# Is the Economic Crisis Impairing Convergence in Innovation Performance across Europe?

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**Abstract**

Are EU Member States converging in terms of their innovative effort? To what extent the current economic downturn is impairing the convergence across the European Union countries in innovation performance? Using macro and micro data, we show that the European Union Member States have converged in their innovative potential over the 2004-2008 period. The economic crisis of the Fall 2008 is striking innovative investment in almost all EU countries, but the catching-up countries are the most affected leading to increasing divergence. The danger of growing disparities in innovative capabilities may lead to divergence also in income and well-being. The paper discusses some of the innovation policies that can be carried out at the EU level to facilitate cohesion.

**Keywords**: convergence, technological capabilities, European innovation and technological policy, financial crisis, cross-country comparison

## Introduction

The European Union (EU) is grounded on three main pillars: cohesion, integration and convergence. It will be important for analysis and policy advise to investigate what the impact will be of the 2008 global financial crisis on each of these pillars (see Hodson and Quaglia, 2009 p. 944). While a few recent studies have addressed the impact of the financial crisis in terms of income, productivity and employment convergence, less attention has, so far, been devoted to the impact on innovation performance.[1]Convergence in innovation is a crucial component of a successful European integration since, on the one hand, innovation provides a key asset to enhance economic competitiveness and, on the other hand, it facilitates cohesion in the social and political sphere (see Sharp, 1998). We assume, in fact, that the lack of convergence in innovative activities will jeopardize also EU cohesion policies, since it will make the least developed countries more dependent on the knowledge generated elsewhere or, even worse, will not allow them to benefit at the same level from the available knowledge.

The existence of major technological gaps *within* Europe has traditionally been recognized as constraining the building of a European System of Innovation (see, for example, Pavitt, 1998, Lorenz and Lundvall, 2006). Enlargement has led to a more heterogeneous EU in terms of innovation capabilities and technological development. Moreover, New Member Countries are more vulnerable not only in terms of scientific and technological infrastructure, but also in terms of financial institutions, and are therefore likely to be hit more severely by adverse economic effects. The reduction of national disparities in scientific and technological competences is therefore a key priority in allowing the EU to close the gap with the US and Japan (see Archibugi and Coco, 2005). This article's aim is to investigate the dynamics of countries' technological convergence and innovation performance in the light of two major events: the EU enlargement, and the impact of the global financial crisis.

European policy makers have widely recognized the importance of science, technology and innovation for the continent's economic growth and well-being. The "Lisbon strategy" puts the "Knowledge Economy" at the centre of its economic policy and asks Member States to make a major effort to invest more in R&D and other innovation related activities. But the European Union is composed of countries which vary considerably in terms of technological expertise. While some of them, such as Sweden and Finland, are world innovation leaders, others are lagging behind.

[1] For a preliminary attempt, see European Commission 2009a.

Moreover, the 2004 and 2007 enlargements have substantially increased not just the number of Member States, but also the range of countries' technological expertise and stages of development. Even more than before, EU policy needs to take explicitly into account the existing variety in technological competence, innovation performance and industrial structure. In contrast to the United States and Japan, a proper European System of Innovation is still far from being in place. Rather, the EU still appears to be an agglomeration of autonomous and highly diverse national innovation systems (Lorenz and Lundvall, 2006).

A large body of literature has already demonstrated the fundamental role played by innovation and technological capabilities in fostering long-term growth performance (Castellacci, 2004; Fagerberg, 1994; Fagerberg and Godinho, 2005). In order to catch up, emerging countries need to develop an endogenous capability allowing them to absorb the knowledge and technology developed elsewhere (Castellacci, 2008; Cohen and Levinthal, 1990). As far as the European case is concerned, differences in economic growth across European regions have already been explained by looking at the differences in generating and adapting technologies developed abroad (Cantwell and Iammarino, 2003; Fagerberg et al., 1999; Fagerberg and Verspagen, 1996). This has led policy makers to rely on EU innovation policy as a fundamental instrument in reaching convergence, including key variables such as productivity and income (Borras, 2003; Lundvall and Borras, 2004; Von Tunzelmann and Nassehi, 2004).

International economic integration may have opposite effects on the distribution of innovative activities. On the optimistic view, economic, social and political integration helps to disseminate best-practice technologies and the diffusion of expertise. Through trade, scientific exchanges, technological collaborations and direct foreign investment, backward countries have windows open which allow them to exploit the technological opportunities offered by the most developed countries (Perez and Soete, 1988). On the pessimistic view, on the contrary, the strongest areas will attract the most knowledge intensive economic activities, providing job opportunities to the best talents. Eventually, backward areas will find themselves confined in an economic specialization in the low technology industries and with decreasing returns, while the most developed areas will further reinforce their leadership (Rodriguez-Pose, 1999).

In the real world, both mechanisms are at work since innovative activities are not homogeneous entities. As shown by a large theoretical and empirical literature, innovation is nurtured by a variety of different sources, including R&D, design, engineering, equipment and machinery, and infrastructure (Pavitt, 1984; von Hippel, 1988). The effect of economic integration is not necessarily the same on all these activities. While economic integration may help in disseminating innovative infrastructure, such as ICTs and other general purpose technologies, integration may have an opposite effect on core activities associated to the generation of new knowledge and innovation which may agglomerate in the most advanced areas.

In this paper we discuss the dynamics of innovation performance across EU Member States. We address empirically the following crucial questions:

i) Has convergence in innovation been achieved in the last years? This will follow previous research carried out for the EU15 (Archibugi and Coco, 2005) and that can now be expanded to include the New Member States (NMS);

ii) To what extent is the current economic downturn impairing the convergence process across the European Union in terms of innovation performance and technological capabilities of countries?

The paper is organised as follows. In the next section we put forward the theoretical background of the analysis. In section II we present the data sources and the methodology. In section III we explore the process of convergence across Europe in terms of technological capabilities and innovation performance over the period 2004-2008. In sections IV and V the impact of the financial crisis is investigated. In section VI we describe the functioning of the European System of Innovation and discuss some policy suggestions in the light of the empirical analysis, while section VII concludes.

## I. Cohesion, enlargement and economic convergence in the European Union

In this article, we concentrate on a specific dimension of economic convergence, namely, *convergence in innovation capabilities.* In this section we first introduce the notion of convergence, we then examine research dealing with convergence in the EU and present the most important empirical results.

The economics of growth literature has always questioned whether there is some kind of mechanism at work leading to convergence across countries in terms of level of income per capita.

Boldrin et al. (2001) distinguish four main hypotheses about convergence proposed by the literature: from a strong convergence hypothesis *a la Solow* (1956), to a non-convergence one caused by the presence of strong increasing returns, as proposed by the new growth literature (Romer 1986; Grossman and Helpman 1991), and reinforced by the role of agglomeration economies (Krugman, 1991). The convergence versus divergence argument has been central to the European integration debate. This is the result of the importance of the socio-political dimension of the EU process of integration – cohesion – which profoundly differentiated EU integration from other regional organizations such as NAFTA or MERCOSUR. During the 1970s the Community regional policy, inspired by the hypotheses of Gunnar Myrdal (1957), tried to counter-balance the agglomeration of capital and human resources towards the more developed regions at the expense of the peripheral ones. Both the Structural Funds and later the Cohesion Fund were grounded on the non-convergence hypothesis and therefore aimed to compensate regions that were lagging behind due to the asymmetric effects of integration (Boldrin et al., 2001; Holland, 1975; Leonardi, 1995).

A great deal of empirical research has investigated the convergence versus divergence hypothesis across European countries at both national and regional level. In a comprehensive study Leonardi (1995) analysed per capita income convergence relative to the period 1970-1995, finding convergence at both regional (NUTS II) and national level. Using data for 64 European regions in the 1980s, Fagerberg et al. (1997) show that innovation and the diffusion of technology are important factors behind European growth. Most of the regions fail to take advantage of more advanced technologies developed elsewhere due to a lack of R&D absorptive capabilities, and therefore they show lower growth rates with respect to rich regions. Boldrin et al. (2001) find neither significant income convergence nor divergence across EU15 regions during the 1980s and the first half of 1990s, while labour productivity shows a moderate tendency to convergence. Martin (2001) provides additional analysis of patterns of regional productivity trends and employment growth over the period 1975-1998. Whilst labour productivity shows very weak convergence across the EU regions, there is a sharp divergence in regional employment. Taking into account the effects of innovation in the EU countries from 1969 to 1998, Jungmittag (2004) shows that technology diffusion is a driving force for growth and labour productivity convergence of catching up countries. Using three alternative methodologies to measure convergence, Neven and Gouymte (2008) investigate the pattern of convergence in output per head across regions in the European Community for the period 1975–90. They find strong differences across sub-periods and across subsets of regions. Southern European regions seem to have caught up in the early 1980s, while the regions in the north of Europe tended to stagnate or diverge in the first part of the 1980s, but converge strongly thereafter. In recent years an increasing attention has been devoted to innovation and convergence at the sub-national regional level.[2] There is, in fact, a rising concern that increasing cross-country interactions are intensifying regional disparities within countries due to intense spillover effects, proximity effects and agglomeration economies.[3]

More recent studies address convergence in technology across Europe.[4] Zizmond and Novak (2007) find significant technology convergence between 15 old EU Member States and the eight New Member States. Krammer (2009) explores the main driver of innovation in sixteen Eastern European transition countries. He emphasizes the role played by universities and the national knowledge base, complemented by both public and private R&D expenditure, as well as the important part played by inflows of foreign direct investment and trade. Johnson et al. (2010) describe the technological development of 13 countries in Europe, claiming that there is substantial potential growth in the technological development of Eastern European nations, and that there are high expectations that they will catch up over the coming 15 years. Finally, Filippetti and Peyrache (2010) show how EU New Member States are part of a global trend of technological capabilities convergence over the last decades.

Summing up, a huge number of empirical studies have addressed the convergence issue in terms of income, productivity, and more recently in technological capabilities.[5] The difficulties in coming to definitive conclusions arise from the fact that the geometry of the EU is a variable one due to the continuous process of integration and enlargement. Most of the studies reviewed do not take into account the recent enlargement process and therefore they do not include the EU New Member States. However, these studies show a general confirmation that domestic technological capabilities – in terms of R&D activities, infrastructure, human resources – are key factors in enhancing catch up processes on which our empirical exercise will build upon. Our contribution will in fact try to shed new light on innovation performance convergence across the EU27 countries taking into account the process of enlargement, but also looking at how the current economic downturn is and will impact on the convergence in progress.

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[2] See Cappellen et al., 2003; Cantwell and Iammarino, 2003; Maurseth, 2001; Moreno et al. 2005; Paci and Usai, 2009; Rodriguez-Pose, 1999; among others.

[3] We are grateful to an anonymous referee for this point. This is related to the growing literature dealing with regional innovation systems (see Iammarino 2005; Rodríguez-Pose and Crescenzi, 2008) and localized technical change (see Antonelli, 2001.

[4] For more structural analysis see Keyat et al., 2004 and Palan 2010.

[5] For some review studies and methodological assessments see Quah, 1996; Petrakos, 2009; Bazo et al., 1999; Lundvall and Lorenz, 2006.

## II. Data sources

The analysis is grounded on the data provided in two Reports from the European Commission, the *Innobarometer 2009* and the *European Innovation Scoreboard 2008* (European Commission, 2009a; European Commission, 2009b). The first is a survey conducted in April 2009 in the 27 Member States of the EU[6] and it is now in its eighth wave. Overall, a statistically significant sample of 5,238 enterprises across Europe was considered according to three main criteria: country, company size (20-49, 50-249, 250+ employees) and industry.

The *European Innovation Scoreboard* (EIS) is a Report of the European Commission – Directorate General Enterprises and Industry - carried out by the MERIT since 2001.[7] The EIS aims at measuring and comparing the innovation performance at country level using a synthetic composite indicator. For our analysis we will use the current EIS composite indicator methodology (European Commission, 2009a), which is based on twenty-nine indicators addressing several dimensions of a country' system of innovation (see table A1 in the Appendix). The composite indicator, the *Summary Innovation Index* (SII), has been calculated with the same methodology over the period 2004-2008. This allows addressing the convergence of innovation performance of countries over a period of five years using both the SII as a whole and its seven dimensions.

As regards the *Innobarometer*, our analysis is based on the following three questions of the survey: (see table A2 in the Appendix):

1. Question no. 1: *"Compared to 2006, has the amount spent by your firm on all innovation activities in 2008 increased, decreased, or stayed approximately the same (adjust for inflation)?"*
2. Question no. 2 *"In the last six months has your company taken one of the following actions*[increased, decreased or maintained the innovation spending] *as a direct result of the economic downturn?"*
3. Question no. 3 *"Compared to 2008, do you expect your company to increase, decrease or maintain the total amount of its innovation expenditures in 2009?"*

[6] We have excluded non-EU countries to limit our analysis to the EU Member States.
[7] Both the Innobarometer and EIS reports can be find on the web site: http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=51&parentID=48

The first question will be used to investigate the medium-term steady-state trend of the European firms' innovation spending before the crisis. The second question sheds some light on the direct effects of the current economic downturn on the firms' innovation investments. Finally, the third question captures the *expectation* of firms on innovation investment.

A major caveat in the Innobarometer data is that respondents are not requested to provide the amount of innovation investment. Thus, we are not able to take into account how much the firms modify their total investment or disinvestment in innovation. However, the data are able to inform on the firms changing strategies and this provides a reliable source for our main objectives on the convergence hypothesis.

## III. The good news: the convergence in innovation performance across the EU

As already mentioned, economic convergence represents one of the main pillars of the EU project and enlargement. Since the very beginning of European integration, a good deal of effort and resources has been put forward by policy makers to achieve this goal. In this section we assess to what extent convergence across EU Member States[8] has occurred in terms of innovation performance.

### *Methodology*

To address convergence we use the SII and its seven dimensions as a measure of innovation performance at a country level (see European Commission, 2009a). Composite indicators of innovation and technological capabilities have demonstrated they are quite stable over time (Archibugi et al., 2009), which is not surprising considering that they capture an economic structural dimension. The emergence of a convergence over a medium term period of five years would already be a significant achievement. Moreover, the SII also allows exploring convergence in the seven innovation dimensions of the SII indicator, disentangling the areas in which convergence is actually occurring and shedding some light on its components' dynamics.

In order to make our results robust we apply two different methodologies already used to address convergence in the growth literature (Barro and Sala-i-Martin, 2005). Both rely on the simple

[8] Malta and Cyprus have been excluded from the analysis of the paper due to a lack of data.

concept that, in case of convergence, lagging behind economies tend to grow faster than the best performer. The first model is usually referred to as the "beta-convergence model" and takes into account only the first and last year, in our case 2004 and 2008 respectively. We use the following equation for the beta-convergence model:

$$\ln\left[\frac{y_{T,i} - y_{0,i}}{y_{0,i}}\right] = \alpha + \beta \ln y_{0,i} + \varepsilon_i \qquad (1)$$

where the dependent variable represents the entire period variation rate (2004-2008), $\alpha$ is a constant, $y_{0,i}$ is the initial value (at time *0*) relative to country *i,* and ε is the error term. We run eight different regressions for this model, one relative to the SII index, and the other relative to the seven sub-indexes which feed into the SII (see Table A1 in the Appendix). Thus in the first case *y* represents the SII Index, while in the other cases it represents the sub-indexes, as for example *Human resources, Finance and Support* and so on. This allows us to check the presence of beta convergence relative to the global innovation performance, as measured by the SII Index, and relative to the seven innovation dimensions in the considered period. If the parameter β is significantly negative one can conclude in favour of unconditional beta-convergence.

The second model is instead based on the entire longitudinal data set, usually referred to as *panel data*. Panel data have been increasingly used thanks to two characteristics. First, they allow controlling for individual heterogeneity which is a relevant characteristic when dealing with countries. Second, they are more informative with respect to time series or pure cross-sectional data. For our analysis we use the *fixed effects* specification. The following equation is used for the fixed-effects model:

$$\ln\left[\frac{y_{t,i} - y_{t-1,i}}{y_{t-1,i}}\right] = \alpha_i + \beta \ln y_{t-1,i} + \varepsilon_{t,i} \qquad (2)$$

where the dependent variable is the log of the SII annual variation rate relative to the country *i*, the regressor is represented by the log of the SII value for country *i* at time $t$-$_1$, and $\alpha_i$ are interpreted as parameter to be estimated as in the fixed effect model specification. This model refers only to the SII while it is not run for the seven dimensions.

*Results*

Figure 1, where we plot the SII performance in 2004 against the 2004-2008 SII variation rate, shows the achievement of convergence in technological capabilities and innovation performance across European countries. Countries with a low SII figure in 2004, including Bulgaria, Romania, Latvia and Slovak Republic, have been performing relatively better over the last five years in comparison with the countries which were better performing in 2004, i.e. Denmark, Sweden and the United Kingdom.

**[Figure 1]**

Table 1 summarizes the "robust" estimates of the two models showing the coefficients related to the SII indicators. As a whole the results of both the models confirm the hypothesis of convergence among European countries. Both coefficients are negative, as expected, and significant. In Table 2 we report the results of the beta-convergence model relative to the seven EIS dimensions. Also in this case, coefficients have negative and significant signs with the only exception of the "Innovators" dimension.[9] Our results also show that "Finance and Support", which includes Public R&D, venture capital, private credit and broadband, and "Throughputs", which include patents, trademarks, design registrations and the technology balance of payments, are the two dimensions in which convergence occurs at a faster rate.

**[Table 1]**

**[Table 2]**

Composite indicators like the SII are likely to show a stable dynamic performance over time due to the structural nature of the phenomena they deal with. The fact that both models account for convergence over a period of five years signals the presence of a significant process of convergence across Europe in innovative activities. An analysis of the coefficients for the seven SII sub-indices related to the innovation dimensions of the SII also shows that convergence has been faster in less structural variables such as venture capital and broadband access. On the other hand, structural

[9] The fact that the "Innovators" dimension is not significant can depend on the circumstance that relative to this indicator data are taken from the Community Innovation Survey which are available only for two years.

dimensions such as “Firm investment”, “Human Resources” and “Economic Effects” consistently show a slower convergence over the considered period.

In Figure 2 we report the dynamic of the SII and the seven innovation dimensions for New Member States (NMS) compared to the EU27 simple average over the period 2004-2008. Romania, Bulgaria and Latvia show a faster growth of the SII composite indicator. As a whole, the NMS show a similar growth composition to the EU27 average, with some notable exceptions. Specifically, Bulgaria and Hungary seem to be relatively weak on “Human Resources”, while Poland shows a strong dynamic regarding “Firm Investment” relatively to its other dimensions. With regard to the “Firm Investment” dimension, all the NMS perform better than the EU27 average.

To summarize, this evidence shows that a process of convergence in innovation performance has been occurring. Laggard countries, mostly the NMS, have been narrowing their gap in terms of technological accumulation and innovation performances in comparison to the European leading nations. We cannot associate the convergence in innovation to deliberate EU policies rather than to other factors. But the announcement and the implementation of the EU integration is associated to a decrease rather than an increase in divergence in innovative performance.

**[Figure 2]**

## IV. The bad news: the effect of the crisis on innovation investment across European countries

The economic crisis had a rather significant effect on the investment in innovation across all Europe. But this bad effect has not been even across countries. In this section we first explore the dynamics of firms’ innovation investment over the three years 2006-2008. This allows us to identify four groups of countries based on their innovation investments patterns. We then assess the impact of the crisis on the firms’ innovation investments across Europe as a whole and upon the four groups of countries.

*The raise of the Parvenu*

To explore the dynamics of the firms’ innovation investments over the period 2006-2008 we build a simple composite indicator, the *Innovation Investments Indicator*($InnoInv_{06\text{-}08}$). $InnoInv_{06\text{-}08}$ is based on the balance between the percentage of firms increasing and decreasing their innovation expenditures over the period 2006-2008 (see the methodology in the Appendix). In this way, the *InnoInv*$_{06\text{-}08}$represents an indicator of medium-term firms' innovation investments. Similarly to the SII of the EIS, the indicator is normalized ranging between 0 and 1.

In Figure 3 we plot on the x-axis the *InnoInv*$_{06\text{-}08}$ performance, while on the y-axis we report an index of structural innovative capacity such as the SII. A clear correlation between the innovative performance relative to the period 2006-2008 and the structural innovative capacity does not arise, being the correlation rate equal to 0.05. In this way we are able to define the following four quadrants and relative groups of countries:

1. The *Parvenu*: although they do not exhibit a high strength of their national innovation systems, they have been increasing their investments more than the average relative to the considered period. This group includes several NMS, including Poland, Slovakia, Lithuania, Bulgaria, Romania, Slovenia which come from the ex-socialist block.
2. The *Aristocracy*: this group consists of those countries which show both a structural consolidated leadership of their innovation performance, and at the same time they are keeping on increasing their investments in innovation. These countries are Sweden, Austria, Germany, Finland and Belgium. This brilliant performance is associated not only to hereditary privileges, but also to continuous efforts in learning and innovation.
3. The *Declining Nobility*: these countries, even though they have a strong national innovation system, have been increasing their innovation expenditures relatively less over the 2006-2008 period. They include Denmark, Ireland, United Kingdom, Luxemburg, France and the Netherlands. Also a new member country, Estonia, belongs to this group.
4. Finally, the *Third State*: this group of countries is characterized by both a low innovation performance at the national level and a low performance in firms' innovation spending. Interestingly, this group includes both NMS such as Hungary, Latvia and the Czech Republic, but also the Southern European countries (Italy, Spain, and Portugal).

**[Figure 3]**

The data presented in this section confirm the results reported in the previous section and based on the EIS. Until the financial crisis, Europe as a whole was expanding its investment in innovation, and firms in at least some of the laggard countries were expanding their innovative investment more than the EU average.

*The impact of the crisis across European countries*

In Figure 4 we plot the average firms' answers relative to questions no. 1 and 2 of the *Innobarometer* (see above). The responses clearly show that the economic downturn is having a profound impact on the firms' innovation behaviour across Europe. The percentage of firms increasing their innovation expenditures drops dramatically from 40% to 11% as a direct effect of the crisis. In turn, the percentage of firms decreasing their innovation spending surges from 11% up to 27%. The number of firms which are expected to maintain their innovation spending at the same level has increased to more than 60% from about 50%. The crisis is cutting programmes aimed at expanding innovation, but it is having less of an effect on the disinvestment of ongoing investment. Given the structural nature of innovative activities, this comes as no surprise.

**[Figure 4]**

The impact of the economic downturn on firms' innovation spending is also evident by looking at the data at the country level, as reported in the Figure 5. The figures report the difference between the share of firms increasing and those firms decreasing their innovation investments in response to the crisis. In general, apart from Austria, Finland and Sweden, in all the other countries the share of firms reducing innovation investments exceeds that increasing them in response to the crisis. Crucially, among the countries with the strongest negative impact, most belong to the *Parvenu* group. It is worth observing that we also find Greece within this group of countries. Among the relatively less affected by the recession we find advanced and dynamic economies such as Austria, Finland and Sweden. Let us look at this evidence in greater detail.

**[Figure 5]**

## V. How bad is the bad news? The impact of the crisis within the four groups of countries

Our hypothesis is not only that the crisis is affecting countries to a different extent, but also that it is somehow reversing the convergence in innovation performance achieved in the past. In order to test this hypothesis, we put together all the three questions of the Innobarometer (see section two and tables A2 in the Appendix). Also for the second and third question we use the balance between the percentage of firms increasing and decreasing their innovation respectively in 2009 as a response of the crisis *(InnoInv$_{09}$)* and in terms of expectations *(InnoFor)* (see methodology in the Appendix). This will allow testing if the reduction of innovation investment is occurring in the short term only, or if it will instead have consequences also in the medium term.

In Figure 6 we summarize the results for the three indicators. As expected, the *Parvenu* is the group of countries with the greatest increase in innovation investment over the period 2006-2008. However, the *Parvenu* is also the group most negatively affected by the crisis, followed by the *Third State.* The other two groups, the *Aristocracy* and the *Declining Nobility*, are also those with the highest innovative rate, as shown by the SII. In a nutshell, *as a direct result of the crisis,* the innovation leaders are doing relatively better that the catching-up and lagging behind countries. This is exactly the opposite of the convergence process highlighted in Section two.

However, when we turn to look at the prospects as shown by *InnoFor*, the picture seems to change again. First, the groups *Aristocracy*, *Declining Nobility* and *Third State* seem to persist in reducing further their innovation expenditures: the number of firms reducing innovation investment is even larger then in the previous case *(InnoInv$_{09}$)*. And the only group that is showing a moderate counter-cyclical behaviour is the *Parvenu*. That is, in this case the number of firms which foresee reducing their expenditures in innovative activities is lower than in the previous situation. Although the *Parvenu*'s figure remains the highest among the four groups, it is quite close to those of the *Declining Nobility* and *Third State*.

**[Figure 6]**

To sum up, if we take into account also firms' expectations on innovation investment, the impact of the recession is even more profound than what emerged in the previous section. The *persistence* of the crisis is emphasized by the fact that there is a marked tendency of the firms in the *Aristocracy*, the *Declining Nobility* and the *Third State* countries to keep on decreasing innovation investment.

This is true in particular for the Western countries which belong to the first two groups, but it holds to a lesser extent for the *Third State* as well. On the contrary, the *Parvenu* show a moderate signal of prompt recovery.

## VI. Lessons for the European Innovation System

*The polarization of innovation capabilities across the EU countries*

So far, our analysis has been grounded on the innovation intensity of European countries. This method of presenting the data is certainly relevant in guiding policy making, but it may hide the reality that some countries are larger than others. In Table 3 we report some among the most relevant variables which address the state-of-the-art of the innovation capabilities relative to the four groups of identified countries in the EU in comparison to the United States. Additionally, a broader distinction between the EU15 and the ten countries of Central and Eastern Europe that joined the EU in 2004 and 2007 (what we call EU10) is also put forward.[10]

The differences across the four groups are striking. The *Aristocracy,* which accounts for nearly one fourth of the total EU labour force and population, concentrates more than half of the triadic patent and around 45 per cent of business R&D: this group of countries, dominated by Germany and shaped by Sweden, Finland, Austria and Belgium, appears as the engine of the European industrial innovation. The *Declining Nobility* is the largest group of countries in terms of labour force and population, and it plays an even greater role in terms of public knowledge: it has the largest share of public R&D and scientific articles; not surprisingly, this group is dominated by the United Kingdom and France, both countries with large governmental activities in science and technology. The *Parvenu* accounting for less than 18 per cent of the EU27 labour force shows a negligible share of both patents and business R&D. The contribution of these countries in generating new industrial innovation is still very small.

**[Table 3]**

[10] This EU10 including Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia. We exclude from the analysis Cyprus and Malta.

It may be equally useful to divide the EU countries between the pre-2004 and the post-2004 members, especially since the dividing line is able to capture (with the exclusion of two small economies such as Cyprus and Malta) the contribution provided by the ex-planned economies. Not surprisingly, the differences between the EU15 and the new EU10 are even more acute. The EU10 – which accounts for one fourth of the EU labour force, provides almost an irrelevant contribution in terms of patents (less than 1 per cent of the total EU), and a minor one in terms of business R&D (less than 5 per cent). The situation is less impressive when we look at the research sector as measured in terms of researchers (both public and private), the number of technical and scientific articles and the public R&D expenses. Here the difference is less dramatic especially with regards to the number of researchers. These simple data show that the transition to business oriented innovation system is far from being completed in the ex-planned economies. If the main goal of the EU innovation policy is to build a European System of Innovation, it seems obvious that the core priority is to better integrate such an important part of the continent.

We have also sketched in Table 4 a comparison between EU27 and the United States.[11] The USA has 66 per cent of the European labour force,[12] but it is far ahead, compared to the EU, in business sector innovation expenditure and for number of researchers. In quantitative terms, the EU still has to make substantial changes before becoming the largest knowledge economy of the world. In terms of internal disparities, it is certainly true that also across the Unites States there are differences as large as those in Europe (it is sufficient to compare the Silicon Valley with the Midwest). However, there are at least three main reasons for believing that these differences play a greater role across the EU: i) within the US national system of innovation there exist consolidated mechanisms of *transmission of knowledge and technology* which have been built over the last century; ii) the US system of innovation shares the same institutional setting, such as the same education system, STI policies, industrial policies, immigration policies, and the same rules of the game more in general (Rodríguez-Pose, 1999); iii) human resources represent a fundamental mechanism of diffusion of knowledge, especially of tacit knowledge (Polanyi, 1966). The large mobility of human resources within the US, also encouraged by a homogeneous labour market, is a fundamental driver of the diffusion of knowledge generated in specific areas across the country (Zimmermann 1995, 2005).[13]

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[11] For a comparison between the EU and US see Crescenzi et al. 2007; Dosi et al., 2006; European Commission, 2009c.

[12] As is well known, activity rates are higher than in Europe, a fact that should be borne in mind when analyzing the drivers of US competitiveness compared to the EU.

[13] For an investigation of the convergence within the Unite States see Barro and Sala-i-Martin, 1991. For studies which consider the European and United States experiences similar in terms of market integration see Sala-i-Martin and Sachs, 1991.

*The functioning of the European Innovation System and some policy recommendations*

What can this evidence tell us about the European Innovation System? We take for granted that the European system should build upon substantial variety between National systems. Moreover, the tools available within European governance are substantially limited if compared to those operated by national and local governments. However, there is an increasing awareness of the need to coordinate science, technology and innovation policies at the Community level. In Figure 7 we plot an "ideal" European Innovation System taking into account the EU multi-level (Community and Member States) governance of innovation. We single out the different components of the European system: the four groups of countries which contribute to the core of the innovation activities; the production of core innovation and new knowledge; the cross-European flows of knowledge, technology and human resources; the absorptive capacity which allows countries to take advantage of the technological opportunities generated outside national boundaries; and joint large-scale projects in basic research.

**[Figure 7]**

With the polarization of the generation of knowledge and innovation across the EU, a few countries are responsible for the bulk of innovation and knowledge production. The technology gap provides a fundamental potentiality for lagging behind countries to catch-up and, in fact, some of them have already benefited from this. However, we have pointed out the presence of a general fragility as the effects of the crisis have shown.

The lessons learnt about catching up, indicate that international differences in the rate of innovation are explained by: (i) capital accumulation and infrastructure; (2) investment in education and quality of human resources; (iii) expenditure in R&D and related activities (see Abramowitz, 1986 and Fagerberg, 1994 among many others). R&D expenditures by themselves (both public and private) cannot be expected to make a substantial difference (Pavitt, 1998). Therefore, we claim that a more articulated policy needs to be put in practice beyond the R&D 3% target established by the Lisbon Agenda. As suggested by the Report *A Knowledge-intensive Future for Europe* (European Commission, 2009c, pp. p. 24-25), more importance should be given to investment in knowledge diffusion and absorption depending on the specific national context. In the light of our own empirical findings, we can provide the following policy recommendations.

- EU innovation policies aimed at enhancing the mechanisms underlying the diffusion of knowledge and the circulation of human resources seem totally justified since they will facilitate the catching up of laggard and more fragile areas, and increase the potential innovative output of Europe.
- A greater harmonization of the labour market and of the educational system will also be able to increase absorptive capacity and therefore the innovative potential generated by an increased number of countries. As shown above, a highly qualified labour force reduces the risk of disinvestment in innovation in adverse economic conditions.
- Large-scale European projects in basic research would serve to push the EU towards the scientific frontier making possible to tap future major technological development. In fact, evidence from the US shows that the academic research that corporate practitioners find more useful is publicly funded, performed in universities, and publicly accessible (Mansfield, 1995; Narin et al. 1997; Pavitt, 2001). This will be also a good method to make knowledge available to all European players and, consequently, to generate the conditions for convergence, especially if priority is given to the creation of absorptive capabilities in the laggard countries.
- Finally, countries need to build their own endogenous capacity to tap and absorb knowledge and technology generated elsewhere, as well as a suitable environment for attracting human resources. That is, policies aimed at restructuring and developing technological capabilities in the EU10 countries are a *condition sine qua non* to spur innovation and catching-up processes.

## Conclusion: is the economic downturn impairing the convergence in innovation performance in Europe?

A decade has passed since the 2000 Lisbon summit, in which the European Council declared its intention of making the European research area the “world’s most competitive and dynamic knowledge-based economy” in the world. As a result of the process of enlargement, we have shown that the EU has become not only larger but also more heterogeneous and polarized in terms of knowledge generation, innovation performance and development of technological capabilities. In the South and in the East, there are substantial European areas that are still lagging behind in knowledge and competence-building, but the current gap in innovation performance can also be an opportunity for the NMS to catch-up with the more advanced countries. In a few years, these countries have managed to narrow, albeit to a limited extent, their divergence with the leading nations. This still leaves these countries far behind the scientifically and technologically more developed European countries, but we show that there is at least a trend toward the reduction of the divergence. The emerging countries, however, are also those most vulnerable to external shocks: these are also the countries that have most reduced their innovative investment as a direct consequence of the economic crisis. This casts some doubts on the structural nature of the observed convergence process in innovation capabilities.

Our results reinforce the idea that specific innovation policies should be considered as important as structural policies in the overall cohesion strategy of the EU. To fully exploit the benefits of these policies, three specific factors of the EU context should be considered: i) the high polarization in terms of the creation of knowledge, ii) the potential offered by a system of public R&D and human resources that has not yet been transformed into a consistent business innovation strategy, iii) a weakness of the newcomers in sustaining their innovative projects when there are external shocks, such as the recent financial crisis.

In the light of our findings, can we argue that the economic downturn is hampering the convergence in innovation in Europe? Answering this question is complicated by the fact that many other interrelated elements play a role, such as fiscal imbalances, capital flows, and the credit and currency markets among others (for the role played by differences in the financial system see Begg, 2009). However, from our results we can certainly conclude that the negative effects of the crisis are remarkable and this, at least from the innovation investment viewpoint, is not likely to improve in the immediate future. Insofar as the New Member States are the worst hit by the recession, this is also affecting the process of convergence in innovation performance. The possibility that some countries will take a long time to recover is not good news for the EU as a whole. This could seriously hinder the reduction of regional disparities which is a key factor for the EU to compete today with US and Japan, and in the very near future also with emerging economies such as China, India and others. Strengthening the innovative potential of laggard countries may become a crucial priority to allow the EU to grow and to compete in the global economy.

Finally, an important issue to address would be the impact of the crisis at the sub-national regional level. Is the crisis exacerbating regional disparities in terms of technological innovation as well? This would shed some light on the presence of a double-level effect of divergence in innovation performance across countries and regions, and on the mechanisms underlying this relationship. The availability of data at the regional level describing the impact of the crisis would therefore be useful (see for example European Commission, 2010).

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## *TABLES*

Table 1: Results of the Model 1 (beta-convergence) and Model 2 (fixed effects), relative to the SII performance

| | *beta-regression estimates* | *fixed-effects estimates* |
|---|---|---|
| Independent variable | SII variation rate (2004-2008) | Yearly SII variation rate (2004-2008) |
| $\beta$ | -0.36*** | -1.76*** |
| Observations | 32 | 96 |
| F-test | | 0.04 |

Note: Robust standard errors: *** p<0.01, ** p<0.05, * p<0.1

Table 2: Results of the Model 1 (beta-convergence) relative to the seven innovation dimensions* of the SII

| Independent variable | Human resources | Finance and Supp. | Firm investment | Linkages & Entrepr. | Throughputs | Innovators | Economic effects |
|---|---|---|---|---|---|---|---|
| $\beta$ | -0.90*** | -1.46*** | -0.34** | -0.35** | -1.51*** | -0.02 | -0.59*** |
| Observations | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

Note: Robust standard errors: *** p<0.01, ** p<0.05, * p<0.1

* The seven dimensions are derived from the EIS (Table A1 in the Appendix)

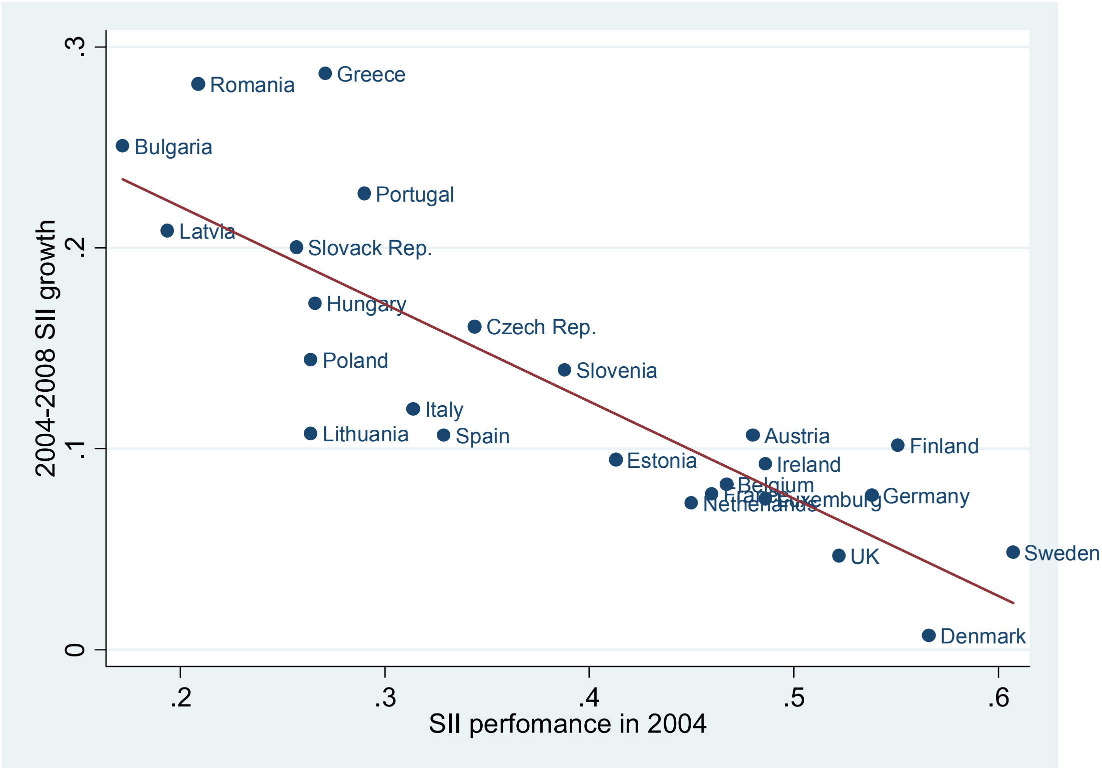
Table 3: Innovation variables for group of countries ordered by labour force and population, 2007

| | Total researchers | Triadic Patents | BERD | PUBR&D | Articles | Population | Labor force |
|---|---|---|---|---|---|---|---|
| Declining Nobility | 35.78 | 37.40 | 38.47 | 38.02 | 40.33 | 30.85 | 31.36 |
| Third State | 21.15 | 7.22 | 14.97 | 22.62 | 22.69 | 27.47 | 26.55 |
| Aristocracy | 32.65 | 54.89 | 44.62 | 33.04 | 30.05 | 23.48 | 24.62 |
| Parvenu | 10.26 | 0.46 | 1.85 | 6.17 | 6.84 | 18.14 | 17.39 |
| | | | | | | | |
| EU15 | 86.73 | 99.18 | 95.32 | 91.76 | 91.45 | 78.84 | 79.53 |
| EU10 | 13.27 | 0.82 | 4.68 | 8.24 | 8.55 | 21.16 | 20.47 |
| | | | | | | | |
| European Union | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| United States | 112.28 | 107.57 | 159.52 | 94.17 | 83.41 | 61.35 | 66.61 |

Source: Our elaboration on OECD "Main Science and Technology Indicators 2009", and World Bank "World Development Indicator", 2009.
Note: BERD is business R&D; PUBR&D is public R&D; articles are scientific and technical articles in international journals recorded by the Institute of Scientific Information.
EU15: Member countries up to 2004.
EU10: Eastern and Central European member countries that joined the Union in 2004 and 2007: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, Slovenia.

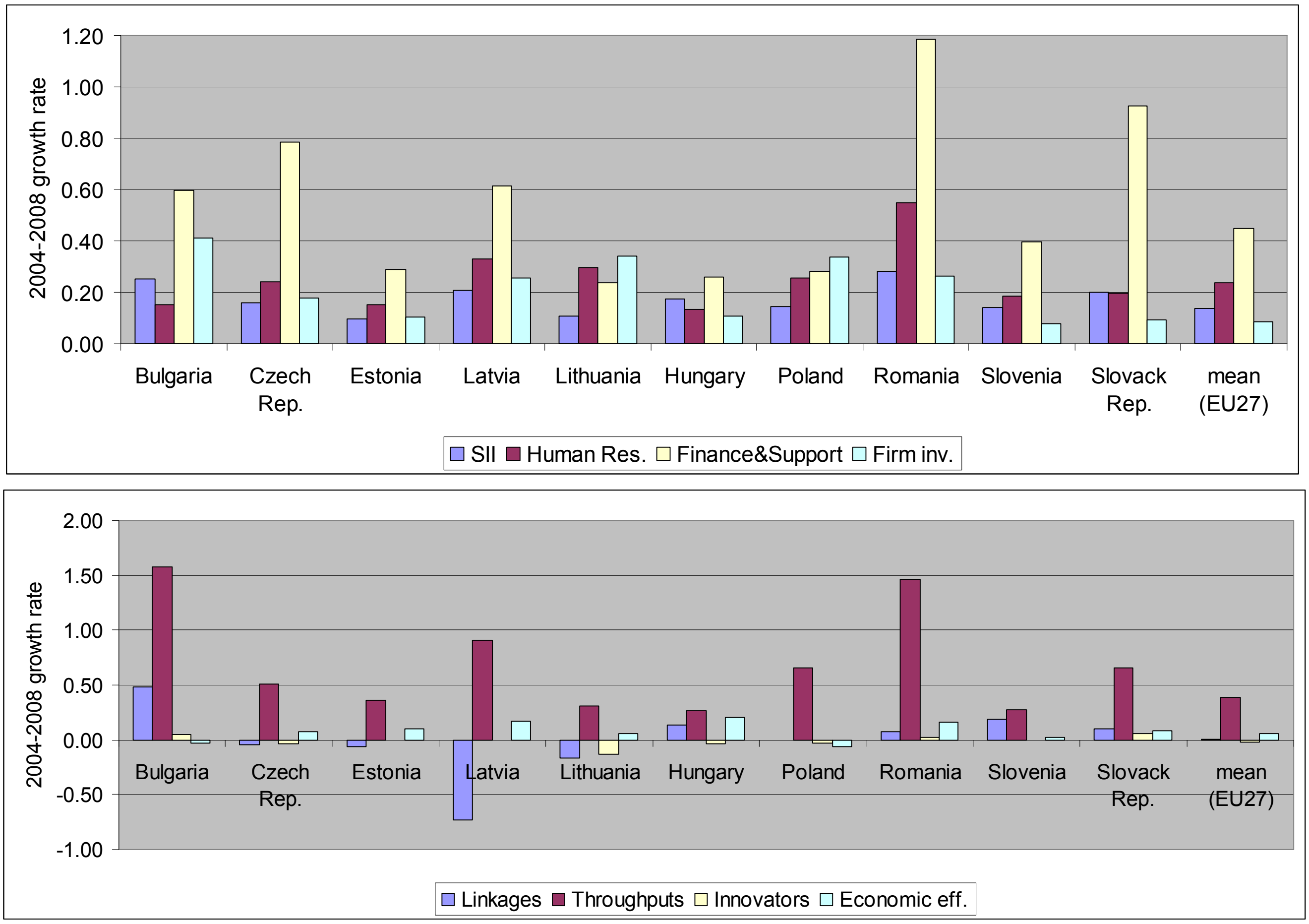
*FIGURES*

Figure 1: Convergence in innovation performance across the EU27 countries over the five years 2004-2008



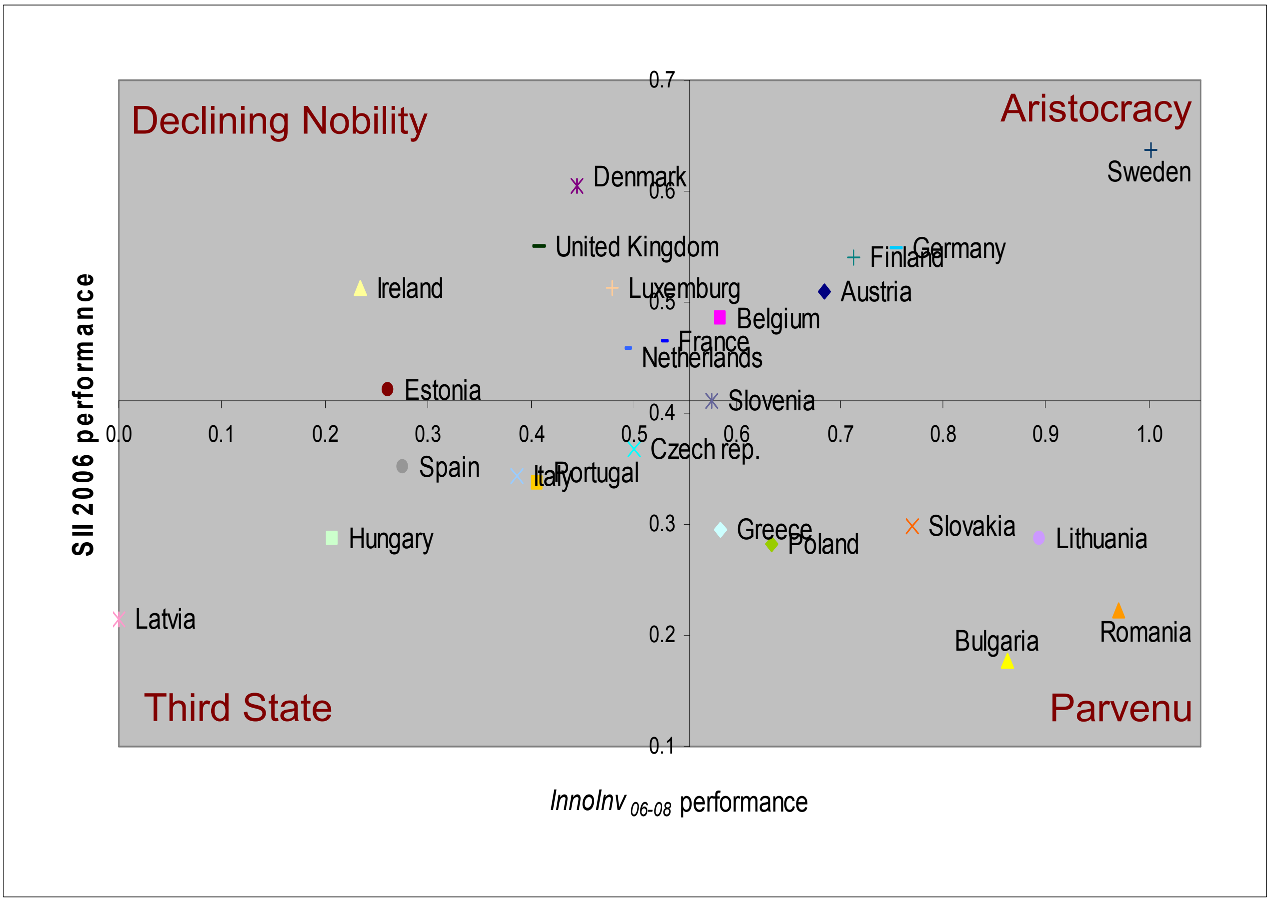

Source: Author's elaboration on European Commission (2008, 2009) – SII: Summary Innovation Indicator.

Figure 2: Growth rates for the SII and the seven innovative dimensions of the SII* for the New Member States and EU27 mean, 2004-2008




* The seven dimensions are derived from the EIS (Table A1 in the Appendix)

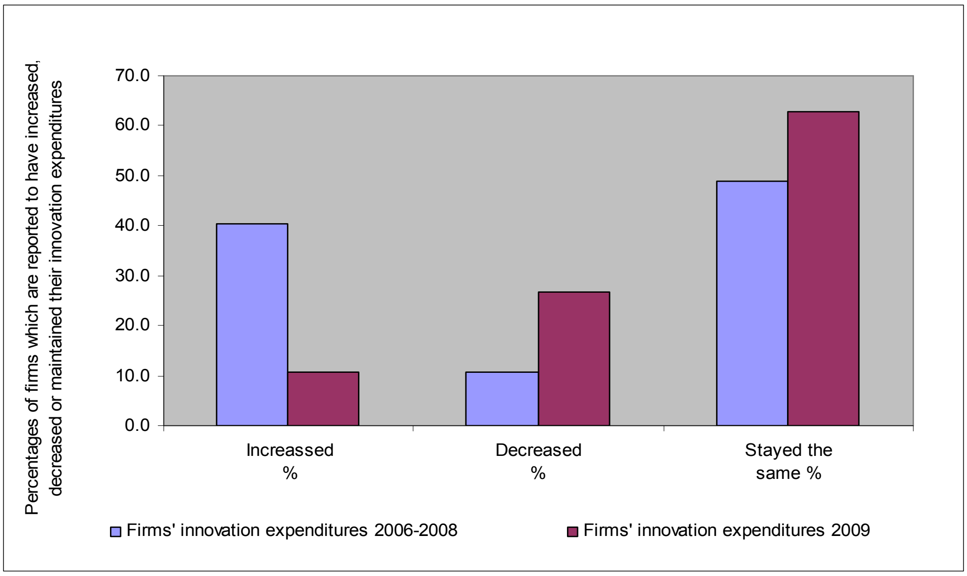
Figure 3: Medium-term firms' innovation performance ($InnoInv_{06-08}$) and national innovation system strength 2006 SII




*Source:* authors' elaboration on *Innobarometer* data, and on *EIS* data (see tables A2 and A3 in the appendix)

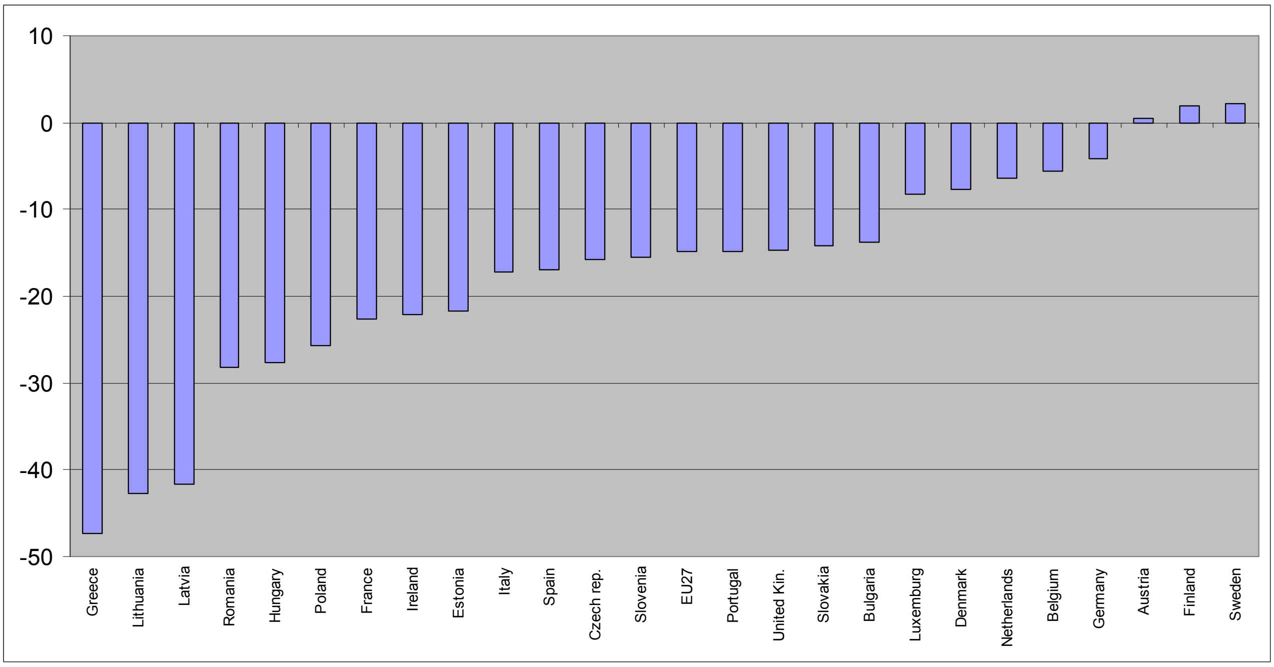
*Note*: axes cross at average values

Figure 4: Firms' innovation investment: 2006-2008 versus the first six months of 2009




*Source:* authors' elaboration on the two questions of the *Innobarometer* (see tables A3 and A4 in the appendix)

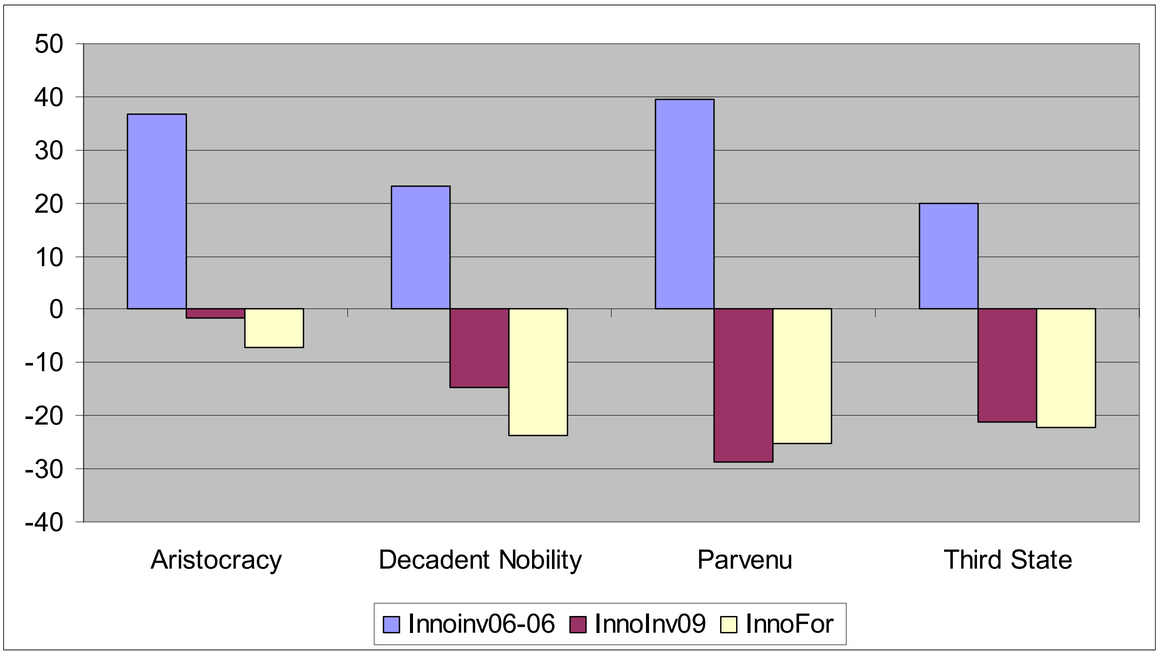
Figure 5: The impact of the current recession on firms' innovation investments*




*Source:* authors' elaboration on *Innobarometer* data (see Tables A3 and A4 in the appendix)

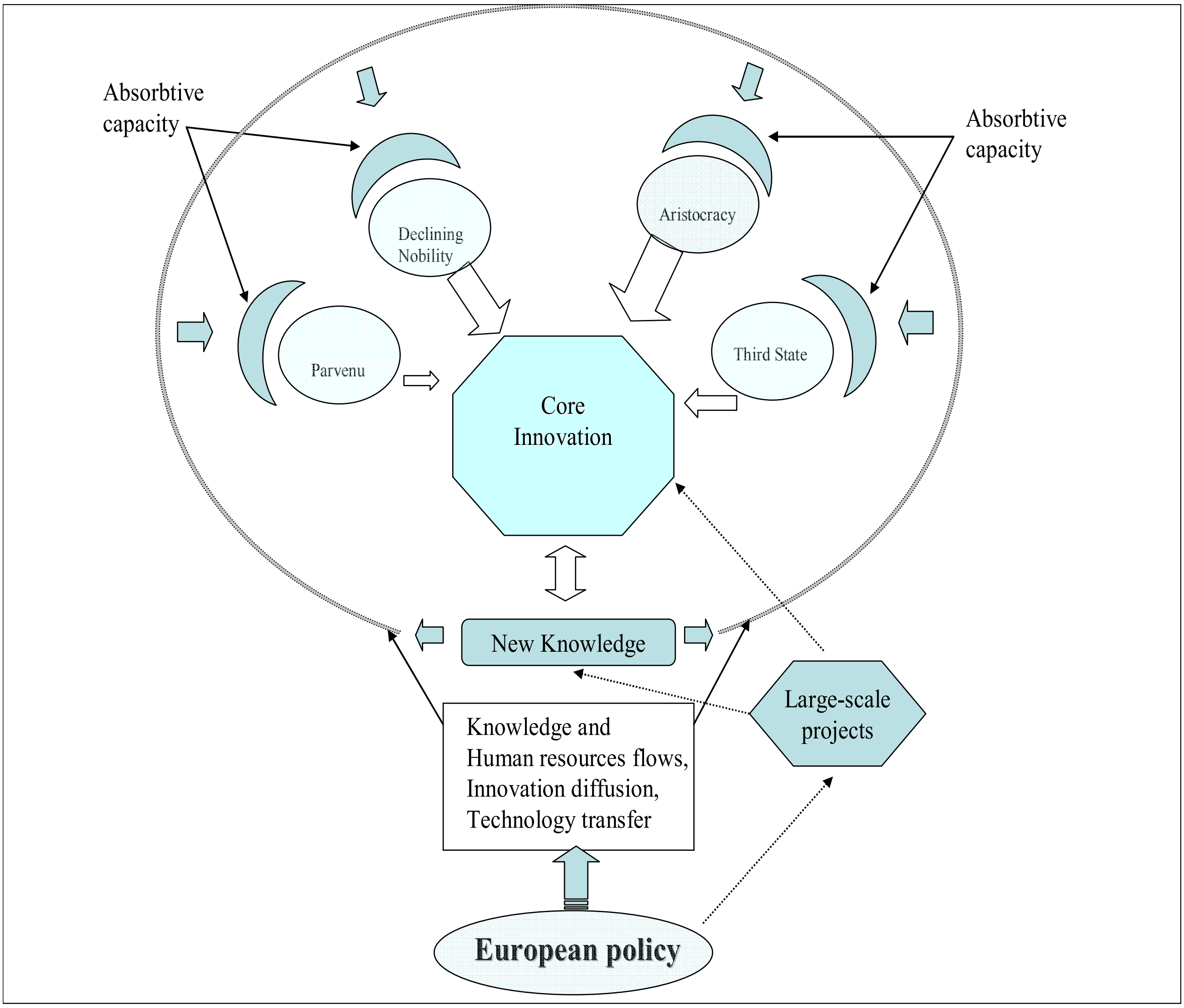
* Calculated as the difference between the share of firms increasing and firms decreasing their innovation investments

Figure 6: Balance between firms' innovation investment before (InnoInv06-08), during (InnoInv09) and after the crisis (InnoFor)




*Source:* authors' elaboration on the three questions of the *Innobarometer* (see tables A3-A4 in the appendix)

Figure 7: An "ideal" European System of Innovation: the development and diffusion of innovation outcomes across the EU countries




Source: authors' elaboration

# Appendix

Table A1. Indicators for the InnoStruct of the European Innovation Scoreboard 2008

| Dimension | Indicators |
|---|---|
| *Human resources* | S&E and SSH graduates per 1000 population aged 20-29 (first stage of tertiary education)<br>S&E and SSH doctorate graduates per 1000 population aged 25-34 (second stage of tertiary education)<br>Population with tertiary education per 100 population aged 25-64<br>Participation in life-long learning per 100 population aged 25-64<br>Youth education attainment level |
| *Finance and support* | Public R&D expenditures (% of GDP)<br>Venture capital (% of GDP)<br>Private credit (relative to GDP)<br>Broadband access by firms (% of firms) |
| *Firm investments* | Business R&D expenditures (% of GDP)<br>IT expenditures (% of GDP)<br>Non-R&D innovation expenditures (% of turnover) |
| *Linkages & entrepreneurship* | SMEs innovating in-house (% of SMEs)<br>Innovative SMEs collaborating with others (% of SMEs)<br>Firm renewal (SME entries plus exits) (% of SMEs)<br>Public-private co-publications per million population |
| *Throughputs* | EPO patents per million population<br>Community trademarks per million population<br>Community designs per million population<br>Technology Balance of Payments flows (% of GDP) |
| *Innovators* | SMEs introducing product or process innovations (% of SMEs)<br>SMEs introducing marketing or organisational innovations (% of SMEs)<br>Share of innovators where innovation has signifi cantly reduced labour costs (% of firms)<br>Share of innovators where innovation has signifi cantly reduced the use of materials and energy (% of firms) |
| *Economic effects* | Employment in medium-high & high-tech manufacturing (% of workforce)<br>Employment in knowledge-intensive services (% of workforce)<br>Medium and high-tech manufacturing exports (% of total exports)<br>Knowledge-intensive services exports (% of total services exports)<br>New-to-market sales (% of turnover)<br>New-to-firm sales (% of turnover) |

*Source*: European Innovation Scoreboard 2008 (Merit 2009)

Table A2. Results from the three questions from the Innobarometer 2009*

| Country | Question no. 1 (2006-2008) | | | | Quesiton no. 2 (2009) | | | | Quesiton no. 3 (forecast) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Increased % | Decreased % | Stayed the same % | Total | Increased % | Decreased % | Stayed the same % | Total | Increased % | Decreased % | Stayed the same % | Total |
| Austria | 40.8 | 5.8 | 53.4 | 100 | 11.2 | 10.7 | 78.1 | 100 | 15.25 | 17.88 | 66.88 | 100 |
| Belgium | 40.1 | 9.4 | 50.5 | 100 | 12.0 | 17.6 | 70.5 | 100 | 16.23 | 20.56 | 63.21 | 100 |
| Bulgaria | 52.6 | 10.1 | 37.3 | 100 | 11.9 | 25.7 | 62.3 | 100 | 20.09 | 30.06 | 49.85 | 100 |
| Czech rep. | 40.3 | 13.1 | 46.6 | 100 | 13.8 | 29.6 | 56.5 | 100 | 16.86 | 35.98 | 47.15 | 100 |
| Denmark | 35.2 | 10.4 | 54.4 | 100 | 17.2 | 24.9 | 57.9 | 100 | 13.42 | 34.63 | 51.95 | 100 |
| Estonia | 32.0 | 14.9 | 53.1 | 100 | 7.9 | 29.6 | 62.5 | 100 | 6.61 | 43.11 | 50.28 | 100 |
| Finland | 42.7 | 6.4 | 50.9 | 100 | 16.7 | 14.8 | 68.5 | 100 | 19.58 | 20.94 | 59.48 | 100 |
| France | 35.3 | 7.0 | 57.7 | 100 | 7.0 | 29.7 | 63.2 | 100 | 8.61 | 37.81 | 53.58 | 100 |
| Germany | 43.2 | 5.2 | 51.5 | 100 | 10.3 | 14.4 | 75.3 | 100 | 10.1 | 20.94 | 68.96 | 100 |
| Greece | 45.8 | 15.0 | 39.2 | 100 | 2.0 | 49.3 | 48.7 | 100 | 11.61 | 45.06 | 43.33 | 100 |
| Hungary | 36.0 | 21.3 | 42.7 | 100 | 4.6 | 32.2 | 63.2 | 100 | 17.59 | 37.85 | 44.56 | 100 |
| Ireland | 30.8 | 14.9 | 54.3 | 100 | 9.9 | 32.1 | 58.0 | 100 | 12.43 | 42.32 | 45.25 | 100 |
| Italy | 35.8 | 13.4 | 50.8 | 100 | 8.9 | 26.1 | 65.0 | 100 | 9.84 | 35.46 | 54.7 | 100 |
| Latvia | 27.3 | 21.2 | 51.5 | 100 | 9.2 | 51.0 | 39.8 | 100 | 11.23 | 53.41 | 35.36 | 100 |
| Lithuania | 54.9 | 11.0 | 34.2 | 100 | 6.3 | 49.1 | 44.6 | 100 | 14.5 | 61.3 | 24.2 | 100 |
| Luxemburg | 31.9 | 5.6 | 62.5 | 100 | 8.6 | 16.9 | 74.5 | 100 | 11.9 | 31.81 | 56.28 | 100 |
| Netherlands | 35.6 | 8.7 | 55.7 | 100 | 10.4 | 16.8 | 72.8 | 100 | 9.16 | 27.8 | 63.05 | 100 |
| Norway | 35.8 | 6.9 | 57.3 | 100 | 12.9 | 27.2 | 59.8 | 100 | 16.74 | 27.2 | 56.06 | 100 |
| Poland | 46.1 | 13.3 | 40.6 | 100 | 8.2 | 33.8 | 58.0 | 100 | 17.84 | 31.07 | 51.09 | 100 |
| Portugal | 37.2 | 14.0 | 48.8 | 100 | 13.4 | 28.2 | 58.4 | 100 | 18.7 | 26.67 | 54.62 | 100 |
| Romania | 56.4 | 9.2 | 34.4 | 100 | 10.7 | 38.8 | 50.5 | 100 | 18.24 | 39.65 | 42.12 | 100 |
| Slovakia | 48.6 | 9.9 | 41.5 | 100 | 16.5 | 30.7 | 52.7 | 100 | 15.1 | 41.79 | 43.11 | 100 |
| Slovenia | 39.5 | 9.1 | 51.3 | 100 | 5.1 | 20.6 | 74.2 | 100 | 9.06 | 31.98 | 58.96 | 100 |
| Spain | 28.8 | 11.2 | 60.0 | 100 | 10.1 | 27.2 | 62.7 | 100 | 11.55 | 40.89 | 47.55 | 100 |
| Sweden | 54.2 | 5.8 | 40.0 | 100 | 14.8 | 12.6 | 72.6 | 100 | 21.99 | 25.4 | 52.61 | 100 |
| Switzerland | 47.8 | 8.9 | 43.4 | 100 | 17.5 | 9.0 | 73.5 | 100 | 13.7 | 18.2 | 68.1 | 100 |
| UK | 32.9 | 9.6 | 57.5 | 100 | 8.5 | 23.2 | 68.4 | 100 | 14.21 | 25.53 | 60.27 | 100 |

*Source*: European Innovation Scoreboard 2008 (European Commission 2009)

* With respect to the Innobarometer 2009, the results are been re-scaled to make them comparable across countries

**Methodology: the three indicators**

*1.* The *InnoInv<sub>06-08</sub>* Indicator: is based on following *Innobarometer 2009* question: *"Compared to 2006, has the amount spent by your firm on all innovation activities in 2008 increased, decreased, or stayed approximately the same (adjust for inflation)?".*

$InnoInv_{06\text{-}08\,country\text{-}i} = (X_{country\text{-}i} - X_{country\text{-}min}) / (X_{country\text{-}max} - X_{country\text{-}min})$

Where $X_{country\text{-}i}$ = (% firms increasing - % firms decreasing) - see Table A3

*2.* The $InnoInv_{09}$ Indicator is based on following *Innobarometer 2009* question: *"In the last six months has your company taken one of the following actions* [increased, decreased or maintain the innovation spending] *as a direct result of the economic downturn?"*

$InnoInv_{09\,country\text{-}i} = (X_{country\text{-}i} - X_{country\text{-}min}) / (X_{country\text{-}max} - X_{country\text{-}min})$

Where $X_{country\text{-}i}$ = (% firms increasing - % firms decreasing) - see Table A4

*3.* The *InnoFor* Indicator is based on following *Innobarometer 2009* question: *"Compared to 2008, do you expect your company to increase, decrease or maintain the total amount of its innovation expenditures in 2009?".*

$InnoFor_{country\text{-}i} = (X_{country\text{-}i} - X_{country\text{-}min}) / (X_{country\text{-}max} - X_{country\text{-}min})$

Where $X_{country\text{-}i}$ = (% firms increasing - % firms decreasing) - see Table A5