Step4EU*: A Policy Brief*

Europe after the European Research Area and times of increased uncertainty:

Framing the need for new science policies

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Summary

An increasing internal divergence on knowledge investments across Europe is identified, together with an increasing gap between Europe as a whole and North America, mostly after a decrease in annual budgets for S&T across most of European countries between 2009 and 2012. As a result, this policy brief argues that new paradigms and conditions for responsible science and innovation policy across EU require the *collective action* of R&D institutions and a system approach to higher education, together with new initiatives towards international cooperation. This should consider active public policies to attract and retain qualified human resources, as well as considering public actions towards promoting new markets. The way in which the economic fabric may gain competitiveness and access to external markets may require enhancing the degree of internationalization of the scientific community and encouraging international R&D and advanced education partnerships.

1. Context and relevance: an increasingly diverging Europe

In a decade hit by recession and economic and budgetary problems, which public policies for science, technology and education are necessary in the near future, both for individual member states as well as the EU as a whole?

Two main observations have driven this question. First, Figure 1 compares the accumulated investment per researcher in Europe and Norte America over the last three decades (with reference to 1982) and shows levels of investment in Europe 50% lower than in the USA by 2012. Analysis also shows that the average investment in R&D per citizen in Europe has decreased comparatively to that in USA. The question that arises is about the diversity of political options in Europe as a whole and at the various European member states that have allowed this overall situation.

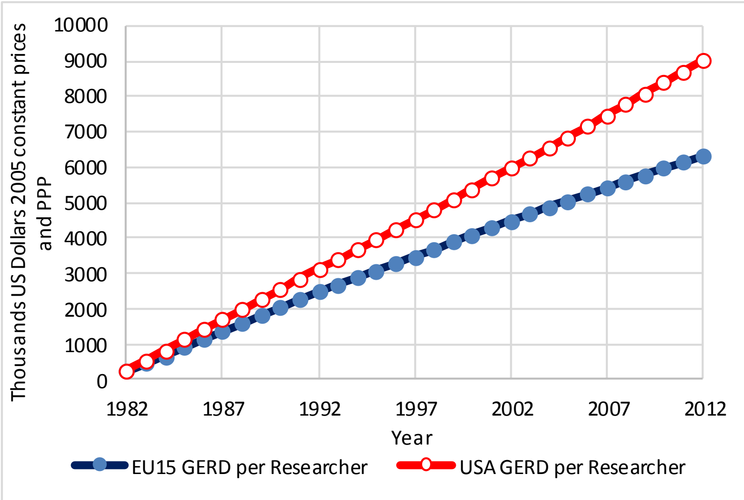


Figure 1 – Cumulative R&D expenditure per researcher, as integrated over the period 1982-2012 (U.S. Dollars 2005 constant prices and PPP). Source: OECD.

This question is relevant because it has become a common place to argue that science and technology permeates everyday life, but a new debate is emerging about the related role of the State, with emphasis in Europe (Mazzucato, 2013). The continuous need for growing investments in formal knowledge activities by countries and firms (Aghion, et al., 2009), underlines the search for competitive advantages and the establishment of sustainable bases for further development of the required "smart specialization" for Europe (Foray, 2009; 2015). This trend often combines mixed patterns of competition and collaboration (Bengtsson and Kock, 2000) and, in the specific case of Europe, is growingly intertwined to face a fast-paced, globalized and uncertain world (e.g., Owen et al., 2012; Stilgoe, et al., 2013).

Our second observation is that the quasi stagnation of R&D public investment in Europe over the last decade, which now accounts for about 2.0% of EU's GDP (for comparison, GERD in the US is about 2.8% GDP), hides a major trend of internal divergence inside Europe itself. For example, in the year 2000, Germany and France presented similar national R&D budgets; today, Germany outpaces France by 50%. Italy budgets have declined since 2007, and in real terms are 15% lower than in 2000. And, most of small countries have slowed down, or cancelled, previous increases in R&D budgets. This debate has emerged as a result of the deep international crisis that has been affecting Europe and to which many analysts, scientists and scientific organizations have turned their attention, in several European regions, with special emphasis on southern European countries.

Undoubtedly there was progress in Science, Technology and Higher Education throughout Europe (e.g., Celis and Gago, 2014), but as a whole, Europe has met neither its goals nor its promises in this area (EC, 2014). The challenges for Europe are immense, independently if they are global, national or local in nature, as most are to all effects transversal (e.g., global warming). An adequate policy framework not only helps mediating the interface between science, education and society, but also contributes to shaping systems, strategies and development patterns. Ultimately, the question is how to avoid the surprising estimates of UNESCO (2012), that warns about the possibility to have a "lost generation" of 200 million of young people – the bulk of which are expected to possess some kind of higher education qualification.

2. Key findings: the dynamics of the investment in science and technology

In terms of political action, science policy is undertaken through annual appropriations for Science and Technology (S&T), which are approved each year by national parliaments within the context of state budgets (i.e., "GBOARD - Government Budget Outlays or Appropriations of R&D", in technical nomenclature). Looking back to what the evolution of the European scenario has been over the last two decades regarding budget appropriations for S&T, Figure 2 shows that, in 1995, France and the northern European countries had the largest appropriation per capita for S&T. By contrast, over the 2000-2009 period, in line with an increase in the German budget allocated to S&T, which grew by 60%, there was a relative stagnation of the French budget after a 12% decrease between 2005 and 2007. During that period (see, for example Gago and Heitor, 2007), some small and medium-sized European countries increased their investment in S&T, particularly Portugal and Ireland (which almost tripled their budget) and Finland and Belgium (about 1.6 times more).

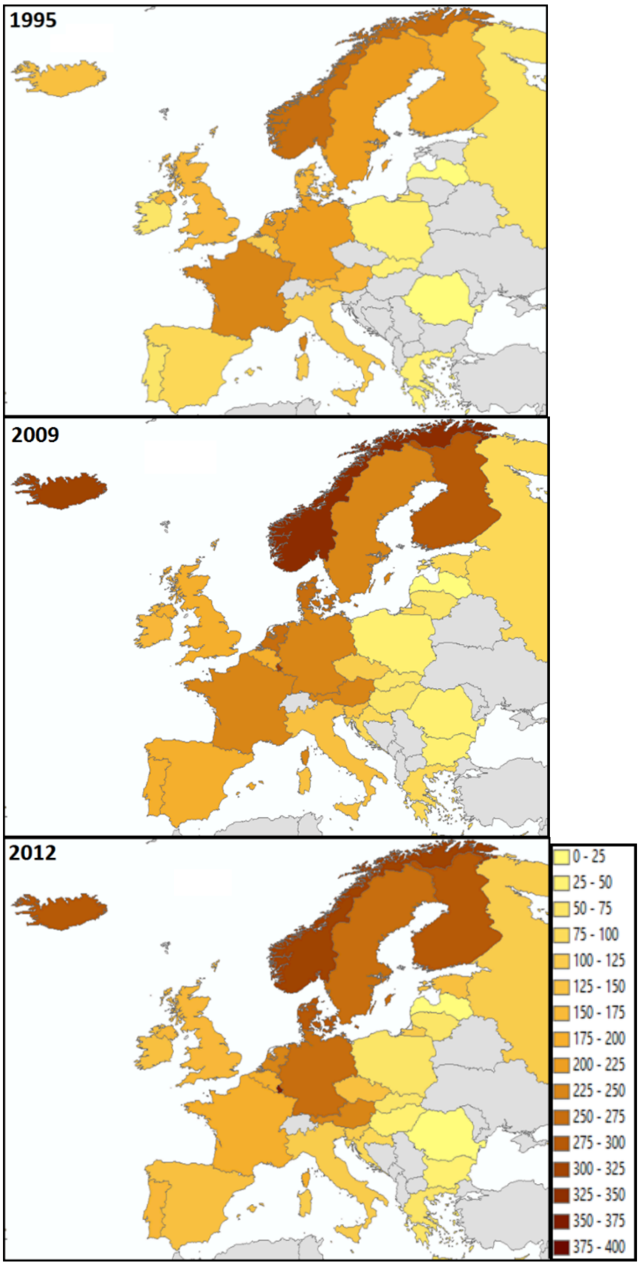


Figure 2 – Evolution of “Government Budget Appropriations or Outlays for R&D”; GBOARD)/capita) in Europe for 1995, 2009 e 2012 (values corrected for “Purchasing Power Standard, PPS”, per inhabitant in 2005, at constant prices).
Source: EuroStat.

It is important to note that Germany is the only EU country that continued to increase its S&T budget, even in times of crisis. From 2013, Germany’s S&T budget has been similar to that of France and the UK taken as a set. By contrast, only Germany and northern European countries have met the European targets for R&D expenditure, which were set at 3% of GDP (EC 2014).

In order to understand the situation in Southern Europe, it is interesting to look at the specific case of Portugal. Its annual budget for S&T only reached 1% of GDP in 2008, despite the expectation that this figure could be achieved in the 1980s (see, for example, Gago, 1990). It was only about 0.5% in 2000 and 0.8% in 2005, accounting for nearly 3% of the overall public budget only by 2011 (Heitor and Bravo, 2010; Heitor et al., 2014). It therefore increased by 33% in relation to GDP between 2005 and 2011 and by 23% in relation to the global State budget. In Europe, only Estonia, Luxembourg and Slovenia grew at a higher rate during that period.

In Portugal (as well as in Spain, as discussed by Núñez, 2013), however, there has been in recent years a decrease in the budget allocated to S&T, associated with the perception that policies must be changed. In this regard, two types of arguments have been put forward, which are often conflicting to each other and may result from distinct political influences. On one hand, there is a recurrent argument in Portugal for targeting public support to companies and mostly to business competitiveness, and, on the other hand, the need for increasing selectivity criteria of public support based on the claim of overqualified personnel. This has resulted in the reduction of the share allocated to advanced education (i.e., reduction of doctoral and post-doctoral scholarships funded by the Portuguese Foundation for Science and Technology, FCT) and scientific employment (i.e., ending a large majority of PhD researcher contracts, directly supported by FCT).

As a result of these policies, the level of support for attracting young researchers from abroad to work in Portugal has been considerably reduced. Besides, the brain-gain effect, which had finally took place in 2009 after so many decades of outflows of talents, has probably faded away (i.e., brain-drain, as discussed in detail by Heitor et al., 2014). The argument of overqualified personnel and the related reduction of the level of support for advanced education have re-emerged the debate on the sustainability of doctoral and post-doctoral studies in Portugal, in a context of growing international competition for qualified human resources (OECD, 2012; Stilgoe et al., 2014; Heitor et al, 2015).

Despite the lack of accurate data on the migration qualification structure, Figure 3 shows the substantial growth of migratory flows from Southern to Northern Europe since 2010, mostly of qualified young people (OEm, 2014). The respective impact on the reduction of the scientific and technological capacity in Southern European countries and regions is not dully quantified or described, but has been recurrently debated by the scientific and academic community.

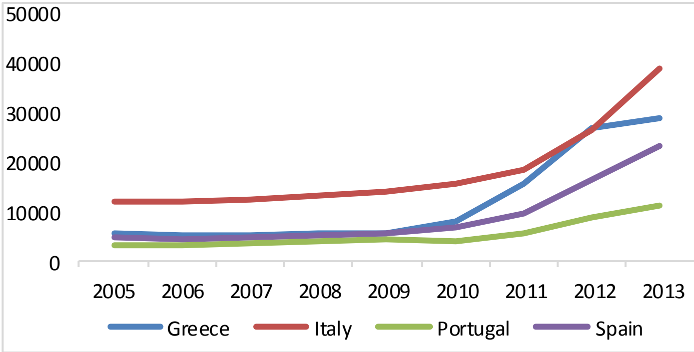


Figure 3 a) Number of people entering in Germany by country of origin, 2005-2013
Source: Statistisches Bundesamt Deutschland, Fachserie 1 Reihe 2- 2005 a 2013

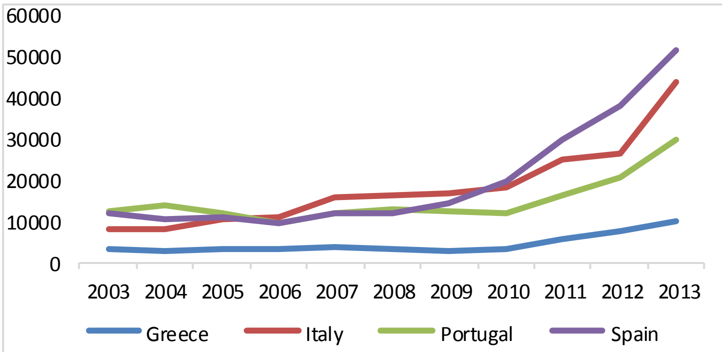


Figure 3 b) - Number of foreigners in UK with a "National Insurance Number", by country of origin, 2003-2013
Source: Department for Work and Pensions – UK

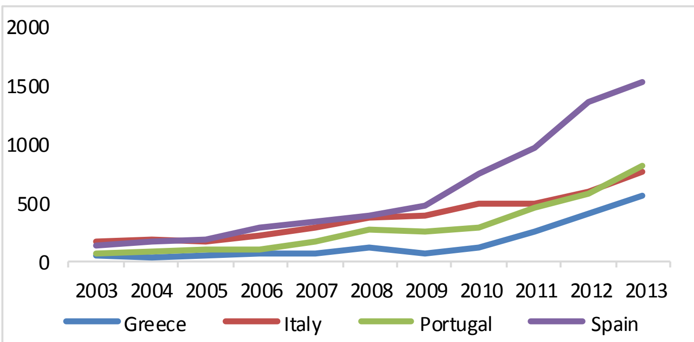


Figure 3 c) - Number of people entering Norway, by country of origin, 2003-2013
Source: Statistics Norway, Immigration, emigration and net migration, by citizenship.

Figure 3 – Flows of people from Southern to Center and Northern Europe, 2005-2013

Still regarding Portugal, one of OECD's last reports regarding the status of science and technology at international level, OECD (2012), identifies three fundamental aspects that characterize the development of the country's scientific and technological capacity in recent decades. First, the OECD recognizes the Portuguese progress in scientific output, with publications in the top-quartile journals per GDP, similar to OECD average. Second, industry-financed public R&D expenditure per GDP and businesses in particular, remains well below OECD average. Third, the base of tertiary education of working population, considered as a whole, is still considerably below OECD's average levels (i.e., "adult population at tertiary education level").

In the context of the previous indicators, it is reasonable to ask the question, so what has changed in Europe in the last decade? In addition to the number of graduates in Science, Technology and Mathematics per 1.000 inhabitants (Figure 4), where European peripheries (and Southern European countries in particular) underwent the most significant changes within the framework of the OECD, the reinforcement of education and qualification of new resources and their institutional integration, along with the attraction and retention of researchers from around the world, are confirmed as a distinct feature of some of those countries (e.g., Slovakia, Poland, Check Republic, Romania and Portugal). In addition, advanced training of human resources, as measured in terms of new PhDs per 10.000 inhabitants (Figure 5) has considerably improved throughout European peripheries.

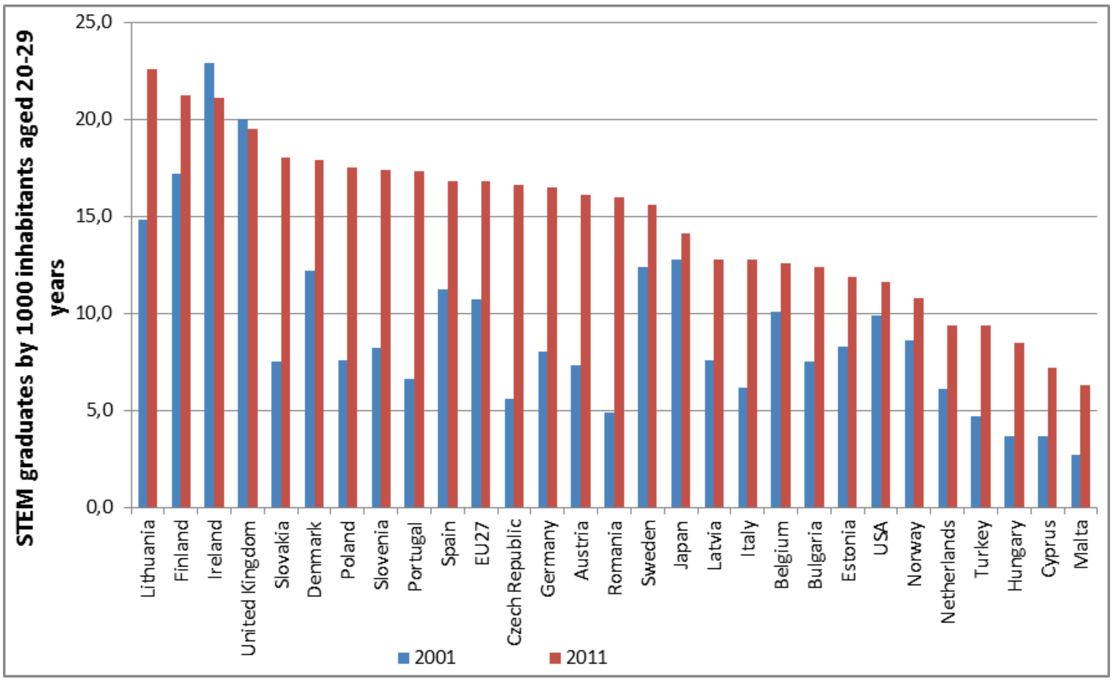


Figure 4 – STEM graduates per 1000 inhabitants with 20-29 years old in a sample of EU countries and the USA, 2012. Source: Eurostat.

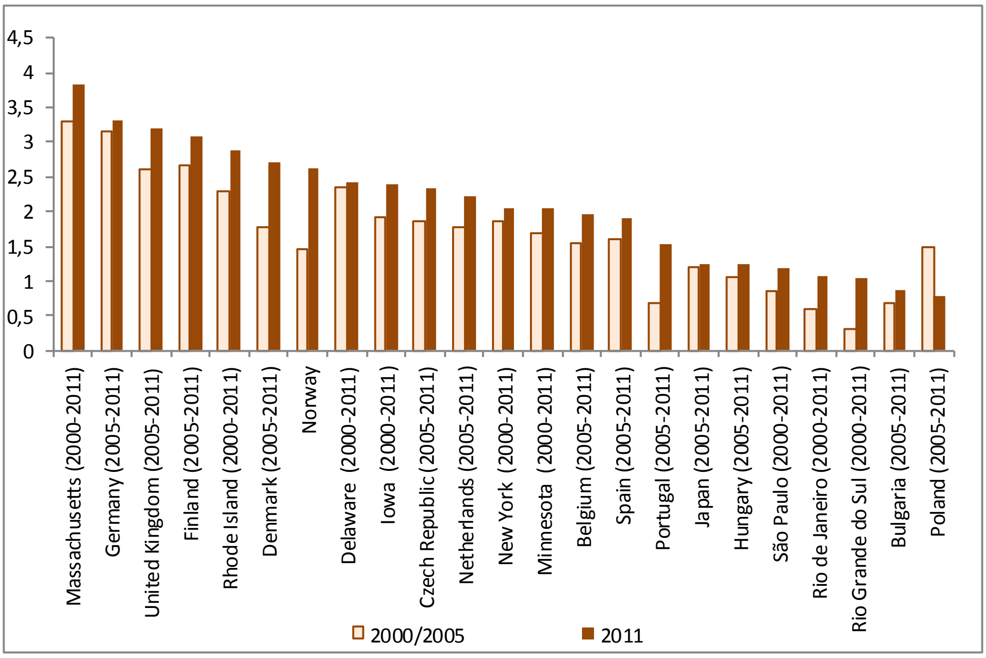
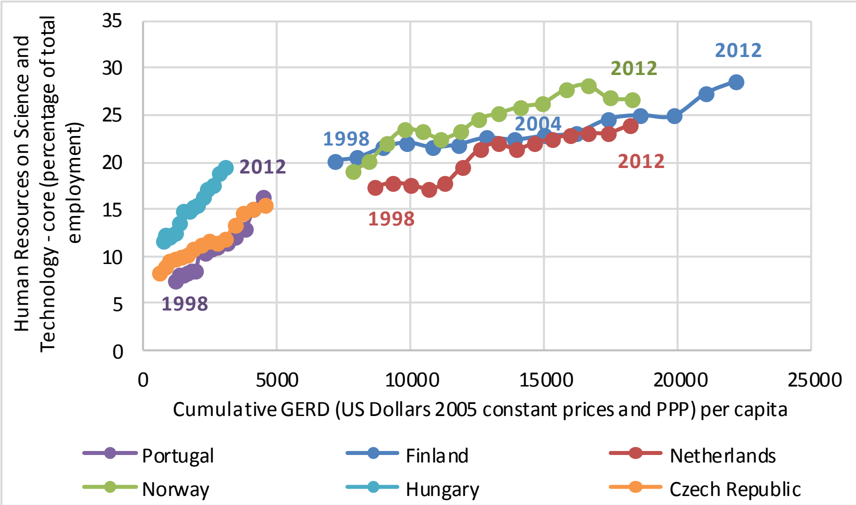
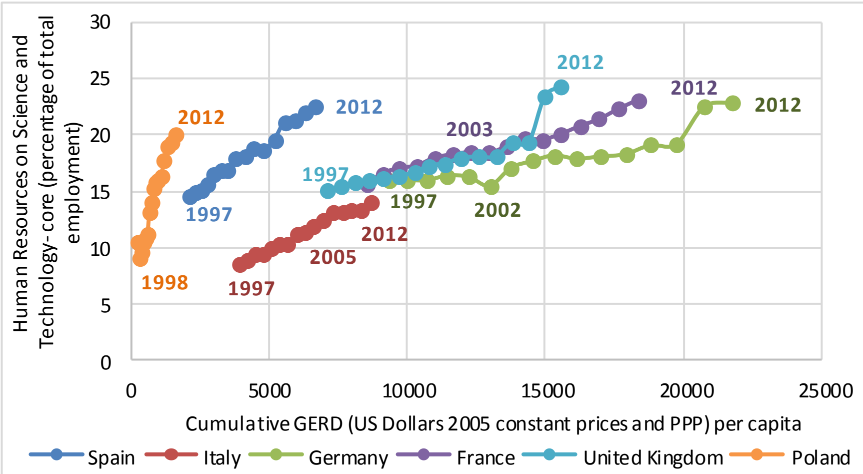


Figure 5 – New PhDs per 10.000 inhabitants for 2000/2005 and 2011 in a sample of EU countries and (North and South) American regions.
Source: Eurostat; UNESCO; INEP; NSF; IBGE; NBS; SSB.NO.

Figure 6 relates the development of total Human Resources in S&T occupations, HRSTO, to the accumulation of gross expenditure in R&D over the last decade, showing that R&D investment efforts in many EU countries, including Hungary, Check Republic and Portugal (as small and medium EU countries, Figure 6a) and Spain, Poland and Italy (as large EU countries, Figure 6b) were particularly used to qualify people. Nevertheless, those investment efforts still remain relatively tiny, compared to other small and medium-sized countries. For example, Norway, Holland and Finland have made considerably higher accumulated investment efforts in R&D than those "less mature" countries and are characterized today by a comparatively highly qualified workforce.



a) Sample of small and medium EU countries.



b) Sample of large EU countries.

Figure 6 – Human Resources in S&T (core coverage) versus cumulative gross expenditure in R&D, GERD (1998-2005); Notes: HRST in percentage of total employment, GERD per capita in U.S. Dollars 2005 constant prices and PPP; HRSTC - Core refers to those people who have successfully completed education at the third level (HRSTE) – ISCED levels 5 and 6 and are employed in a S&T occupation (HRSTO) – ISCO major groups: 2 (professionals) and 3 (technicians); Source: OECD, Eurostat.

Within this framework, our analysis suggest that the formulation of S&T policies in the countries identified above with relatively lower levels of accumulated expenditure in R&D should keep on being targeted particularly to foster advanced education of human resources, by encouraging the qualification of human capital. This is because those countries have evolved considerably in terms of the number of researchers and the education level of their young people in recent decades, but still have some way to go in terms of the qualification of their workforce, mostly in a context of increasing competition for qualified human resources at an international level. For example, the unprecedented increase in the level of emigration from southern to northern Europe since 2010 reveals unsustainable migratory paths in Europe that are affecting the performance of Europe as whole, with short term implications that are augmenting to European divide identified above in this paper. The case of Spain should also be highlighted, as Figure 6 illustrates, namely in terms of the low level of aggregate investment in R&D compared to other larger EU countries, particularly Germany, France and England.

3. Implications and Recommendations

It has become commonplace to mention human capital as an essential condition for knowledge creation and dissemination, in a way that any effort toward greater human capital is extremely important for the social and economic development of any part of the world. In itself, this objective calls for policies to expand the social base toward scientific and technological development and the effective appropriation of scientific and technological culture (Majewski, 2013). This obviously requires opening access to higher education through several mechanisms that take into account non-linear people's experiences and life trajectories (Saar et al., 2014).

A simple estimate of students, aged between 20 and 24, who are currently attending higher education, in addition to those that already hold an advanced academic degree, and keeping the current higher education completion rates, makes us assume that all European regions will achieve 30% of graduates aged between 30-34 by 2020 (Heitor et al. 2014). Consequently, in order to meet the European Strategy 2020 goals, which entails achieving 40% of graduates in that population group by 2020, it is necessary that many more thousand of students aged between 20 and 24 all over Europe conclude their graduate studies, beyond the current graduation levels.

The analysis still shows that the success of opening higher education within the framework that emerges at international level, in which innovation must be considered together with competence building and advanced education, calls for complex interactions between formal and informal qualifications (Helpman, 2004). This requires continuation of a major effort at a wide European level to broadening the social base of knowledge-based activities and strengthening the "top" of the knowledge production system.

If we try to develop further the implications of this argument and the terms which must drive the formulation of national S&T policies across Europe, it is obvious that three vital issues must be addressed: a) scale, especially when it comes to the undeniable need to go on increasing public efforts in S&T; b) diversification, namely regarding the need to perceive the difference between instruments and the role of public and private funding; and c) time, regarding the need to understand a continued effort in S&T. Three main recommendations for science policy in Europe emerge from this rationale, as follows.

<u>The basic assumption: linking public investment in science and technology to the systematic reinforcement of human capital</u>

Within a framework of high volatility of a fast-changing society and economy – as it always has been – and at a time where there are segments of society that start to show indicators that most closely resemble the socio-economic features of developed countries, one should conclude (perhaps counter-intuitively) that the system must go on expanding and diversifying in order to meet the quantitative and qualitative needs of the future. The analysis must consider the need to cover an increasing diverse population, the demands of society and of volatile and highly uncertain markets. This implies massifying the qualification of the workforce within a broad range of economic sectors.

It is important to clarify the potential for growth of human resources in science and technology. Despite the rapid growth of human resources in S&T over the last 30 years, there is still a high growth potential and, above all, the need to further develop this growth process. For example, human resources employed in science and technology occupations (i.e., "HRSTO") in Portugal and many other European peripheries account for less than a quarter of the workforce in the age group 25-64, whereas, in 2012, this share was around 40% for the EU-27 average and more than 50% in Holland, Finland or Denmark, as well as in Europe's most industrialized areas.

<u>Understanding the impact of S&T policies in economy as a function of its level of diversification and internationalization</u>

It is important to note that, despite the current framework of a growing financial vulnerability of many European regions, the accumulation of investment in S&T over the last 30 years has allowed to offset the technological balance. It was in this context that the evolution of business expenditure in R&D in Portugal, Spain, Check Republic and many other countries reflects increasing private sector efforts in valuing scientific development and technological capacity, namely in terms of their innovation potential, access to emerging markets and development of exports.

Figure 7 helps clarify this debate, taking into account that Germany is the only large European countries where the impact of R&D in exports is especially visible, because of its highly diversified economic structure in recent decades. The figure quantifies the level of economic structure diversification through the inverse of the Herfindahl-Hirschman Index (HHI) for economic structure (considering industrial output, or manufacturing, only; see, for example, Waterson, 1984), which is defined as the inverse of the sum of the square of the market share of the various industrial sectors operating in the economy. It therefore allows for analysing the relative levels of concentration/diversification of industrial activity, showing that the impact of R&D activities accumulated over the years is mostly contingent upon the structure of the economies.

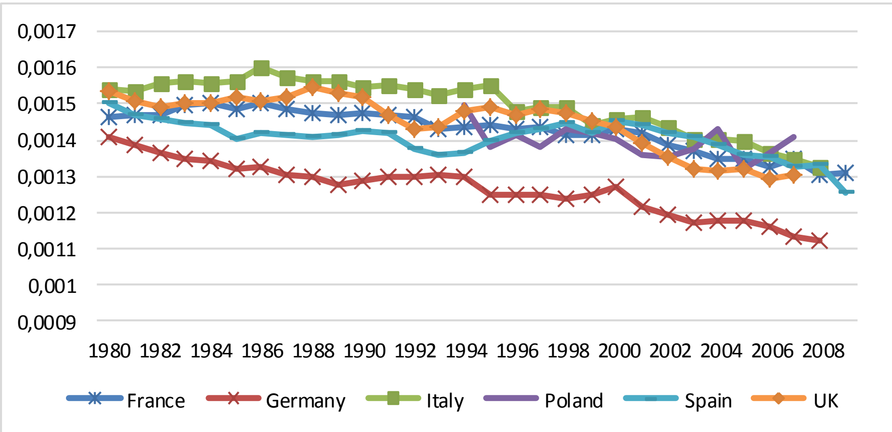


Figure 7 – Levels of diversification of economic structure, 1980-2010, as quantified by the Inverse Hirshman-Herfindahl Index for the economic structure (only manufacturing) for a sample of large EU countries.
Source: OECD.

Our analysis suggests that only those European nations that have increased the investment in S&T and managed, at the same time, to diversify their economic structure have fully guarantee the necessary *absorptive capacity* to foster the impact of S&T in economic development (see, for example, Cohen and Levinthal, 1990; Freel, 2005; and Vinding, 2004). The implications for southern and eastern European countries are notorious and call for the need to combine an increase in the budget allocated to investment in R&D with measures oriented towards technological diversification and intensity of the industrial base.

It should also be noted that the concepts of economic diversification and the related development of a sustainable industrial basis, in addition to being distinctive features of the most developed economies, are also associated with the development processes of the countries that have become direct competitors of Western economies in recent decades, such as South Korea (Amesden, 2001) or Taiwan (Berger, 2005). Diversification, in particular, seems to allow for economic growth of countries and regions, mostly because of the increase in consumption. It is also important to the extent that the weight and therefore the dependence on economy of each industrial sector have lost ground. Because almost all knowledge-intensive exports are associated with high-tech manufacturing industries, investment in those industries should also allow for mitigating the risk of regional crises, in that it becomes possible to look for potential markets in other regions. By doing so, diversification is associated with the creation of socioeconomic resilience, i.e. the ability of the socioeconomic fabric, and companies in particular, to promote themselves and recuperate from financial shocks, such as recessions or crises. Nevertheless, the processes related to industrial diversification and specialization, which are linked to competence broadening and development, respectively, are extremely complex and mostly associated with knowledge and technology learning and incorporation processes in people and organizations (Sheffi, 2007).

Job creation and quantification is a key issue of the local socioeconomic impact of industrialization processes and, consequently, in the context of the previous analysis, sustainable development of technological and industrial bases calls for building distinctive competences. This process must be based on qualified human resources and investment in research and development, thereby contributing to continuously develop those competences, gain experience and, therefore, may help build up competitive advantages (Cohen and Levinthal, 1990).

Promoting the *Entrepreneurial State*

Although the functions that are socially allocated to scientific institutions start being shared by a wide spectrum of institutions, Public States are now faced with demands for an increased presence of its capacity to promote knowledge creation and dissemination (Mazzucato, 2013; Stilgoe, 2013). In fact, we could also argue on the exclusive role that Public States should take on to ensure system diversification, inter-institutional mobility, initial cooperation with companies, as well as institutional integrity and internationalization. However, one must remember that the role of the State as guarantor of institutional diversity and integrity must be implemented through funding and assessment mechanisms.

The indicators used in this study show that, at the threshold of the 21st Century, the average funding rate per researcher in most southern and eastern European countries continues to be a third of that in the most industrialized European countries, and a researcher in higher education in Europe has approximately half the funding of a researcher in the US. Comparatively, the level of GDP per capita in most southern European regions (e.g., Portugal and Greece) is about 75% of the average share for Europe which shows an effective deficit of R&D funding in those regions, particularly in cumulative terms.

The importance of this discussion lies in the fact that several models of economic growth have allowed for explaining the increase in per capita income in developed countries depending on the degree of knowledge accumulation, which has provided grounds for considering S&T evolution as endogenous to economic and social development (Romer, 2000; Conceição and Heitor, 2002). Within this framework, there has been in recent literature the need for considering institutions and policies in order to explain cross-country differences in terms of knowledge and per capita income generation.

Against this background, the evolution and modernization of European science and technology, as a whole, cannot be devised in a conceptual void, not even ignoring the complex arrangement of values involved, in addition to the facts that characterize science output and dissemination. Among other aspects, it is appropriate to point out the seminal work of Robert Merton, a prominent sociologist (deceased in 2003) who, in the 1950s, showed us the so-called “serendipity” nature of knowledge production and diffusion (Merton and Barber, 2004). From the stories of Archimedes to the accidents that were on the basis of the discovery of penicillin by Fleming, and the development of new materials such as Teflon, accidental happenings in science, but mostly in innovation, are today well-known and documented (e.g., Johnson, 2014).

It must be made very clear that we do not mention any lack of scientific values, but a well clear priority to increase the dimension of the science and technology system, as well the average funding per researcher. Against this background, Paul Romer (2000) is well worth mentioning. Among other aspects, he showed that the role of public policies designed for preparing scientists and graduates is particularly critical for long-term economic growth, and these policies have been responsible for the fast growth of the number of engineers and scientists in the US in the post-war period.

In this respect, we cannot expect that private initiative, per se, increases R&D activity and solve the issues of employment and wealth in Southern and Eastern Europe. The need that emerges from diversifying mechanisms for funding innovation and developing S&T, namely its link to companies and to the productive fabric, requires public policies that promote scientific employment in association with areas of large public and private investments. Public policies are also critical to mobilize public resources in science and technology, allowing qualified people and knowledge to be available to conduct R&D in companies.

To summarize, this policy brief shows that public policy formulation in Europe after a decade hit by recession and economic and budgetary problems must take into account countercyclical measures, while focusing on advanced education of human resources and strengthening S&T in all branches of knowledge. The continuous qualification of the workforce at large is a persistent challenge that requires broadening the social base for advanced education, as well as for internationalization.

The current level of southern and eastern European economic and technological development requires a major and sustained effort of R&D public financing. This will contribute not only to graduate new PhD students but also, directly and indirectly, to foster demand. This has been the way regions and countries with high levels of R&D and a large percentage of R&D have made in companies and funded by companies have followed. The faster and greater involvement Europe at large addresses this challenge the quicker it will be kept up with.

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