Public Investment in R&D: Does public investment in R&D in lagging regions of the European Union have an impact on Innovation and GDP growth? If so, is it the most efficient mechanism to foster economic growth in these regions?

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I. Theory/ Model

1. Question to be researched: What is my empirical question?

   My research is aimed at answering whether **public investment** in R&D in lagging regions of the European Union **does pay off** and if so, if the **public** sector is the **most suitable agent**, in terms of *effectiveness and efficiency*, to undertake these R&D initiatives.

   The definition of the two **benchmark measures** that I shall use are defined as it follows:

   - *Effectiveness*: To have a positive impact on GDP growth
   - *Efficiency*: To be more profitable in terms of GDP growth than private investment, both in the short and the long run.

2. Why this question is relevant?

The existing literature on research policy opens a debate about the convenience of investing in R&D for those regions which do not count on an appropriate infrastructure, tradition or amount of resources devoted to this type of activities. On the one hand, aspects such as minimum threshold, existence of technological spillovers or increasing returns on scale, which encourage a free-riding behaviour of firms and regions, face frontally, on the other hand, other arguments concerning the increasing costs of transmission of tacit knowledge, the absorptive capacity of R&D or the lack of more profitable alternatives for these lagging regions.

Within this theoretical debate and in the context of the European Union, what can one observe about the research policy which is being conducted at the European, National and Regional levels? How investment in R&D is being carried out? Do we see a tendency towards agglomeration of R&D expenditure in core regions, or on the other hand, do we observe increasing efforts from lagging countries and regions to increase their technological potential by investing in R&D? Are the public and the private sectors investing equally in every region? Which policies are being adopted at the European, National and Regional level? Do we focus on transfer policies from the core to the periphery? Which are the plans for the future?

The European Union (EU) under the special summit of Lisbon (March, 2000) declared that "over the next ten years, Europe should become the most competitive and dynamic knowledge society in the world, capable of sustainable economic development, accompanied by a quantitative and qualitative improvement in the level of employment, and greater social cohesion". This statement put research and development and technology as one of the key policies the EU should pursuit. The vision was clear. However, the concrete policies to follow and the resources they may take are still to be specified.

The EU investment in R&D lags behind when compared to other industrialised areas. In this sense, the EU investment in R&D does not represent more than 1.8%[1] of the GDP, while this measures rises up to 2.6% and 2.8% for the United States and Japan.

Moreover, this gap tents to increase since the average annual growth in R&D expenditure in the EU has been around 3% in the last five years, while in the USA raised over 5% and over 4% in Japan.

Nevertheless, this situation is not even across the EU. A more detail analysis would show that, there are great differences at the national level in the Member States. In the EU, we could distinguish four different set of countries. The first group is composed of the Nordic countries: Finland and Sweden. These countries, with strong telecommunication sectors, count on high levels R&D investment, comparable to those levels reached in Japan and the US. The members of the second group, would be those countries with lower levels than the Nordic countries, but still above the EU average. These countries are Denmark, France, Belgium, Germany and the United Kingdom. The third set of countries would be those situated slightly below the average: Ireland, the Netherlands and Austria. The final group gathers those Member States with levels far behind the EU average. Spain, Italy, Portugal and Greece rank in this last group. As we can see, national efforts on R&D differ greatly from one member state to another. One example of this disparity between Member states could be the fact that Sweden invest 700% more in R&D than Greece.

However, which is the trend that is being followed? Are R&D activities concentrating more in those areas with already high levels of R&D?

Countries such as Finland and Ireland have increased their R&D investments up to 13.02% and 10.92% respectively, 400% and 350% more than the EU average. The reason for this drastic increase is that these two small countries have relied their economic structure on high tech sectors.
Equally, one should also remark the fact that after this outstanding evolution for these two countries, there has been a proportionally higher investment in R&D expenditure, being carried out by countries such as Portugal, Spain and Greece; which were those which had lower levels. On the other hand, it is also remarkable that countries with relative high level of resources devoted to Research, such as France, the United Kingdom and to a certain extent Germany, seem to devote less resources to these activities.

As we can see, there are increasing efforts from peripheral countries to narrow the gap in technology. In particular, the examples of Portugal (a country which has increased its R&D expenditure by 10% each year) or Spain (with increases at a rate of 6.32%) are very explanatory. Portugal and Spain have devoted to R&D activities over 300% and 200% the EU average.

This increasing effort from peripheral regions has been recognised, but still it remain well behind the EU average and its overall objective.

[1] Source: European Commission. DG RTD (2000)

However, **who is investing in these countries?** Although it is true that both the private and the public sectors have increased their investments in R&D, it is the public sector which has been proportionally increasing its investment in the peripheral regions. In this sense, and just as an example, the proportion of public investment in objective 1 regions of Spain and Portugal represented over 70% of the overall investment, which strongly contrasts with levels of 25% in non-objective 1 regions of France or Germany.

Finally, the European Council of Barcelona in march 2002 has emphasised the necessity of devoting increasing resources to R&D activities if the overall goal of the Lisbon Council (to become the most competitive and dynamic economy in 10 years) is to be achieved. In this sense, the European Union and its Member States agreed to increased its R&D expenditure up to 3% of the GDP in the following years, as a mean to catch-up and overpass other economies, such as the American or the Japanese ones.

A closer analysis of the R&D investment composition reveals that the EU lags behind from other economies, due to the small private investment rates. Thus, the Barcelona Council did also conclude that at least two thirds of the overall investment in R&D should be coming from the private sector. At this respect and in order to incentive private investment, the European Commission foresees a series of measures, such as tax credits, better property right protection, further development of the venture capital scheme or a more favourable institutional set-up, intended to boost private investment in R&D. However, are these measures equally effective in all regions of the EU? Are these measures equally suitable for all regions? Will all regions be able to foster private investment? Should this investment be concentrated in some dynamic regions and allow transfer of technologies afterwards towards other regions?

3. Theoretical Relevance

Traditionally, there have been different approaches to explain the shape and factors behind economic growth at the regional level. Two of the most influential schools of thought in the field have been the neoclassical theory and the endogenous growth theory, which mainly divert on the perception of the role of technology.

On the one hand, the **neoclassical growth theory**, as defended by Solow (1956) and Swan (1956), describes a model where a series of standard neoclassical assumptions about the functioning of the economy, determinate the growth path of any given region or country. In particular, these models assume the existence of perfect competition (and information), maximising behaviour, no externalities, constant returns to scale[2] (the level of output one firm produces does not have an impact on the overall structure of costs of production, and thus on the returns it achieves) *diminishing returns to each input* (the marginal utility of any given extra unit of any given input is lower than that of the previous one) and some positive and smooth elasticity of substitution between the inputs (i.e. labour and capital can be substituted in order to produce any given output).

Under these assumptions, the model predicts productivity growth as a result of the increases in the amount of capital each worker is set to operate. However, as capital

[2] Under this assumption, the production of one unit or one thousand units of output would not affect the overall cost per unit of production.

per worker increases, the marginal productivity of capital declines, due to the diminishing return on capital, and with it the scope for further increases in the capital-labour ratio. As a result, **conditional convergence** between regions and countries is predicted: the lower the starting point of real per capita GDP, relative to the steady-state position, the faster that economy would grow.

The problem with this approach, following Barro and Sala-I-martin (1995:11) is that "the long-run per capita growth rate is determined entirely by an element –the rate of technological progress- that is outside the model, …and thus we end up with a model of growth that explains everything but long-run growth, an obviously unsatisfactory situation".

More recent studies have tried to resolved this problem by introducing technology as the key variable in the economic growth equation. This new trend has been denominated the **endogenous growth theory**[3].

Romer[4] (1986) specified a model of long-run growth in which technology stopped to be regarded as an exogenous factor outside the growth equation. He introduced the concept of knowledge into the production equation and defended its increasing marginal productivity, in contrast to the neoclassical assumption of diminishing returns. In his model, Romer (1986:1003) argues that " long-run growth is driven primarily by the accumulation of knowledge by forward-looking, profit maximisation agents".

In the same line, Romer (1990) reinforces the centrality of technology with regards to the processes of economic growth and argues for the necessity of considering technology and technological chances as an endogenous factor, since these technological advances are nothing else than the result of "intentional actions taken by people who respond to market incentives"

The consequence of this new model for growth is that "the level of per capita output in different countries need not converge, growth may be persistently slower in less developed countries and may even fail to take place at all"[5]. As we can see, convergence is not an automatic process as predicted by the neoclassical theory. Under these premises, divergences across regions could even broaden depending on the level of technological effort carried out by each region (Rebelo 1991)

As a conclusion, we could say that the endogenous growth theorists have emphasised the role of technology as the key element to foster long-run growth, and under these principle, convergence between regions and national does not necessary occur automatically. Divergence may be broaden depending on the technological investment.

Some further support to the importance of technology to explain growth has been rendered by members of the academic trend which has been denominated "**Evolutionary Economics**[6] **"** Scholars belonging to this strand (Dosi, Soete,

[3] The literature also refers to endogenous growth theory as the New Growth Theory
[4] Romer is considered to be one of the main initiators and developers of the Endogenous Growth Theory.
[5] See Romer (1986:1003)
[6] This school of thought has also been denominated as Schumepterian or neo-schumpeterian

Verspagen, Pavitt or Kleinknecht) have pointed out that, according to their theory, growth is a consequence of many factors which may remain outside the economic domain. In particular they consider *culture, institutions and science*[7] as three key elements which determinate long-run growth.

The central idea in this body of literature, is that economic growth cannot be explained by distinguishing "economic" and "non economic" (especially, institutions and technology) factors, since all of them have are interrelated and they all, with their interrelations, shape the process of economic growth. Dosi (1984) establishes the importance of a "social system" where innovation is generated as the result of different separate "domains": technological, economic and institutional domains. Therefore, for these authors, any model which just regards economic factors (such as R&D, or capital accumulation) is far too narrow and ill-defined.

Under this perspective, the economy is a process of constant transformation, and the changes of institutions and technologies over time are the key factors which drive economic growth. Thus, if economy is in a constant transformation, the differences in economic growth are hard to predict *a priori* since it is difficult to predict the *evolution* of all the involved factors and their interaction. This fact also implies that in the long run, economic convergence between nations and regions does not need to be achieved automatically. The process of convergence or divergence would depend upon the developments of institutions and technological change. In fact, convergence and divergence could appear at the same time for a series of countries, giving birth to the creation of "Regional Clubs"[8]

As a conclusion we see that economists have always identified technological change as the key factor behind economic growth. It is clear after this review, that there have been differences among scholar in the way technological change works. In this sense, neoclassical theorists believed technology was an exogenous factor publicly available to every firm and region; while new growth theorists considered it to be endogenous to the growth model and regarded it as a partly public, partly private good. Finally, Schumpeterians believe in the effects of cumulativeness of innovations and the different capabilities of firms and regions to do so depending on their historical and institutional background.

Nevertheless, in recent years new approaches have been introduced in this ongoing debate of determining the successful factors behind Regional Economic Growth. These "technology theories" have enhanced the importance of **knowledge and innovation**.

It is widely accepted that **technology and technological advances** are the main factor behind innovation. Authors, such as Bershnahan and Trajtenberg (1992) have reinforced this importance of technology by arguing that "advanced technology and information is the single most important force driving the secular process of economic growth". In the same line, Romer (1990), Grossman and Helpman (1991) or Lichtenberg (1992) have showed the relationship between investment in technology and in R&D and increases in productivity and growth

[7] See Freeman and Soete (1987) or Dosi, Pavitt and Soete (1990)
[8] Verspagen (1997), Fagerberg and Verspagen (1996)

Traditionally, **investment in R&D** has been regarded as one of the key policies to secure technological potential and therefore innovation and, consequently, growth. R&D increases the possibility to achieve a higher standard of technological advances for firms and regions, which would allow them to introduce new and superior products and/or processes conducting to higher levels of income and growth. The relationship between the variables (From R&D to Technology Potential to Innovation to growth) seems to be, as the path for policy makers to follow, thus, clearly defined.

Nevertheless, there are a series of questions which seem to introduce some doubts about the validity or **suitability of investing in R&D** in all type of regions in general, and lagging regions in particular.

One of the main concerns is closely linked to the fact that R&D activities are very costly and in general they require a high **amount of resources** before being capable of providing a technological advancement and thus yield the economic effort of the investment. This question is especially sensitive for lagging regions, which traditionally have lacked from a clear-cut scientific and technological strategy.

Moreover, and reinforcing this idea, many scholars –i.e. Scherer 1982- have highlighted the existence of **increasing returns on investment of R&D activitie**s. These increasing returns arise thanks to the positive economies of scale and scope derived from further concentration of these activities.

A second factor which may play an important role in deterring lagging regions from investing in R&D is, as mentioned by Storper (1995) the fact that **innovations linked to technology** are non-rival and non-excludable goods – new ideas can be used at a zero marginal cost-, and **difficult to appropriate**. Technological developments tent to be mobile and, although there may be attempts from firms to capture the results of the research initiatives, these forms (patents, lead-time) are regarded as highly imperfect[9],and technological advances can finally spread out throughout the economy.

A third factor which may question the necessity of investing in R&D in lagging regions may arise when analysing the fact that **innovation may spill over** from leading to lagging regions. Due to the above-mentioned public nature of knowledge and its difficulty to be appropriated, firms may not have an incentive to invest in R&D, hoping to benefit from research efforts carried out by other firms.

As we can see, all these three factors (requirement of a minimum threshold and positive externalities, appropriation of innovations linked to technology and the existence of innovation spillovers) seem to call for an innovation model which would tent to agglomerate all the R&D activities in, already technological advanced regions, so that the general system would benefit from higher returns of scale and technological spillovers. From that point of view the developed innovations in these regions would then spill over to all the other lagging regions.

However, there are also some **drawbacks in this strategy** which are important to highlight and which would incentive a lagging region to invest in R&D activities and avoid free-riding.

[9] See Harabi (1995)

Firstly, even if one can admit the existence of increasing returns on investment due to the economies of scale and scope associated with the accumulation of R&D efforts, that fact, as pointed out by Rodriguez-Pose (1999), **does not mean** that **investment in R&D** in lagging regions **cannot be profitable**, or at least they may report higher returns than alternative investment opportunities for those regions.

Secondly, it is true that technology is mobile and difficult to appropriate; but this **mobility is not costless or territorially even**.

As we can see, technological spillovers as described above and their diffusion mechanisms are complex and not all firms or regions may be endowed to benefit from them.

A further factor which would influence the ability of firms and regions to benefit from technological spillovers is the fact that in order to do so, these firms and regions would require "learning capacity" to actually obtain any valuable since they may not be able of using this knowledge, due to a lack of skills. Therefore, in order to acquire this capacity firms would have to invest in order to upgrade their level of "knowledge literacy"

These two factors indicating the costs of benefiting from spillovers have been backed up by empirical evidence. Evidence shows that technological spillovers tend to cluster in some specific geographical locations (geography does indeed matter).
Thus, who benefits more from spillovers?
From a geographical point of view, and as a result of the difficulties to benefit from technological spillovers , as we have seen above, innovative firms tent to agglomerate in given technological advanced regions and therefore, these regions which are close to the foci of innovation generation, which besides already count on a high level of skilful labour and accumulative knowledge and which are better related to other innovative regions seem to be the major beneficiaries from spillovers.

On the contrary, it seems that peripheral regions would not benefit from these spillovers (at least not to the same extent) since geographically, they remain distant from the innovation poles and with difficult access to innovative networks. Moreover, these regions are characterised by a lack of "learning capacity" due to their low levels of starting knowledge and skills.

Under these predictions, peripheral regions would fall into a self-reinforcing vicious circle, difficult to escape from. An initial disadvantage in terms of innovative capability would lead any given region to lower levels of production and thus growth rate. This lower growth would deter, according to the agglomeration phenomenon of innovation, further innovation to occur and thus, lower rates of growth would perpetually remain.

The relevance of these questions about the public intervention in undertaking R&D activities is even enhanced by the rise of new approaches highlighting the **importance**

of formal and informal institutions in the "learning process[10]**"** and the creation and assimilation **of knowledge** and innovation.

Soete and ter Weel (2000) defend the idea that technical change is "a complex dynamic process that involves many **social and economic factors** and a wide range of individual, institutions and firms" In this context, "the capacity of an economy to derive competitive advantages from technical change and innovation is in the end dependent on the dynamic efficiency with which firms and institutions can diffuse, adapt and apply information and knowledge"

At the regional level, the relevance of the social factors in the ability of a region and the organisations there based, to innovated had also been highlighted. In this sense, Verspagen (1997) argues that the ability of a region or country to either innovate (or imitate innovations) depends heavily on institutions such as the educational system which are determined by the overall social conditions of a region.

The importance of institutions has also been pointed out by many other scholars. It is of particular interest the approaches which believe in the necessity to enhance **"Innovation Systems"** within a region or a nation as a mechanism to create and capture innovation.

Richard R. Nelson[11] (1993) argues that Innovation Systems are a "way of describing and analysing the set of institutions that generate and mould economic growth, to the extent that one has a theory of economic growth in which technological innovation is the key driver". Freeman (1987) defines them in a similar manner, arguing that they are "a network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies" or as, Freeman (1992:169), " a set of institutions which are more directly concerned with scientific and technical activities"

The basic idea behind these systems lay on the fact that the globalisation process and the new technological advances have expose firms to increasing competition. This fierce competition puts pressure on firms to innovate either in their products or processes, so that they can benefit from the Schumpeterian concept of entrepreneurial discovery. However, these innovation processes are carried out in cooperation with other organisations as they tent to lack the resources or the ability to launch these activities in isolation. These organisations include firms (suppliers, clients and competitors), education institutions (universities), governments Each of these organisations generate knowledge when interacting with the others; and it is the role of institutions to facilitate the generation and assimilation (learning process) of this knowledge among the different agents.

4. <u>Proposed alternative</u>
   In order to analyse the public efficiency of direct investment in R&D, it would be necessary to calculate the impact of this investment, not only on innovation

[10] The concept of "learning" has been described by Lundvall as the most important process a firm and a region has to undertake in order to foster "innovation" and associated economic growth
[11] See chapter 2 of "Regional Innovation, Knowledge and Global Change", Edited by Acs, Z.

activities (i.e. number of new patents), but also on the final objective, which is economic growth (i.e. GDP)

The results of this analysis should be compared with other **alternative initiatives** (i.e. private efficiency of R&D investment), which do also try to foster economic growth, in order to point out the main benefits and pitfalls of this sort of public intervention. It should also take into account the **nature of the investment** and the difference between **short and long term effects** of investments on economic growth.

5. Theoretical significance of the model
This model would provide a tool to determinate whether the public sector is the most suitable agent to undertake R&D initiative and the fields of investment which seem to be more profitable in terms of long and short term returns.

6. Policy implications of my research
Depending on the results of the analysis, some policy guidelines should be provided about the nature and role of public investment in R&D. In that sense, questions such as whether the public sector should invest in R&D, or to incentive private R&D or to create the enabling structures to absorb technological spillovers, etc… should be determined.

II. Methodology

1. Methodology
I intent to use both quantitative and qualitative methods in order to draw some general and more specific conclusions about my research question.

1.A. Quantitative Analysis
In fact, the first part of the analysis would be based on a *multivariate analysis*. Regional economic growth (measured by the GDP), innovation activity (measured number of patents) and Total Factor Productivity will be regressed against a set of variables, which would measure the impact of private and public R&D. An approximate model would be the following one:

$$GDP^{12} = \alpha + \beta 1\ R\&D_{pub} + \beta 2\ R\&D_{priv} * D + \beta 3\ R\&D_{pub} * \text{Technological Gap} * D + \beta 4\ R\&D_{priv} * \text{Technological gap} * D + \beta 5\ R\&D_{pub} * \text{Level of skills} * D + \beta 6 * R\&D_{priv} * \text{Level of skills} * D + \beta 7\ R\&D_{pub} * \text{Demographics} + \beta 8\ R\&D_{priv} * \text{Demographics} + \beta 9\ R\&D_{pub} * \text{Economic structure} + \beta 10\ R\&D_{priv} * \text{economic structure} + \varepsilon$$

For each of the variables, I shall use proxies depending on the availability of data.

The aim of these regressions would be to analyse the **effectiveness** (sign of the coefficients) and **efficiency** (significance of the difference between public and private coefficients) of public R&D in terms of GDP growth. In this analysis, we

[12] The analysis will be carried out for three different dependent variables: GDP growth, Number of patents and Total Factor productivity.

would assess some of the variables which have been highlighted in the theoretical model[13] and especially, it take into account both the **direct** impact and the **indirect** impact (absorptive capacity[14]) of R&D on GDP.

The analysis does also take into account the fact of analysing if a region is core or periphery (with the introduction of a dummy variable) since theoretically, it may constitute a significant factor.

Equally, this analysis would consider the ability of a region to benefit from R&D depending on its structural features (level of skills, demographics, economic structure, etc…)

From this previous analysis, I intent to achieve some general conclusion about the influence, significance and differences in the impact on GDP from public and private R&D activities.

Nevertheless; GDP, innovation rate and the productivity of factors can be influenced by many other factors. Thus, a second type of methods would be appropriate to shed some light.

1.B Qualitative Analysis

A set of *comparative case studies* where a description of the context, the process, the content and the outcome of the different R&D policies carried out by some regions –and the economic and social agents interacting within that framework- would be analysed.

The selected regions for this comparative case study would be: The Basque Country (Sp), Dublin County (Irl) and the Basilicata Region (It). The reason for this selection is due to the different approach the three regions have adopted in terms of investment in R&D. In fact, the Basque Country has developed an intensive public R&D, while in the case of Dublin, it has been the private initiative (mainly, multinational companies) which has emphasised the investment in R&D. Basilicata, on the other hand, remains at low rate of both public and private investment levels in R&D.

The case studies will be **on cascade**. First, a comparative analysis will be carried out between the Regione Basilicata (peripheral region with very little investment in R&D) and the Basque Country and Dublin County (peripheral regions with relatively high levels of R&D investment)
Secondly, there will be an analysis comparing the Basque Country (Peripheral region with relative high levels of public investment) and Dublin County (Peripheral region with relative high levels of private investment)

Although it is too early to establish the variable/s which would be analysed, as a preliminary approach, we can mention that social capital and the institutional set-up[15] can represent two of the variables.

[13] See point 3
[14] Absorptive capacity can be defined as the ability of a region or an agent to benefit from technological spillovers.
[15] Social capital and the institutional set-up has to be understood in a broad sense.

2. Data and data sources

The main sources of information will be:

- Existing Literature on the topic
- Statistical Data bases: Eurostat, National (i.e. INE) and Regional (i.e. EUSTAT, OECD) statistic offices
- Public and published information carried out on the topic by Regional Development Agencies, Regional Governments, Business Innovation Centres, Chambers of Commerce or previous studies about the topic carried out by other institutions such as the European Commission (DG Regional Policy), or the OECD
- Interviews with key representatives of regions' main agents

3. Foreseen problems.

Some of the problems which may be encountered whilst carrying out the research could be:

- *Lack of consistent information* at the regional level of the different levels of private and public R&D investment
- *Accessibility of information*. Some of the relevant information may be difficult to obtain , especially for the case studies, where a set of open interviews is established.

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