselves around specific mix of theses different features, we should bear in mind that the same global policy concerning IM regulation may have different implications depending of the context of their application. The descriptive statistics analysis we have done in Part II offers us tools to better apprehend this reality.

V.3. Dealing with the diversity of national profiles

The descriptive statistics given in part II lead on to the following results:

i. **Generally speaking, countries which display the highest level of innovation are also those which show the highest adoption rate** and conversely countries with weak capacity to innovate are also weak adopters. Thus, the complementary dynamics linking innovation and adoption seems to be at work. However exceptions exist which are certainly not to neglect if we are to understand how countries can react to European incentives. **These exceptions are Luxemburg, Ireland, Belgium and Estonia which display low level of adoption compared to their innovative capacities, and Italy, Poland, Lithuania and Netherlands which have a very high rate of adoption compared to its rate of innovation**. Specific characteristics of their system of innovation strongly oriented toward internal resources or sectoral specializations towards sectors of high intensity of internal innovation may explain the three former exceptions. Indeed, some sectors are essentially relying on adoption (Trade, Transport and communication, Electricity, gaz and water supply and Financial intermediation) while others are recording at the same time very high innovation rate and very low adoption rate (Manufacturing and Computer and other business services).

Generally speaking, the complementary dynamics linking innovation and adoption seems to be at work in many European countries. However exception exist which could be explained by cultural factors or by sectoral specialization. **Luxemburg, Ireland, Belgium and Estonia display low level of adoption compared to their innovative capacities, whereas Poland, Lithuania, Italy and Netherlands have a very high rate of adoption compared to its rate of innovation**.

ii. **Globally also, and according to the first point, countries highly endowed with resources to innovate and using invention protect methods as incentive to**

innovate, display also high rates of adoption. Exceptions are often the same than in the first point: Poland and Italy lowly doted in R&D expenditures and in human capital display very high adoption rates.

iii. **Concerning the organizational factors such as the capacity to introduce organizational change within the firm or the capacity to cooperate with other organizations, differences between countries do not recover exactly their differences in terms of innovative potential or adoption. Other cultural factors seem at work**. Thus, Italy and Lithuania record very low level of organizational change and high adoption rates whereas Denmark, Luxembourg and France have the highest rate of organizational change together with low adoption rates. Adoption in Scandinavian countries is largely cooperation oriented whereas in Germany and Austria cooperation is less used in the adoption process.

iv. More generally, concerning the IM indicators, it seems that **two groups of countries correspond to the model described above either disposing of all the determinants of adoption and being well integrated in the UE with high adoption rate (most of the countries in groups 1 and 2 of the typology proposed in part II: Germany, Austria, Luxembourg, Netherlands, Denmark and Sweden with some specificities) or, on the contrary, lacking of most of the determinants of adoption, being more weakly integrated with very low adoption rates (countries from the Eastern and Baltic countries, group 4 and 5 of the typology).**

In this last group of countries **(Easter and Baltic countries)**, **acting towards a better integration to the EU, using the policies presented above may permit to reinforce their capacity to adopt innovation. We should underline however that such a policy might have no effect if it is not accompanied by actions aiming at reinforcing the own innovative potential of these countries in order to boost their absorptive capacity.**

v. Another group of countries (Group 3 of the typology: Italy, Portugal, Greece and Spain) performs well in innovation performances and is relatively well integrated into the Internal Market (Barriers to trade and competition are low within these countries). However, **some weaknesses in their innovation potential, use of**

HRST and a low level of cooperation prevent these countries to completely enter within the virtuous circle of innovation/adoption.

In such a context of low barriers to trade and competition, developing **IM regulations oriented towards the reinforcement of cooperation may particularly benefit to these three countries (Group 3) in order to reinforce at the same time their innovative potential and their capacity to absorb the innovation adopted.**

V.4 Innovation Adoption and Productivity growth

The expected relationship between innovation diffusion/adoption and productivity growth is positive as highlighted in previous empirical and theoretical literature (Nelson-Phelps, 1996). To check this hypothesis, we carry out a double analysis: descriptive and regression.

Firstly, through a descriptive analysis we study the correlation between the extent of the change in the adoption of innovation in each country, change computed between the data in CIS3 and that of CIS4, and productivity growth in the period between 2000 and 2005 from EUROSTAT. The results point to the next conclusions:

i. Although the general correlation seems to be positive but non-significant, if looking at the countries, it can be observed how this positive relationship is mostly due to the correlation among both variables for the countries with productivity decreases. They 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. On the contrary we do not observe such a clear relationship for the countries with increasing growth rates 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 decreases of productivity, which can take more advantage of such intangible asset.

ii. If we disaggregated adoption into its main categories, for both product and process innovation adoption, the relationship seems more clearly positive than in the general case, being even 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.

Additionally, through the estimation of a growth equation, we have obtained that:

iii. The parameter of the innovation adoption rate is positive and significant, 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. Therefore, it seems that an effort in incentivizing enterprises increasing innovation adoption, either in the form of cooperating with other enterprises of 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.

Both through a descriptive and regression analysis it seems that **an effort in line of incentivizing enterprises increasing innovation adoption**, in other words, increasing the cooperating with other enterprises of incorporating innovations made by other enterprises, **has a positive and clear impact on productivity growth.**

V.5 Suggestions for future implementation of CIS data and questionnaires

As a result of the experience working with the CIS dataset in order to study the innovation diffusion process in the EU countries, we can offer some suggestions for future implementation of CIS data and questionnaires:

- It is important for policy makers to dispose of precise information about the diffusion/adoption of innovation. In spite of the important limitations of the CIS data in measuring diffusion and adoption, these data are still probably the most relevant tool that is available at the moment, and the only one likely to provide a general overview of these processes at the EU level. Some improvements in the survey may allow coping with the main limitations highlighted in this study. In particular, **collecting more quantitative information** about the way innovation is produced would be of great help in econometric and economic analysis. For instance, the shares (or the intensity) of innovation made within the firm, in cooperation or developed by others should be registered directly for each case. Moreover, the usefulness of the CIS data comes from the possible crossing of several items. Most of these crossing cannot be implemented using aggregated data available on Eurostat website while micro data are needed. **Increasing the availability of data at the micro level** (which for now is restricted to only few EU member states) would thus provide more tractable information and richer analysis of the adoption process and its determinants.

- A second suggestion would be that of **trying to eliminate the subjectivity in some of the questions of the CIS** questionnaire in order to be able to better define categories and quantify the answers. Some of the present questions, for instance, ask to define whether an innovation has been developed “mainly” by other firms or in collaboration. This subjectivity impedes to measure or consistently define the same processes across countries due to the possible biases related to the subjectivity of the answer. As suggested above, this subjectivity may be partly solved by asking the share of innovation that relies on each type of innovation and not as a result of the interpretation of the word “mainly”.

- **In the present CIS3 and CIS4 questionnaires, the items allowing to deal with the innovation adoption issue, do not provide separated information about diffusion occuring within the country and across countries.** A revision of this question may solve directly this problem.

- **EUROSTAT should provide a technical annex on how the macro data** provided in their web-site **have been treated starting from the micro data**. Aggregation issues and different methodologies may be in fact a problem for researchers which have to know, first, how the statistical office treated micro data in order to obtain macro ones.

- So far in CIS we know if a firm has made innovation or adoption but not **the intensity of such processes**. Therefore, a firm making some innovation but at a very small scale and a big firm making a lot of innovation are, at the moment, considered equally. Both of them would answer yes, and this is all the information given in CIS. We have information about the share of turnover due to innovation. But this is only available for product innovations. This can hardly be asked for process innovations or other types of innovation (organizational, marketing, etc). **However a question (even qualitative) about the importance of innovation in the firm activity could be added**. This question should be asked for each type of innovation (innovation made within the firm/ innovation made in collaboration / innovation made by others).

- Some general questions on the firm, such as the value of the Exports, were in the questionnaire of CIS3 but it is not present in CIS4. Although we understand that the questionnaire changes from wave to wave in order to be improved, it is not desirable to eliminate variables since this prevents to have a panel.

- Finally, in addition to these marginal changes, it may be useful to constitute a working group to suggest improvements of the CIS in order to better account for innovation diffusion. This working group might suggest for instance a set of items, in order to explicit and validate the different channels of transmission between IM and diffusion of innovation.

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Appendices of Part II.

Appendix II.1. Description of the CIS4 micro dataset used as main datasource for the research[42]

A complete description of the original CIS micro dataset is presented in the below table. CIS 4 data are presented in absolute value (thousand Euro for expenditure and turnover) and also in percentage. The tables and indicators available for the CIS4 are:

- **General information about the enterprises (inn_cis4_gen).** Indicators:

Enterprises which are part of an enterprise group
Enterprises which are part of an enterprise group and have a foreign head office
Sell goods in local/regional market
Sell goods in national market
Sell goods in other EU, EFTA and/or EU -CC countries
Sell goods in any other country

- **Basic economic information on the enterprises (inn_cis4_bas).** Indicators:

Total turnover in 2002
Total number of employees in 2002
Total number of enterprises in the population in 2004
Total turnover in 2004
Total number of employees in 2004

- **Product and process innovation (inn_cis4_prod).** Indicators:

Product, developed mainly by the enterprise or enterprise group
Product, developed by the enterprise together with other enterprises or institutions
Product, developed mainly by other enterprises or institutions
Process, developed mainly by the enterprise or enterprise group
Process, developed by the enterprise together with other enterprises or institutions

[42] AQR-IREA has the CIS4 database, and the agreement to be used.

Process, developed mainly by other enterprises or institutions
Turnover of unchanged or marginally modified products
Enterprises that have new or significantly improved products only new to the firm
Turnover of new or significantly improved products only new to the firm
Enterprises that have new or significantly improved products new to the market
Turnover of new or significantly improved products new to the market
Turnover of new or significantly improved products only new to the firm as a share of total turnover
Turnover of new or significantly improved products new to the market as a share of total turnover

- **Innovation activity and expenditure in 2004 (inn_cis4_exp**). Indicators:

Enterprises, engaged in intramural R&D
Expenditure in intramural R&D in 2004
Enterprises, engaged in extramural R&D
Expenditure in extramural R&D in 2004
Enterprises, engaged in acquisition of machinery, equipment and software
Expenditure for acquisition of machinery, equipment and software in 2004
Enterprises, engaged in acquisition of other external knowledge
Expenditure for acquisition of other external knowledge in 2004
Enterprises, engaged in training
Enterprises, engaged in market introduction of innovations
Enterprises, engaged in other preparations
Enterprises, engaged in innovation activities
Total innovation expenditure
Enterprises, engaged continuously in intramural R&D
Enterprises, engaged occasionally in intramural R&D
Total innovation expenditure as a share of total turnover
Intramural R&D expenditure as a share of total turnover
Extramural R&D expenditure as a share of total turnover
Expenditure in acquisition of machinery, equipment and software as a share of total turnover
Expenditure in acquisition of other external knowledge as a share of total turnover

- **Highly important effects of innovation during 2002-2004 (inn_cis4_eff).**Indicators:

Increased range of goods and services
Entered new markets or increased market share
Improved quality in goods or services
Improved flexibility of production or service provision
Increased capacity of production or service provision
Reduced labour costs per unit output
Reduced materials and energy per unit output
Reduced environmental impacts or improved health and safety
Met regulation requirements

- **Public funding of innovation (inn_cis4_pub).** Indicators:

Enterprise that received any public funding
Enterprise that received funding from local or regional authorities
Enterprise that received funding from central government (including central government agencies or ministries)
Enterprise that received funding from the European Union
Enterprise that received funding from the 5th or 6th Framework Programme

- **Innovation co-operation during 2002-2004 (inn_cis4_coop)** Indicators:

All types of co-operation
Other enterprises within your enterprise group
Most valuable method, with other enterprises within your enterprise group
Suppliers of equipment, materials, components or software
Most valuable method, with suppliers of equipment, materials, components or software
Clients or customers
Most valuable method, with clients or customers
Competitors or other enterprises of the same sector
Most valuable method, with competitors or other enterprises of the same sector
Consultants, commercial labs, or private R&D institutes
Most valuable method, with consultants, commercial labs, or private R&D institutes

Universities or other higher education institutions
Most valuable method, with universities or other higher education institutions
Government or public research institutes
Most valuable method, with government or public research institutes
Enterprise engaged in any type of innovation co-operation, National
Enterprise engaged in any type of innovation co-operation, within other Europe
Enterprise engaged in any type of innovation co-operation, within United States and other countries

- **Highly important source of information for innovation during 2002-2004 (inn_cis4_sou).** Indicators:

Within the enterprise or enterprise group
Suppliers of equipment, materials, components or software
Clients or customers
Competitors or other enterprises of the same sector
Consultants, commercial labs or private R&D institutes
Universities or other higher education institutes
Government or public research institutes
Conferences, trade fairs, exhibitions
Scientific journals and trade/technical publications
Professional and industry associations

- **Hampered innovation activities (inn_cis4_ham).** Indicators:

Enterprise with innovation activity abandoned at the concept stage
Enterprise with innovation activity abandoned after it began
Enterprise with innovation activity seriously delayed
Lack of funds within your enterprise or enterprise group, high important factor of hampering innovation activities
Lack of finance from sources outside your enterprise, high important factor of hampering innovation activities
Innovation costs too high, high important factor of hampering innovation activities
Lack of qualified personnel, high important factor of hampering innovation activities

Lack of information on technology, high important factor of hampering innovation activities
Lack of information on markets, high important factor of hampering innovation activities
Difficulty in finding cooperation partners for innovation, high important factor of hampering innovation activities
Markets dominated by established enterprises, high important factor of hampering innovation activities
Uncertain demand for innovative goods or services, high important factor of hampering innovation activities
No need to innovate due to prior innovations, high important factor of hampering innovation activities
No need to innovate because no demand for innovations, high important factor of hampering innovation activities

• **Patents and other protection methods (inn_cis4_pat).** Indicators:

Applied for a patent
Registered a trademark
Registered an industrial design
Claimed copyright

• **Organisational and marketing innovations (inn_cis4_mo)**. Indicators:

Enterprise introduced organisational and/or marketing innovations
Enterprise introduced organisational innovation
Enterprise introduced marketing innovation

• **Highly important effects of organisational innovation (inn_cis4_oref).** Indicators:

Reduced time to respond to customer or supplier needs
Improved quality of goods or services
Reduced costs per unit output
Improved employee satisfaction and/or reduced rates of employee turnover

Appendix II.2. Main characteristics of the micro data sample by sector

In the CIS3 dataset, the sectoral breakdown was not homogeneous between countries. In the case of the wave for CIS4 all the countries, except Italy, use the same NACE, as indicated in the table below. The inconsistent classes observed on CIS3 for some countries (like the common class for wood and textile, or wood and chemistry, ...) do no longer appear on CIS4.

However, as can be seen in the table below, for some countries, all the industries are not observed (in red):

- Codes 50 (sale, maintenance and repair of motor vehicles) and 52 (retail trade, except of motor vehicles): This means that a large group (code G) that would merge the codes 50, 52 and 51 (wholesale trade) is not consistent through all the countries.

- Codes 70 (real estate activities) and 71 (renting of machinery and equipment without operator): In this case, a large group "Real estate, location and services to enterprises" (code K) that would merge the codes 70, 71, 72, 73, 74, is again not consistent through all the countries.

- Codes F (Construction) and H (Hotels and restaurants): there is not information available for many countries.

Since the information for codes F and H was not available for CIS3, we decided to discard this information, which on the other hand, would not be consistent for all countries in CIS4.

Table A.II.1. Number of firms by NACE code and by country – CIS4.

NACE	BE	BG	CZ	DE	EE	ES	GR	HU	LT	LV	NO	PT	RO	SI	SK
			110			957					56				
20_21	79	579	304	136	128	602	12	168	72	202	189	228	359	101	80
22	106	311	145	125	79	432	17	124	33	61	217	92	161	53	62
27	34	109	145	92	5	321	8	54	11	17	52	57	135	31	35
28	186	661	328	294	82	1017	20	260	37	71	212	119	294	169	167
50	117		192			419			60	102				97	
51	488	3041	571	168	153	980	123	379	124	191	430	700	2247	255	207
52	154		601			504			108	274		95		161	
60_61_62	224	904	288	196	131	453	9	202	80	138	321	165	405	126	96
63	109	266	140	105	83	304	20	74	30	84	157	133	199	42	54
64	17	152	99	71	21	185	11	40	30	30	58	46	106	20	18
70			195			209				108				21	
71			67			138				14				8	
72	126	195	149	159	61	708	22	92	26	42	282	132	148	44	59
73_74	367	201	1146	565	82	1907	19	124	104	406	268	697	315	271	78
C	24	127	131	56	38	227	13	44	45	38	154	95	138	17	39
DA	195	1744	280	147	103	1236	45	347	91	191	250	269	741	91	153
DB	107	2379	301	106	165	686	34	265	119	126	103	533	1100	93	108
DC	6	254	108	22	30	241	5	67	21	9	6	163	379	27	46
DF_DG	117	222	162	207	29	864	20	84	39	38	79	119	197	48	48
DH	63	310	188	148	63	531	13	136	32	43	76	105	190	67	68
DI	76	337	182	92	56	772	21	100	33	48	97	131	228	57	106
DK	112	588	276	284	64	988	17	210	32	69	197	86	304	102	122
DL	115	376	523	443	79	891	16	282	85	68	229	207	332	126	167
DM	75	130	305	149	46	583	15	119	41	37	233	126	248	42	59
DN	82	527	251	102	106	752	19	134	59	106	136	131	465	96	66
E	8	131	150	167	98	161	5	135	81	55	136	81	292	68	72
F	217		511			1092		372	175	256	493	172		334	220
H			329			476				105		28		157	
J	118	166	193	220	45	310	23	138	71	61	218	105	197	65	65

For Italy, the information by industry is given by following more strongly the NACE classification:

Table A.II.2. Number of firms by NACE code in Italy – CIS4.

NACE	IT		NACE	IT
10	335		37	106
15	651		40	287
17	436		45	5317
18	459		50	733
19	300		51	1142
20	326		52	634
21	282		55	1047
22	326		60	714
23	107		61	67
24	365		62	31
25	324		63	563
26	515		64	56
27	302		65	547
28	1028		66	88

NACE	IT		NACE	IT
29	600		67	191
30	83		70	132
31	332		71	91
32	137		72	528
33	190		73	94
34	217		74	1283
35	163		742	265
36	337		743	123

Therefore, we just have to recode the industries for Italy according to the classification observed for the other countries and using the NACE correspondence table, we get the next correspondence for the Italian database (Table A.II.3):

Table A.II.3. Correspondence of NACE codes in Italy – CIS4.

NACE	IT	Recodification		NACE	IT	Recodification
10	335	C		37	106	DN
15	651	DA		40	287	E
17	436	DB		45	5317	F
18	459	DB		50	733	50
19	300	DC		51	1142	51
20	326	20_21		52	634	52
21	282	20_21		55	1047	H
22	326	22		60	714	60_61_62
23	107	DF_DG		61	67	60_61_62
24	365	DF_DG		62	31	60_61_62
25	324	DH		63	563	63
26	515	DI		64	56	64
27	302	27		65	547	J
28	1028	28		66	88	J
29	600	DK		67	191	J
30	83	DL		70	132	70
31	332	DL		71	91	71
32	137	DL		72	528	72
33	190	DL		73	94	73_74
34	217	DM		74	1283	73_74
35	163	DM		742	265	73_74
36	337	DN		743	123	73_74

Finally, the classification by industry in the database is the following one:

NACE2	LIB_NACE2	NACE3	LIB_NACE3
50	Sale, maintenance and repair of motor vehicles	50	Sale, maintenance and repair of motor vehicles
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Retail trade, except of motor vehicles, motorcycles ; repair of personnal and household goods	52	Retail trade, except of motor vehicles, motorcycles ; repair of personnal and household goods
C	Mining and quarrying	C	Mining and quarrying
DA	Manufacture of food products and beverages ; Tobacco products	D	Manufacture
27	Manufacture of basic metals		
28	Manufacture of fabricated metal products, except machinery and equipment		
22	Publishing, printing, reproduction of recorded media		
20_21	Manufacture of wood, products of wood, paper etc.		
DB	Manufacture of textiles, of wearing apparel ; dressing ; dyeing of fur		

NACE2	LIB_NACE2	NACE3	LIB_NACE3
DF_DG	Manufacture of coke, refined petroleum products and nuclear fuel ; Manufacture of chemicals and chemical products		
DH	Manufacture of rubber and plastic products		
DI	Manufacture of other non-metallic mineral products		
DK	Manufacture of machinery and equipment		
DL	Manufacture of computers ; electrical machinery ; radio, television and communication equipment ; medical, precision and optical instruments etc.		
DC	Tanning, dressing of leather ; manufacture of luggage		
DN	Manufacture of furniture ; Recycling		
DM	Manufacture of motor vehicles, trailers and semi-trailers ; manufacture of other transport equipment		
E	Electricity, gas and water supply	E	Electricity, gas and water supply
F	Construction	F	Construction
H	Hotels and restaurants	H	Hotels and restaurants
64	Post and telecommunications	I	Transport, storage and communication
60_61_62	Land, water or air transport		
63	Supporting and auxiliary transport activities ; activities of travel agencies		
J	Financial intermediation	J	Financial intermediation
71	Renting of machinery and equipment without operator and of personal and household goods	K1	Real estate activities and renting
70	Real estate activities		
73_74	R&D and other business activities	K2	Computer, R&D and other business activities
72	Computer and related activities		

Note: NACE2 contains the NACE codes according to a homogenised classification for all countries, at the most disaggregated level. This variable is in fact the same as the NACE variable, except for Italy. **NACE3** contains the most aggregated NACE codes (in order to allow statistical treatments at a more aggregated level)

Appendix II.3. Principal Component Analysis (PCA) concerning sources of information for innovation

A.II.3.1. Objectives

The objectives of this PCA are to analyze correlations between various variables regarding the sources of information for innovation, on the one hand, and to describe European countries according to the importance of these different sources, on the other hand.

A.II.3.2. Database

The database contains the 16 studied countries (see Figure II.11) and 10 variables:

- SENTG_HIGH : percentage of innovative firms highly using internal sources within the enterprise or enterprise group
- SSUP_HIGH : percentage of innovative firms highly using market sources from suppliers of equipment, materials, etc
- SCLI_HIGH : percentage of innovative firms highly using market sources from clients or customers
- SCOM_HIGH : percentage of innovative firms highly using market sources from competitors and other enterprises from the same industry
- SINS_HIGH: percentage of innovative firms highly using market sources from consultants, commercial labs or private R&D institutes
- SUNI_HIGH : percentage of innovative firms highly using institutional sources from universities or other higher education institutes
- SGMT_HIGH : percentage of innovative firms highly using institutional sources from government or public research institutes
- SCON_HIGH: percentage of innovative firms highly using sources from professional conferences, trade fairs, meetings
- SJOU_HIGH: percentage of innovative firms highly using sources from scientific journals, trade/scientific publications
- SPRO_HIGH : percentage of innovative firms highly using sources from professional and industry associations

A.II.3.3. Results

We can observe that the two first axes account for 78,55% of the variance, which can be considered as a good result for a PCA (see Table A.II.3.1).

Table A.II.3.1. Eigen values for each components

Axis	Eigen value	% explained	% acumulated
1	5,460643	54,61%	54,61%
2	2,394835	23,95%	**78,55%**
3	1,160268	11,60%	90,16%
4	0,478872	4,79%	94,95%
5	0,203901	2,04%	96,99%
6	0,164003	1,64%	98,63%
7	0,062807	0,63%	99,25%
8	0,042122	0,42%	99,67%
9	0,02199	0,22%	99,89%
10	0,01056	0,11%	100,00%
Tot.	10	-	-

The correlation circle (Figure A.II.3.1**)** and Pearson correlation matrix (Table A.II.3.2) show:

- A strong and positive correlation between the two market sources and the internal sources within the enterprise is mainly present on the axis 2 and somehow less on the negative part of axes 1 (SSUP_HIGH, SCLI_HIGH and SENTG_HIGH). Countries that are at the top left of the graph (see Fig. II.11) record a high level of use of these three kinds of sources. The internal sources are correlated with almost all other sources except for conferences sources and information from competitors' sources.

- A positive correlation between the information from competitors and the two external sources from scientific journals and professional conferences. These variables (SCOM_HIGH, SCON_HIGH and SJOU_HIGH) are mainly present on the axis 1 and 2.

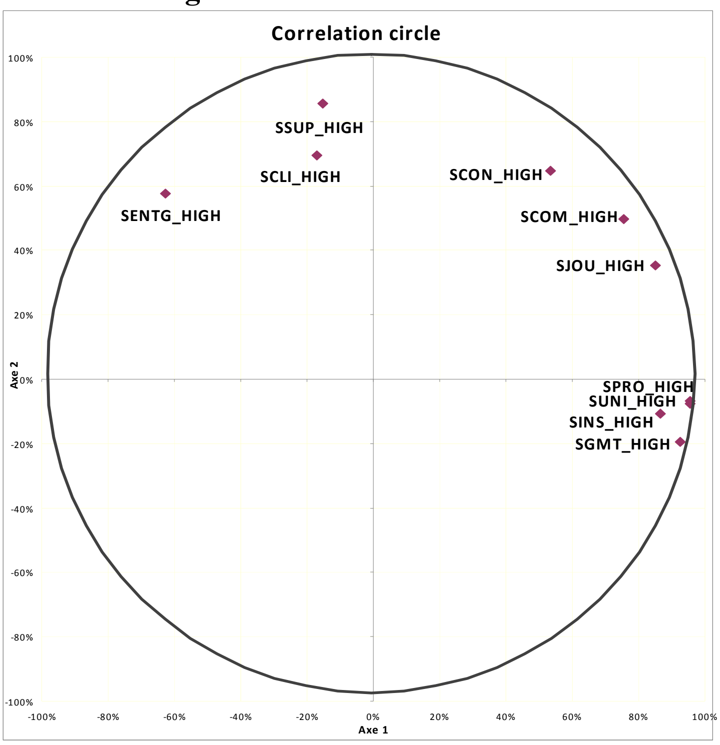
- A positive correlation and strong correlation between the two institutional sources, market sources from external consultants and sources from industry associations (SUNI_HIGH, SGMT_HIGH, SINS_HIGH and SPRO_HIGH). Countries which are on the right of the axis 1 have a high level of this kind of sources.

Table A.II.3.2. Pearson correlation matrix and level of significance (in italics)

	SENTG_ HIGH	SSUP_ HIGH	SCLI_ HIGH	SCOM_ HIGH	SINS_ HIGH	SUNI_ HIGH	SGMT_ HIGH	SCON_ HIGH	SJOU_ HIGH	SPRO_ HIGH
SENTG_HIGH	1	0,5337**	0,6712***	-0,1821	-0,4533*	-0,5575**	-0,5878**	-0,157	-0,4658*	-0,5425**
		0,0333	0,0044	0,4996	0,0779	0,0248	0,0167	0,5614	0,069	0,0299
SSUP_HIGH		1	0,3203	0,1971	-0,1889	-0,2733	-0,3747	0,5501**	0,2379	-0,1725
			0,2264	0,4644	0,4834	0,3058	0,1527	0,0273	0,3749	0,5229
SCLI_HIGH			1	0,3761	-0,2425	-0,0799	-0,1388	0,1057	-0,0551	-0,1935
				0,1511	0,3654	0,7686	0,6081	0,6968	0,8394	0,4728
SCOM_HIGH				1	0,5548**	0,7532***	0,6072**	0,5979**	0,7361***	0,666***
					0,0257	0,0008	0,0126	0,0144	0,0012	0,0049
SINS_HIGH					1	0,8313***	0,8268***	0,3532	0,6189**	0,854***
						0,0001	0,0001	0,1796	0,0106	0
SUNI_HIGH						1	0,9592***	0,3382	0,7054***	0,9468***
							0	0,2001	0,0023	0
SGMT_HIGH							1	0,2672	0,6481***	0,9385***
								0,317	0,0066	0
SCON_HIGH								1	0,8161***	0,3853
									0,0001	0,1406
SJOU_HIGH									1	0,7536***
										0,0007
SPRO_HIGH										1

*** The correlation is significant at 1% level.
** The correlation is significant at 5% level.
* The correlation is significant at 10% level.

Figure A.II.3.1. Correlation circle



Appendix II.4. Factorial Correspondence Analysis (FCA) and additional descriptive statistics concerning innovative expenditure

A.II.4.1. Objectives

The objectives of this FCA are to analyze the correlations between various variables regarding the different modalities of R&D expenditures, on the one hand, and to identify European countries profiles according to the R&D expenditure nature, on the other hand.

A.II.4.2. Database

The database contains 23 countries (Austria, Denmark and Finland are not included because of missing values, see Figure II.14) and 4 variables:

- RRDINX : amount of innovative expenditure engaged in intramural R&D
- RRDEXX : amount of innovative expenditure engaged in extramural R&D
- RMACX : amount of innovative expenditure engaged in the acquisition of machinery and equipment
- ROEKX : amount of innovative expenditure engaged in the acquisition of other external knowledge

A.II.4.3. Results of the FCA

Firstly, we can observe that the two first axes account for 99,50% of the variance, which can be considered as a very good result for a FCA[43].

Table A.II.4.1. Eigen values for each components

Axis	Eigen value	% explained	% acumulated
1	0,000864	95,46%	95,46%
2	0,000037	4,04%	**99,50%**
3	0,000005	0,50%	100,00%

Khi² test shows that the dependence between rows and columns is very significant (the observed value of Khi² is equal to 1,95E+10 and the p-value to 0,00).

[43] The authors may provide more detailed information on the outputs of the PCA to the interested readers.

Appendix II.5. Principal Component Analysis (PCA) concerning invention protection methods

A.II.5.1. Objectives

The objectives of this PCA are on the one hand, to analyze correlations between various variables regarding invention protection methods and, on the one hand, to describe European countries according to the importance of these different methods (see section II.4.3.1), on the other hand.

A.II.5.2. Database

The database contains the 24 studied countries (see Figure II.27) and 4 variables:

- PROPAT_RATE : percentage of innovative firms have applied for patent
- PRODSG_RATE : percentage of innovative firms have registered an industrial design
- PROCP_RATE : percentage of innovative firms have claimed copyright
- PROTM_RATE: percentage of innovative firms using highly trademarks

A.II.5.3. Results

As a first result, we can observe that the two first axes account for 81,45% of the variance. This can be considered a very good result in a PCA context.

Table A.II.5.1. Eigen values for each components

Axis	Eigen value	% explained	% cumulated
1	2,162265	54,06%	54,06%
2	1,095769	27,39%	**81,45%**
3	0,487359	12,18%	93,63%
4	0,254607	6,37%	100,00%
Tot.	4	-	-

The correlation circle (see Figure A.II.5.1) and Pearson correlation matrix (see Table A.II.5.2) show that the strategic methods are well correlated with formal methods except for a formal method using a trademark. This method is at the bottom of the factorial map on the axis 2.

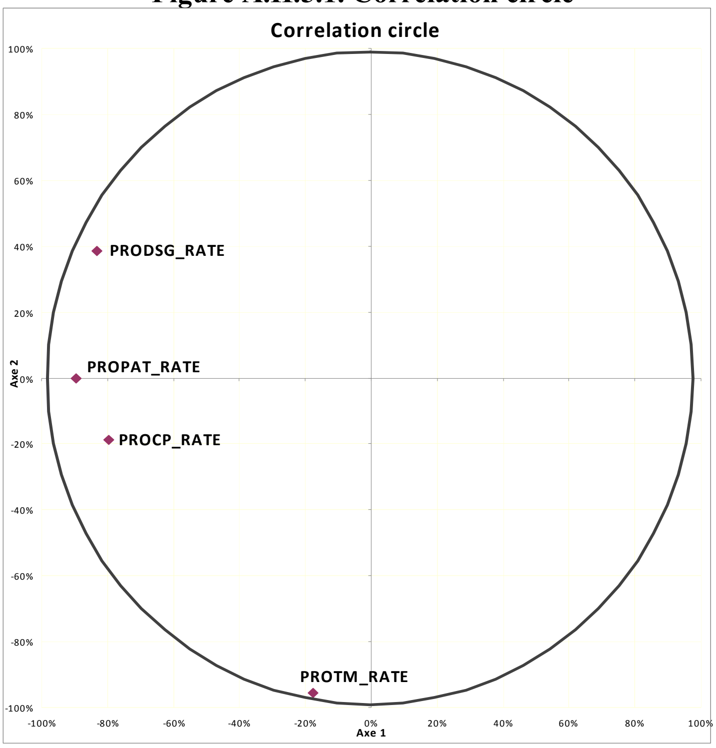
The first axis of the factorial map will allow us to identify which are the countries which deeply or heavily rely on protection (both strategic and formal), as almost all variables are well represented on the left of the axis (except for using a trademark).

Table A.II.5.2. Pearson correlation matrix and level of significance (in italics)

	PROPAT_RATE	PROCP_RATE	PRODSG_RATE	PROTM_RATE
PROPAT_RATE	1	**0.5554*** **	**0.6843*** **	0.1678
		0.0048	***0.0002***	*0.4331*
PROCP_RATE		1	**0.4722** **	0.2085
			0.0198	*0.3282*
PRODSG_RATE			1	-0.1338
				0.5331
PROTM_RATE				1

*** The correlation is significant at 0.01 level.
** The correlation is significant at 0.05 level.
* The correlation is significant at 0.10 level.

Figure A.II.5.1. Correlation circle



Appendix II.6. Product and Process Innovation Adoption correlation matrices

Sources of information	Adoption	Process adoption	Product adoption
Within the enterprise	**0.7952*** **	**0.8130*** **	**0.7398*** **
	0.000	***0.000***	***0.001***
Suppliers	**0.6288*** **	**0.6925*** **	**0.6918*** **
	0.009	***0.003***	***0.003***
Clients or costumers	**0.7866*** **	**0.7777*** **	**0.6625*** **
	0.000	***0.000***	***0.005***
Competitors	**0.7400*** **	**0.7485*** **	**0.6414*** **
	0.001	***0.001***	***0.007***
Consultants, commercial labs or private R&D institutes	0.2169	0.2875	**0.4648***
	0.420	*0.280*	***0.070***
Universities or other higher education institutes	**0.7614*** **	**0.7772*** **	**0.6742*** **
	0.001	***0.000***	***0.004***
Government or public research institutes	**0.7187*** **	**0.7385*** **	**0.6581*** **
	0.002	***0.001***	***0.006***
Professional conferences, trade fairs, meetings	**0.8527*** **	**0.8566*** **	**0.8011*** **
	0.000	***0.000***	***0.000***
Scientific journals, trade/scientific publications	**0.8737*** **	**0.8627*** **	**0.7798*** **
	0.000	***0.000***	***0.000***
Professional and industry associations	**0.8466*** **	**0.8867*** **	**0.8701*** **
	0.000	***0.000***	***0.000***

Innovation expenditure	Adoption	Process adoption	Product adoption
Intramural R&D	**0.6537*** **	**0.6630*** **	**0.5820*** **
	0.001	***0.000***	***0.003***
Extramural R&D	**0.6537*** **	**0.6630*** **	**0.5820*** **
	0.001	***0.000***	***0.003***
Acquisition of machniery and equipment	**0.6537*** **	**0.6631*** **	**0.5820*** **
	0.001	***0.000***	***0.003***
Acquisition of other external knowledge	**0.6548*** **	**0.6630*** **	**0.5843*** **
	0.001	***0.001***	***0.003***
Total innovation expenditure	**0.6537*** **	**0.6630*** **	**0.5820*** **
	0.001	***0.000***	***0.003***

Human resources	Adoption	Process adoption	Product adoption
Human resources in S&T	0.1367	0.1360	0.0278
	0.505	*0.508*	*0.893*

Organisational changes	Adoption	Process adoption	Product adoption
Firms with new or significantly improved changed organisation structures	0.0270	-0.0679	-0.1016
	0.900	*0.753*	*0.637*

Competition	Adoption	Process adoption	Product adoption
Barriers to competition	-0.3637	**-0.4378***	**-0.3985***
	0.126	***0.061***	***0.091***
Markup	-0.0927	-0.0966	-0.0426
	0.743	*0.732*	*0.880*

Barriers to trade	Adoption	Process adoption	Product adoption
Barrier to trade	0.3675	0.3234	0.3590
	0.122	*0.177*	*0.131*

Innovation protection	**Adoption**	**Process adoption**	**Product adoption**
Applied for a patent	-0.2381	-0.2847	-0.2943
	0.263	*0.178*	*0.163*
Claymed copyright	-0.2477	-0.3270	-0.2932
	0.243	*0.119*	*0.164*
Registered an industrial design	-0.2904	**-0.3589***	**-0.3835***
	0.169	***0.085***	***0.064***
Register a trademark	**-0.3971***	-0.3165	**-0.3786***
	0.055	*0.132*	***0.068***

Transposition Deficit Index	**Adoption**	**Process adoption**	**Product adoption**
tdi_intmk	**0.5589***	**0.5930***	**0.6176***
	0.006	***0.003***	***0.002***
tdi_tot	-0.2811	-0.3086	**-0.3556***
	0.194	*0.152*	***0.096***

PMR	**Adoption**	**Process adoption**	**Product adoption**
Product Market Regulation (OECD)	-0.0707	-0.1083	-0.0559
	0.774	*0.659*	*0.820*

Number in italics are p-values.

* Significant to the level of 10%

** Significant to the level of 5%

*** Significant to the level of 1%

Appendix II.7. PCA of economic freedom and adoption rate

In order to see the relationship between Economic freedom and the adoption rate, a Principal Component Analysis has been made, based on the of variables come from the Economic Freedom of the World report, covering 5 areas:

AREA1_2004: Size of government.

AREA2_2004: Legal structure and security of property rights.

AREA3_2004: Access to sound money.

AREA4_2004: Freedom to trade internationally.

AREA5_2004: Regulation of credit, labor and business.

The two first axes account for 74,11% of the variance, which can be considered as a relative good result for a PCA.

Table A.II.6.1. Eigen values for each components

Axis	Eigen value	% explained	% cumulated
1	2,507707	50,15%	50,15%
2	1,197779	23,96%	**74,11%**
3	0,642779	12,86%	86,97%
4	0,365088	7,30%	94,27%
5	0,286648	5,73%	100,00%

From correlation matrix and correlation circle, we can see that:

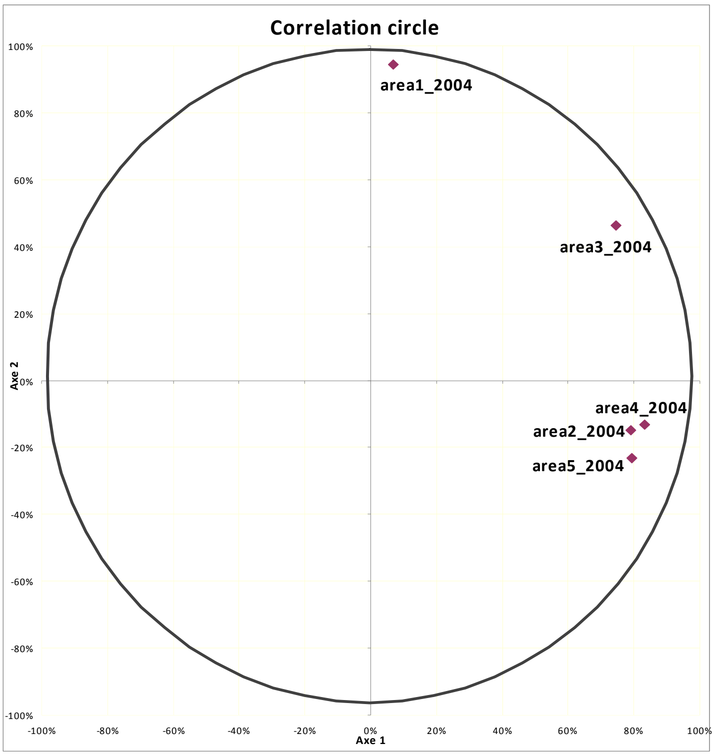
- The size of government and the access to the sound money are positively and significant correlated. These variables are well represented on the second axis.
- The legal structure and security of property rights is positively and significant correlated with the other economic freedom areas (trade and regulations). All of these variables are well represented on axis 1.

Table A.II.6.2. Pearson correlation matrix and level of significance (in italics)

	area1_2004	area2_2004	area3_2004	area4_2004	area5_2004
area1_2004	1	-0,1072	**0.3348***	-0,0180	-0.0576
		0.6021	***0.0946***	*0,9344*	*0,7799*
area2_2004		1	**0,5383*****	**0,4909****	**0,4888*****
			0,0046	***0,0109***	***0,0113***
area3_2004			1	**0,4658****	**0,3609***
				0,0165	***0,0701***
area4_2004				1	**0,6572*****
					0,0003
area5_2004					1

***The correlation is significant at 1% level
** The correlation is significant at 5% level.
* The correlation is significant at 10% level.

Fig A.II.6.1. Correlation circle



Appendix II.8. Summary of the variables used in part II

Table A.II.9.1. Summary of the variables used in part II

Category	Variables	Description	Type	Year	Source
Innovation and adoption	Innovation rate	Share of innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Innovation adoption rate	Share of adopting firms (in percentage of total number of innovatives firms)	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Cooperation-based adoption	Share of innovatives firms which mainly cooperate for developing innovation	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Other organisation-based adoption	Share of innovatives firms which rely on innovation developed mainly by others	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	No adoption	Share of innovatives firms which develop innovation by themselves	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Product innovation	Share of product innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Product adoption	Share of product adopting firms (in percentage of product innovative firms)	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Process innovation	Share of process innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 /CIS4
Innovation and adoption	Process adoption	Share of process adopting firms (in percentage of process innovative firms)	Quantitative	2000 2004	CIS3 /CIS4
Sources of information	Internal sources	Share of innovative firms which use information from internal sources at high level	Quantitative	2000 2004	CIS3 /CIS4
Sources of information	Market sources	Share of innovative firms which use informations from market sources at high level	Quantitative	2000 2004	CIS3 /CIS4
Sources of information	Institutional sources	Share of innovative firms which use information from institutional sources at high/medium/low level or not	Quantitative	2000 2004	CIS3 /CIS4
Sources of information	Others sources	Share of innovative firms which use information from internal sources at high level	Quantitative	2000 2004	CIS3 /CIS4
Innovation expenditure	Intramural R&D	Share of expenditure for intramural R&D (in percentage of total innovation expenditure)	Quantitative	2000 2004	CIS3 /CIS4
Innovation expenditure	Acquisiton of machinery and equipment	Share of expenditure for acquisiton of machinery and equipment (in percentage of total innovation expenditure)	Quantitative	2000 2004	CIS3 /CIS4
Innovation expenditure	Extramural R&D	Share of expenditure for extramural R&D (in percentage of total innovation expenditure)	Quantitative	2000 2004	CIS3 /CIS4

/CIS4Innovation expenditure	Training, market introduction of innovations and design	Share of expenditure for training, market introduction of innovations and design (in percentage of total innovation expenditure)	Quantitative	2000 2004	CIS3 /CIS4
Innovation expenditure	Acquisition of other external knowledge	Share of expenditure for acquisition of other external knowledge (in percentage of total innovation expenditure)	Quantitative	2000 2004	CIS3 /CIS4
Innovation expenditure	Total innovative expenditure	Expenditure for innovation (only for innovatives firms and transformed with neperian logarithm)	Quantitative	2000 2004	CIS3 /CIS4
Human capital ressources	Education level	Average number of employees with high education in innovative firms	Quantitative	2000 2004	CIS3 /CIS4
Human capital ressources	Human ressources in Science and technology	Share of labor force in science and technology domain	Quantitative	2000 2004	CIS3 /CIS4
Human capital ressources	Organizational changes	% of innovative firms having implemented new or significantly changed organisational structures	Quantitative	2000 2004	CIS3 /CIS4
Cooperation	Cooperation	Share of innovative firms engaged in R&D cooperation	Quantitative	2000 2004	CIS3 /CIS4
Market features	Competition	Value-added as a share of labour and capital costs	Quantitative	1998	Griffith et al. (2006), OECD Stan Database
Market features	Barriers to competition	Index (from 1 to 10) of the importance of barriers to competition	Qualitative	1998	OECD PMR indicators
Market features	International market	Share of innovative firms with international market as the most significant one	Quantitative	2000 2004	CIS3 /CIS4
Market features	Exports	Sum of exports and imports (in percentage of the GDP)	Quantitative	2000 2004	EUROSTAT and COMEXT
Market features	Non-tariff trade barriers	Index (from 1 to 10) of the importance of non-tariff barriers to trade	Qualitative	1995 2004	Economic Freedom of the World report
Market features	Barriers to trade and investment	Index containing information about ownership barriers, discriminatory procedures, regulatory barriers and tariffs	Qualitative	1998 2003	OECD PMR indicators
Protection methods	Patents application to protect innovation	Share of innovative firms which have applied for at least on patent to protect inventions	Quantitative	2000 2004	CIS3 /CIS4
Protection methods	Intellectual protection methods	Share of innovative firms using intellectual protection methods (formal or strategic)	Quantitative	2000 2004	CIS3 /CIS4
Protection methods	Security of property rights	Index (from 1 to 10) of the importance of security of property rights	Qualitative	1995 2004	Economic Freedom of the World report
Internal Market	Global transposition deficit indicator	Share of EU directives communicated as having been transposed	Qualitative	1999 2004	Eurostat

Internal Market	Internal market transposition definit indicator	Share of internal market directives communicated as having been transposed	Qualitative	1999 2004	Eurostat
Internal Market	Product market regulation	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	Qualitative	1998 2003	OECD PMR indicators
Innovation and adoption growth	Innovation growth	Increase/decrease of innovation rate between CIS3 and CIS4	Quantitative	2000 2004	CIS3 / CIS4
Innovation and adoption growth	Adoption growth	Increase/decrease of adoption rate between CIS3 and CIS4	Quantitative	2000 2004	CIS3 / CIS4
Innovation and adoption growth	Cooperation-based adoption growth	Increase/decrease of cooperation-based adoption rate between CIS3 and CIS4	Quantitative	2000 2004	CIS3 / CIS4
Innovation and adoption growth	Other organisation-based adoption growth	Increase/decrease of other organisations-based adoption rate between CIS3 and CIS4	Quantitative	2000 2004	CIS3 / CIS4

Appendix II.9. PCA for the typology of EU countries

In order to build a typology of the EU countries, a Principal Component Analysis has been made, based on the following variables:

- The adoption rate
- The innovation rate
- Human resources in S&T (in the labour force)
- The cooperation rate.

The two first axes account for 63,67% of the variance, which can be considered as a relative good result for a PCA.

Table A.II.7.1. Eigen values for each components

Axis	Eigen value	% explained	% cumulated
1	1,381157	34,53%	34,53%
2	1,165542	29,14%	**63,67%**
3	0,999749	24,99%	88,66%
4	0,453551	11,34%	100,00%
Tot.	4	-	-

From correlation matrix and correlation circle, we can see that:

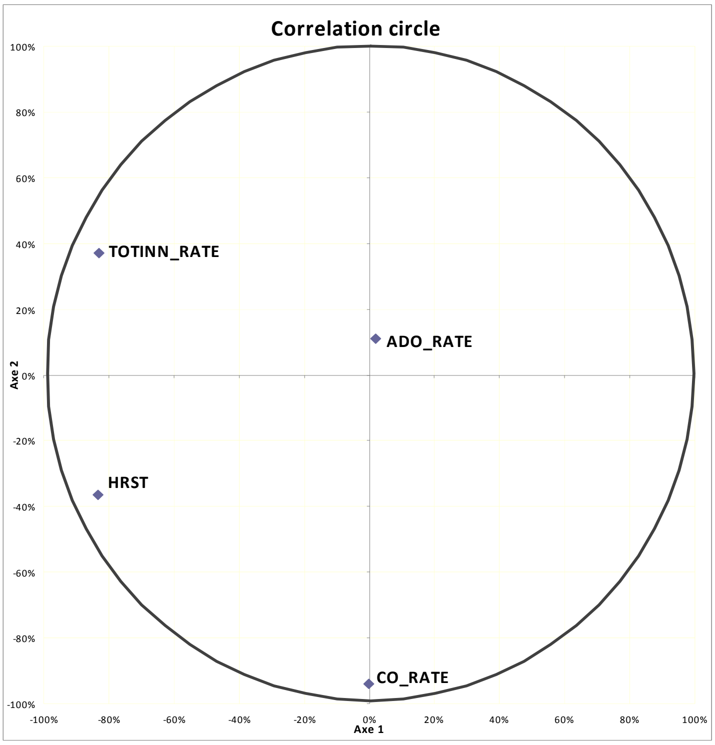
- Innovation rate is positively and significant correlated with human resources in S&T. These variables are well represented on the first axis.
- The cooperation rate is well represented on axis 2.
- The adoption rate is not well represented on either axis 1 or axis 2.

Table A.II.7.2. Pearson correlation matrix and level of significance (in italics)

	cooperation rate	innovation rate	adoption rate	human resources in S&T
cooperation rate	1	-0,2111	-0.0007	0.2115
		0.3006	*0.9973*	*0.2997*
innovation rate		1	0.0194	**0.3811***
			0.9250	***0.0548***
adoption rate			1	-0.0280
				0.8919
human resources in S&T				1

*** The correlation is significant at 1% level
** The correlation is significant at 5% level.
* The correlation is significant at 10% level.

Fig A.II.7.1. Correlation circle



Appendix II.10. Correlations splitting the sample between micro- and macro-based observations

In the following table we have computed the main correlations offered in Part II.3.1 (Descriptive analysis of adoption rates: General strategies) but separately for those countries whose statistical information is taken from the CIS webpage (Macro data) or those whose information has been obtained from the CD ordered to Eurostat with the firm level data (Micro data) as well as those obtained for the whole sample. As it can be observed, the correlations for the whole sample and the ones for the Macro data countries are very similar and lead to the same conclusions. However, there are important differences with the ones obtained with the Micro sample. This can be done both to the reduced number of countries that we are considering when we split the sample between Macro and Micro data countries, as well as some bias occurring because of the different way the information is gathered in both cases.

Table A.II.10. Pearson correlation coefficient and p-value (in parentheses)

	Total sample	Macro sample	Micro sample
Innovation and Adoption rates	***0.5637****** (0.003)	***0.68***** (0.015)	-0.2234 (0.443)
Product innovation and product adoption	***0.3668**** (0.065)	***0.7756****** (0.003)	***-0.5991***** (0.024)
Process innovation and process adoption	***0.3616**** (0.070)	***0.5473**** (0.066)	-0.3156 (0.272)
Cooperation-based adoption and other organisation-based adoption (in product)	0.0677 (0.743)	***0.6924***** (0.013)	0.1263 (0.667)
Cooperation-based adoption and other organisation-based adoption (in process)	***0.4046***** (0.040)	***0.9167****** (0.000)	-0.0683 (0.817)

*** The correlation is significant at 1% level
** The correlation is significant at 5% level
* The correlation is significant at 10% level

Appendices of Part III.

Appendix III.1. Summary of the variables used in part III

Table A.III.1: Summary of the variables used in part III

Category	Variables	Description	Type	Year	Source
Innovation and adoption	Innovation rate	Share of innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Innovation adoption rate	Share of adopting firms (in percentage of total number of innovatives firms)	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Cooperation-based adoption	Share of innovatives firms which mainly cooperate for developing innovation	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Other organisation-based adoption	Share of innovatives firms which rely on innovation developed mainly by others	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	No adoption	Share of innovatives firms which develop innovation by themselves	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Product innovation	Share of product innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Product adoption	Share of product adopting firms (in percentage of product innovative firms)	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Process innovation	Share of process innovative firms (in percentage of the total number of firms)	Quantitative	2000 2004	CIS3 and CIS4
Innovation and adoption	Process adoption	Share of process adopting firms (in percentage of process innovative firms)	Quantitative	2000 2004	CIS3 and CIS4
Internal Market Proxy	Involvement in Business Operations	Weighted average of two regulation indicators: Price Controls (with a weight of 0.45) and Use of command and Control regulation (with a weight of 0.55)	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	Price controls	4 sub-indices: air travel, road freight, retail distribution and telecommunication.	Quantitative	1998 2003	PMR OECD

Internal Market Proxy	Use of command and Control regulation	Controls over Road freight, Retail distribution, Air travel and Railways			
Internal Market Proxy	Communication and simplification Procedures	Regulations aimed at increasing communication. See above in Appendix A.III.4. for more detail description	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	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 (for detailed description of sub-indices see above in Appendix A.III.4)	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	Licenses and Permits system	Easiness to Obtain Licenses, see above in Appendix A.III.4	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	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)	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	Barriers to Competition	Index (from 1 to 10) of the importance of barriers to competition	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	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	Quantitative	1998 2003	PMR OECD

		countries			
Internal Market Proxy	Working days spent to deal with Bureacracy	Index of bureaucratic quality	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	Number of bodies to be contacted in order to run a business	Index of bureaucratic quality	Quantitative	1998 2003	PMR OECD
Internal Market Proxy	Sectoral and ad Hoc State Aid	Proxy for fair competition	Quantitative	1999 2004	Eurostat, Internal Market Scoreboard
Internal Market Proxy	TDI indexes	Number of EU regulations (according to areas) which have been transposed by each member state over the total	Quantitative	1999 2004	Eurostat
Internal Market Proxy	Freedom to Trade	Overall index for: 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		1995 2004	Economic Freedom of the World Index
Internal Market Proxy	Transfer and Subsidies as a % of GDP	Country's ratio of transfers and subsidies to GDP	Quantitative	1995 2004	Economic Freedom of the World Index, International Monetary Fund, *Government Finance Statistics Yearbook* (various years)
Internal Market Proxy	Government enterprises and investment as a percentage of total investment	Data on the number, composition, and share of output supplied by State-Operated Enterprises (SOEs) and government investment as a share of total investment	Quantitative	1995 2004	Economic Freedom of the World Index, International Monetary Fund, *Government Finance Statistics Yearbook* (various

					years)
Internal Market Proxy	Legal Structure and Security of Property Rights	Overall index for protection of property rights	Quantitative	1995 2004	Economic Freedom of the World Index, Global Competitiveness Report.
Internal Market Proxy	Trust	"Most people can be trusted" index in each country	Quantitative	2000 2004	World Social Survey
Innovation expenditure	Total innovative expenditure	Expenditure for innovation (only for innovatives firms and transformed with neperian logarithm)	Quantitative	2000 2004	CIS3 and CIS4
Human capital ressources	Education level	Average number of employees with high education in innovative firms	Quantitative	2000 2004	CIS3 and CIS4
Human capital ressources	Human ressources in Science and technology	Share of labor force in science and technology domain	Quantitative	2000 2004	CIS3 and CIS4
Human capital ressources	Organizational changes	% of innovative firms having implemented new or significantly changed organisational structures	Quantitative	2000 2004	CIS3 and CIS4
Transmission Channel	Cooperation	Share of innovative firms engaged in R&D cooperation	Quantitative	2000 2004	CIS3 and CIS4
Transmission Channel	Markup	Value-added as a share of labour and capital costs	Quantitative	1998	Griffith et al. (2006), OECD Stan Database
Transmission Channel	Trade	Sum of exports and imports (in percentage of the GDP)	Quantitative	2000 2004	EUROSTAT and COMEXT

Appendix III.2. Non-linearity in the relationship between competition and innovation adoption

Table A.III.2 Non-linearity of the impact of competition on innovation adoption

	Adoption rate
Cooperation	1.1
	(2.51)***
Markup (low competition)	8.76
	(4.74)***
Markup squared	0.85
	(1.56)
Trade	0.01
	(2.14)***
TDI Internal Market	0.002
	(0.73)
Integrity of the Legal System	0.02
	(0.95)
Constant	-6.27
	(-4.37)***
Observations	147
Number of id_country	17
R-squared	0.62

Absolute value of t statistics in parentheses
*, ** and***: 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).

List of Tables

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