Which future perspectives for Higher Education? How will evolve innovation, research and the scientific job market? Which impact for jobs? More or less employment? Far too big questions to be answered as such. This book analyses and proposes suggestions for a relevant number of topics pertaining the field. From the Bologna process to the Doctoral education organization, considering globalization and assessment issues, new jobs requirements, mixed competences and skills in a framework of blurred boundaries. It offers the occasion of thinking about the European Research Area in a multifaced way and to identify some possible future paths and solutions for a shared cross national future for research and researchers.

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CONVERGENCE OR DIFFERENTIATION

Human Resources for Research in a Changing European Scenario

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The Supply and Demand for Researchers in EU

Javier Vidal

1. Introduction

In 2010, we are immersed in a global economic crisis. Historically, crisis periods have given rise to a great deal of analyses focussing on the causes and possible solutions. My paper will not be one of them because it deals with an issue, the need for researchers in the EU, which has nothing to do with the current economic crisis. This demand for researchers was already explicit before the crisis, and many policy actions have been implemented in the last decades to increase the number of researchers in the EU. Today many analysts highlight R&D activities as one of the key factors for the EU future implying that there should be less *financial businesses* and more *productive economy* based on scientific and technological knowledge. Although their analyses are in the right direction, in this paper I would like to stress the long term needs for researchers in the EU rather than those derived from the current economic context.

So, why should we be interested in *researchers* in the long term? We should because, as is widely accepted, there is a relation between scientific development and rich societies. Although there is a lot of scientific literature supporting this relation, at this point, I believe that it is more relevant to cite a policy statement in order to stress the extent to which this idea has been extended and has permeated policy makers. The EU Commission predicts dramatic consequences for EU if the lack of researchers is not solved in time.

> *'The identified potential shortage of researchers, particularly in certain key disciplines, will pose a serious threat to EU's inno-*

vative strength, knowledge capacity and productivity growth in the near future (…)" (COM 2005, 1).

I dare say that most regions and countries would agree with this kind of statement, because this threat does not only affect the EU. It would apply to all knowledge-based economies and regions that aspire to maintain and increase their welfare state, as the EU does. So the demand for researchers should not be considered as one more among others, but a key one for the preservation of the EU *way of life*.

Therefore, if R&D is the solution, then we need more researchers, because researchers are those that make R&D possible. This is why the European Commission explicitly demanded and quantified the need for more research personnel and researchers in 2003.

> *'Increased investment in research will raise the demand for researchers: about 1.2 million additional research personnel, including 700 000 additional researchers, are deemed necessary to attain the objective'* (COM 2003, 2).

Since these ideas are well known, and also based on well-known research, in my paper I will not try to demonstrate their relevance again. I would like to clarify some important issues from the policy point of view that are expressed in these two statements. I will focus my analysis on the need for *researchers* rather than on the need for other research personnel, but some of the questions can also be applied to the latter.

2. The demand

2.1 The unbalance between supply and demand

The first point to be clarified is what is meant by *additional researchers are deemed necessary*. It obvious that, if *researchers are deemed necessary*, this is because there is a wrong balance between supply and demand. There could be two factors that

may explain this unbalance: a lack of supply and a lack demand. So there are at least two different causes leading to two different policy strategies to solve this problem.

The first strategy is that the higher educational system has to provide trained researchers in the labour market. In this case, we assume that there is clear need of researchers that should be fulfilled by the educational system. The universities should then increase the number of available researchers by increasing the number of research training programmes. The problem here is with the *supply* of new researchers.

The second strategy is that the productive system should grow towards a more innovative profile and should demand more researchers to fulfilled its needs. Then, the productive sector should increase the number of R&D jobs. The problem here is with the *demand* for new researchers. Although both explanations are possible and not incompatible, the policy consequences are quite different.

On the one hand, if we need to increase the number of research training positions, policy actions should encourage an increase in the resources that universities devote to research training programmes. On the other hand, if we need to increase the number of jobs in R&D, policy actions should encourage an increase in R&D activities in the productive sector. This means that both the funding programmes and the recipient institutions are also different. There is no doubt about the need to combine these two policy strategies.

It is important to realise that, although the two strategies are intimately interconnected, the connexion is not bidirectional. It makes no sense to allocate new funds in EU universities to train a large number of highly qualified personnel in research it there is no clear evidence that they are not needed by the EU labour market, even if they could find a job in R&D outside the EU. Let us remember that the EU wants to avoid the *serious threat to EU's innovative strength, knowledge capacity and productivity growth in the near future*. As a result, before training more new researcher there should be evidence that the EU productive system demands more researchers.

Another possible scenario is that there may be demand for researchers by the EU labour market without EU universities providing such qualified personnel. Of course, it would be possible to attack new researchers from outside the EU to solve this problem with a non-satisfy demand. However, this strategy would not be satisfactory for the EU in the long run, as seems obvious.

No matter how connected these two strategies may be, it is important to establish what the EU priorities are in order to make public resources as efficient as possible. From my analysis I would like to conclude that the EU policy priority should be to increase the *demand*.

2.2 Which fields of research?

Once it is clear that more researchers should be demanded by the productive sector, it is necessary to specify what type of *researcher* would help to increase productivity in the EU. There is not a problem with definitions, since there are some that can be used. For example, the main manual for the OECD R&D statistics, the Frascati Manual, defines researchers as *"professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management of the projects concerned"* (OECD, 2002).

As this suggest, there seems to be consensus about what a researcher is. The problem is that the concepts of *researcher* and *scientist* are used as synonymous in policy documents many times while they are not. I do not want to enter the debate about what *science* is, because it is not necessary here. Nevertheless we need indicators about sciences and research for the definition and evaluation of policy goals. Indicators require operational definitions that do not allow for ambigui-

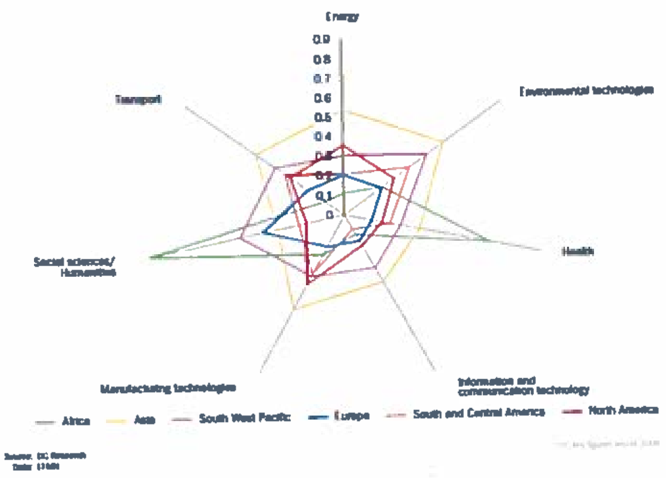
ties. From a statistical point of view, *Social Sciences* are not in the same group as *Science*, and *Arts & Humanities* are considered a different group. All of them are considered *research*, but not all of them are considered *science*. For instance, Eurostat has two different groups of indicators about human resources, one in *Science and Technology* and another in *Research and Development*. The second one is broader and includes the first group.

As a consequence, each document should clarify what kind of researcher is being demanded. Some questions to be answered are the following: 1 *which types of researchers are needed when we set up the goal of 700.000 additional researchers in the EU?* 2 *What field of research will increase the competiveness of the EU economy?* As seems obvious, this goal does not apply to all fields to the same extent. For instance, developments in nanotechnologies, biochemistry, history and anthropology will have different degrees of impact on the competiveness of the EU economy.

Thus, it would be helpful to clarify what fields are more relevant to reach the set goal. It seems clear that, for the improvement of economic productivity, the EU is demanding researchers in Science and Technology rather than researchers in Arts and Humanities. If so, explicit statements would be necessary to improve the social perception of the efficiency of R&D financial programmes.

Figure below shows the relative importance of the different fields in relation to other fields and other world regions. Interestingly, the EU is clear given priority to the Social Sciences and Humanities in comparison with such regions as North America. This should make the EU think about the consequences of such priorities in the long term.

S&T priorities of world regions as expressed in national foresight exercise



2.3 Public versus private sector

Another question to be answered is where those R&D new jobs should be offered in order to reach the goal of improving productivity: in the public or the private sector?

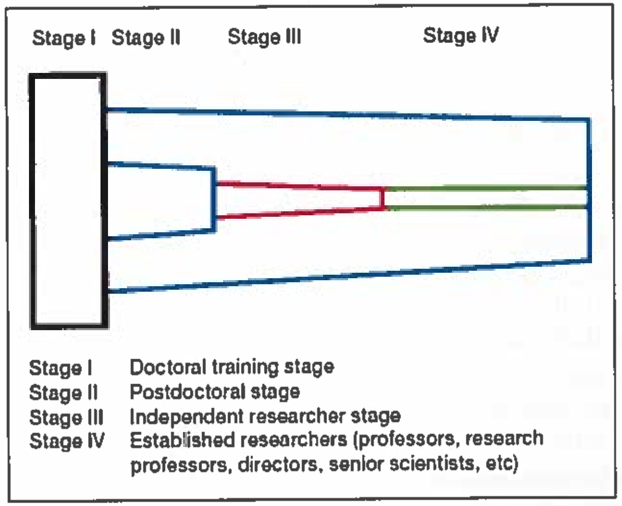
The distribution of researchers shows that in the EU there are more researchers in the public sector than in other world regions as EEUU or China. It is clear that the EU R&D private sector should increase in almost all the areas, not only in human resources. Therefore, the analyses and the policy plans in EU should be oriented to finding ways to develop R&D activities in the private sector.

However, it seems that most of the analyses of how to improve the research career are focused on the public sector. In the public sector, the improvement of the research career has many issues in common with *human resources management: salary, promotions, etc.* But in the private sector, what needs to be done

is to create conditions for increasing and improving R&D activities. This would result in more and better the research jobs in the private sector with higher salaries and better opportunities of promotion.

An example of this *public sector orientation* is the document by the European Foundation, *Research Careers in Europe Landscape and Horizons* (ESF, 2009). For instance, the stages of a *scientific career* proposed in this document have an *academic flavour,* as is shown in figure below.

Schematic presentation of a four-stage researcher career



This academic orientation might only be a consequence of a lack of knowledge about the non-academic career, as is pointed out in the report.

> *Knowledge about the career paths of researchers in non-academic R&D professions is still very limited. It will therefore be an important next step to identify appropriate partners from the private sector who could help to complete the picture of research career destinations and to identify good practice examples for intersectoral mobility* (ESF, 2009).

But this lack of knowledge should not lead us to extrapolate what we know about research career in the academic and public sector to the non-academic and private sector. Both sectors are so different in goals and human resources management that significant mistakes can be made similar solutions for such different problems are implemented.

In summary, it seems that the EU has to make an important effort to improve R&D in the private sector, but there is not enough knowledge about what a research career means in that sector. As a consequence, there is a risk of concentrating policy actions in the development and support of what the EU knows (public-academic) rather than of what the EU needs (private-non academic).

2.4 The doctoral training

We have concluded that the EU needs researchers and that it has an idea of what type of researchers are needed. Now the question is *what is the best way to train them?*

As I have pointed out above, I am drawing on a very broad definition of researcher (Frascati, 2002), to be sure that every type of researcher is included within this definition. But it is also true that different types of researchers are likely to need different models of training. Nevertheless, we focus most of our analyses on the doctoral profile, as if this were the only way to provide research training.

Two questions arise from this approach:

- Are EU doctoral programmes developing the profile of researchers the EU needs or are they too oriented to fulfilling academic needs?
- Is it possible to think of different profiles of researchers and, as a consequence, new alternatives to the traditional doctoral training programmes?

My answers to these questions is that EU doctoral programmes are too oriented to meeting academic needs and that it is possible to think of different orientations. New initiatives to modify traditional doctoral training have been developed and most of them are oriented to non-academic profiles. In all the cases the modifications are designed towards a more professional profile.

These new models tend to be criticized within the academia because there is a lack of academic profile, but this is exactly the objective of these new training models. There is no doubt that while the environment where researchers have to develop their careers has change tremendously in the last few decades, there has been no change in the traditional doctoral training programmes. This is a good indicator of the lack of adaptation of these programs to the needs of society.

In conclusion, new models of research training should arise to fulfil the need for research jobs that should be seen in the next future. The doctoral model is the traditional one for traditional jobs, but new ideas should emerge to provide the kind of training that a knowledge-based society and economy need.

3. The supply

Even if there is a great demand for researches in the private sector for a defined group of scientific disciplines within a well-defined research career and innovative research training programmes, there should be enough persons to meet this demand: there should be enough supply of persons that want to become researchers. Many analysts highlight a lack of scientific vocations. If this were the case, it would not just be a labour market problem. It would also be a problem with the entire educational system: from primary school to higher education. It seems that, for some reasons, people do not want to learn science or technology. Various questions arise this point:

(1) is there a real problem about scientific vocations? (2) Why? (3) What would be the consequences of this lack of vocations in EU? Answers to these questions will help to clear the way to finding the solutions.

3.1 The rise in scientific vocation

When does children's interest in science and technology start? There is a lot of evidence supporting the idea that this interest arises in the first school years. Some psychological research concludes that children are good researchers, even when they are 14 months old (Gopnik, 2009). Children have some of the basic skills that good researchers needs: capacity to find problems, curiosity, observation, experimentation and simulation. Furthermore, Gopnik concludes that children learn in the same way as scientists do.

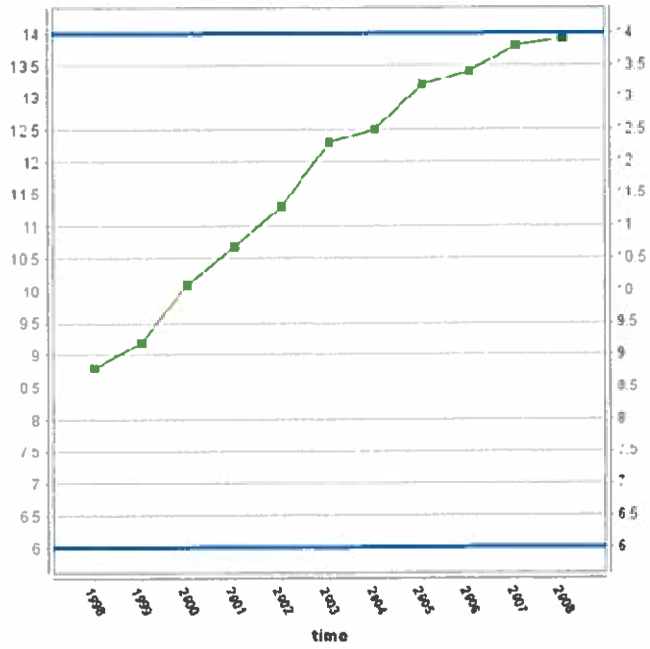
When children start school, this provides them with a few more basic scientific skills, such as the capacity to follow a method and knowledge about different fields. But school takes most of their time to teach them basic knowledge: reading, writing, maths, history, biology, ..To simplify, children have the basic skills a researcher needs and the school provides them with a formal path for learning basic knowledge and formal procedures. The risk is spending not enough time to develop those basic research skills and hiding how fascinating research activity is behind a huge amount of sometimes boring knowledge. This is an important risk because it is more difficult to motivate children toward research than to make them loose their motivation.

In addition, there are many other prejudices and social models that make it difficult to provide an attractive framework for research activities. Society provides children and young people with models of successful and fun professionals. Unfortunately, the most successful models, at least in terms of media dissemination, do not typically include researchers, scientists, academics or inventors. Success models are usually football players, pop singers, fashion models, actors, actresses, etc. There is no doubt that *researcher* is not on the list of the top 10 professions that teenagers dream about.

If those children stay in the educational system, in their path to jump towards Higher Education (HE), at the age of 17 or 18, depending on the country, they have to decide what they want to be (or to study) in combination with what they can be (or study), depending on their grades. At that moment, it is clear for them that studying science and technology will be more demanding due to the type of knowledge and skills they will need to acquire.

Considering all these ideas, students eventually decide what HE programmes to study. Those that choose scientific or technological careers are thought to have a *scientific vocation*. After a few years in HE, they graduate. If there were a crisis of scientific vocations, the number of graduates in HE programmes should have gone down. But, as can be inferred from the figure below, there does not seem to be a global crisis of scientific vocations since the number of S&T graduates in the EU-27 has increased in the last ten years.

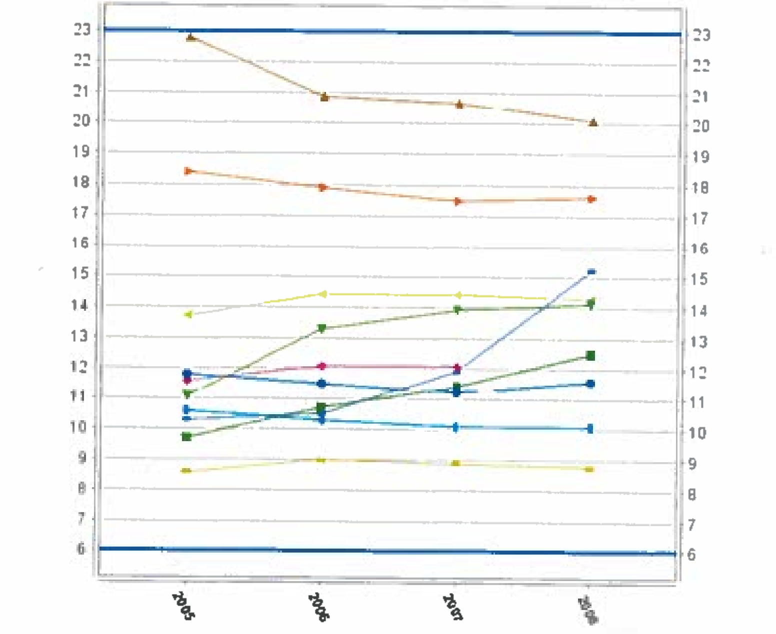
Tertiary graduates in science and technology per 1 000 of population aged 20-29 years



Source:Eurostat

But a careful look at the data by country shows a different picture. As can be seen in figure below in some of the most important countries, in terms of population an economy, such as the UK, France, Italy, Spain or The Netherlands, the value of this indicator has decreased. By contrast, other also important countries show a more positive tendency. This is the case of Germany and Poland. The evolution of this indicator is also negative in another two reference countries: Japan and the USA.

Tertiary graduates in science and technology per 1 000 of population aged 20-29 years



Source:Eurostat

In conclusion, there seems to be a global increase in *scientific vocations*, but there is a concern about those countries that have seen a reduction in the number of graduates in Science and Technology. Not only are those countries key for the development of the EU economy but they also have some of the best research training programmes in the EU. It would be very important to analyse the reasons for this reduction, although there should not be a great problem since, as is well known, the new research jobs will be occupied by scientists and technologists from countries outside the EU in the next few years. The measures to solve this problem will be effective only in the long term. Meanwhile, new solutions should be implemented.

3.2 The scientific country profile

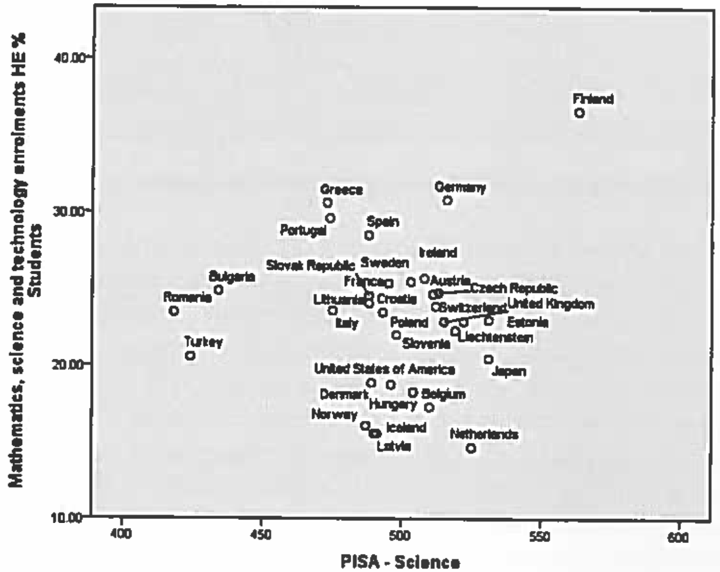
As we have seen, countries have different profile in the number of graduates in scientist and technologist. A combination of multiple variables should explain this behaviour. However, I will show the results from analysing a small number of educational indicators. I looked for indicators about skills, results and professional orientation towards science (in the broadest sense) in three different age groups. The objective was to obtain a global picture of a country rather than doing a longitudinal or a cohort analysis of its evolution. The three indicators used are the following:

- The results at *science* in the OECD evaluation project, known as PISA (see OECD, 1999 and 2000 for more details). This indicator provides information about 15 year-old students.
- The rate of enrolment in science and technology programmes in HE. This indicator provides information about 17-18 year-old students.
- The number of tertiary graduates in mathematics, science and technology. This indicator provides information about the 20-29 year-old graduates.

In, the hypothesis tested was as follows: *if a country has 15 year-old students with good skills in science, there will be more HE students enrolled in mathematics, science and technology programmes in HE*. However, as can be seen, there is no a clear correlation between these two variables.

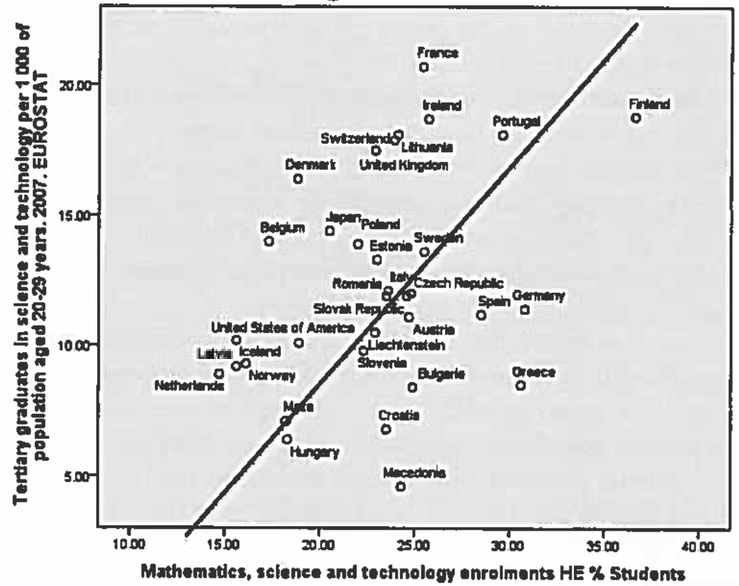
Nevertheless, it can be seen that no country is in the top left hand corner. This means that if a country obtains bad results at the PISA (science) evaluation a high percentage of enrolments in Mathematics, Science or Technology (MST) in HE should not be expected. On the contrary, if a country obtains good results at PISA (science) evaluation, enrolments in MST in HE could be high or low. Thus, other variables should explain this variation. All of this means that although students with bad skills in science are unlikely to enrol in MST Higher Education Programmes, students with good skills in science will not necessary enrol in MST HE programmes.

Graph 1. Relation between the results in science at PISA and the % of enrolments in HE.



In Graph 2, the tested hypothesis was as follows: *the more students enrol in mathematics, science and technology HE programmes, the more tertiary graduates there will be in science and technology*. Although this hypothesis seems rather obvious, the results do not provide evidence to support it. It is interesting to note that most of the differences among countries can be explained by the dropout rate. The top left hand corner in this graph would contain the best fit between enrolments and graduates, but no cases are obtained. Hence, there should be other variables explaining why once students enrol a MST program in HE they do not manage to graduate. If so, the *lack of scientific vocations* may be more related to the success or failure of the HE program than to student real vocation. A careful analysis of dropout rates in MST Higher Education programmes should be done to see the extent to which possible failures may explain a decrease in the number of science and technology graduates in some countries.

Graph 2. Relation between the % of enrolments in HE and the graduates.



Finally, I took one step further. This time, I looked for an indicator of the *presence of science* in society. This fourth indicator consisted in the results obtained by each country in the Shanghai ranking of universities (ARWU, 2010). The reason why I chose it is that, as is well known, the Shanghai ranking provides a picture of the quality of universities with a great bias towards the quality of research in each institution. In this case, I did a cluster analysis. It is not easy to perform a detailed analysis of the dendrogram, and it is also difficult to infer the causes and implications of what can be seen. However, in this case, some *familiar* groups of countries seem to arise. By *familiar* I mean that these groupings arise in other types of economic, social, or even geographical analyses.

The first group, at the top, comprises the UK, Ireland, Germany, Austria, France, Denmark and Sweden. Another group is made up of Hungary, Poland, the Czech Republic and Slovenia. Another group contains Greece, Portugal, Spain and Italy (also including USA and Norway). And Finland is the only member of its group (probably due to its very good results in the PISA indicator).

As I mentioned, clear conclusions cannot be drawn from this analysis, but at least we can draw a very general one. When we put together very different indicators about science and technology various groups of countries arise. These groupings coincide with those obtained in other different types of analyses. Some of these groups are known as *south of Europe, central Europe, ex-soviet republics*, etc. As a conclusion, although it is impossible to find a small group of variables for describing to what extent a country is *scientifically oriented*, there seem to be latent variables that could explain certain *attitudes of the countries towards science and technology*. There does not seems to be a general problem with *scientific vocations* at the level of individual attitudes in the EU, but there are educational, cultural, social or economic variables that could explain some of the identified problems in some countries.

3.3 The final graduate satisfaction

Finally, I would like to point out that five years after HE graduation, there are not significant differences in the degree of satisfaction with a given study programme or institution between graduates in science and technology and those in other fields. These data have been taken from the REFLEX database (see link below for more information), which contains answers from a survey to graduates in 14 European countries. In general it may be said that, once students get their degree, they are satisfied with what they have studied and are ready to find a job in their own field. Therefore, their *vocation* remains.

Table 1. Satisfaction with the graduation programme

Would you choose same study programme at same institute * Field of graduation programme Crosstabulation

			Field of graduation programme: Other	Field of graduation programme: Science and technology	Total
Would you choose same study programme at same institute	Yes	Count	9883	7448	17331
		% within Field of graduation programme	62.1%	63.2%	62.5%
	No, a different study programme at the same institute	Count	2046	1302	3348
		% within Field of graduation programme	12.8%	11.0%	12.1%
	No, the same study programme at a different institute	Count	1329	965	2294
		% within Field of graduation programme	8.3%	8.2%	8.3%
	No, a different study programme at a different institute	Count	2185	1752	3937
		% within Field of graduation programme	13.7%	14.9%	14.2%
	No, I would decide not to study at all	Count	481	321	802
		% within Field of graduation programme	3.0%	2.7%	2.9%
Total		Count	15924	11788	27712
		% within Field of graduation programme	100.0%	100.0%	100.0%

Source: REFLEX database

4. Conclusion

The EU needs a stronger R&D sector to assure the competiveness of its economy in the next future. There is a policy goal of increasing the number of researcher, but, as my analysis has suggested, the policy priority should be to increase the *demand* by the private sector of the economy. Besides, it would be necessary to specify which fields of research would be essential to overcome the current unfavourable context. Although, there is a global rise in *scientific vocations* in the EU, there should be a greater concern about those countries that have seen their number of graduates in Science and Technology reduced in the last decade, because those countries are key for the development of the EU. Analysing the causes of this reduction would be essential. Whatever measures are taken, they should be oriented not so much to changing individual attitudes but to introducing reforms and action plans in the areas of education, society and economy.

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