

7. Is it possible to measure scientific creativity? Some first elements of reflection

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Abstract

This article elaborates on whether it is possible to measure scientific creativity. It is based on the assumption that the scientific process embeds an element of creativity. Which analogies can be drawn comparing creativity in science with creativity in a broader sense? What is purely qualitative and what is possible to quantify? What is the role of demand in scientific creativity? Is it possible to measure which input would generate optimal creative output? How could we measure the optimal framework conditions for the creative process in science? Given this new field of reflection, this article does not give definitive responses but only food for further development of indicators and for different interpretation of already existing data. Empirical data are largely taken from the European Commission, DG Research work on the Science, Technology and Competitiveness key figures report 2008/2009 as well as ad hoc studies.

Introduction

The Research Directorate General (DG Research) is in charged of coordinating the efforts to develop a European Research Area, its mission consists on developing the

¹ Disclaimer: The views expressed are purely those of the writer and may not in any circumstances be regarded as stating an official position of the European Commission.

European Union's policy in the field of research and technological development and thereby contribute to the international competitiveness of European industry. In addition, DG Research coordinates European research activities with those carried out at the level of the Member States; it provides support to the Union's policies in other fields and aims at providing a better understanding of the role of science in modern societies and stimulates a public debate about research-related issues at European level.

To this end, DG Research produces, among others, a major publication every year on Science, Technology and Competitiveness (Research Directorate General 2009). In addition, DG Research is in charge of ERAWATCH that provides information on European, national and regional research policies, actors, and programmes in the EU and beyond. Currently ERAWATCH covers 43 countries in total: 27 EU Member States, countries associated with the European Community's Research Framework Programme and main trading partners of the EU.

There are, thus, a number of initiatives initiated by DG Research that provide a vast amount of information and indicators in research, science and technology that could have potential use for measurement creativity at aggregate levels. However, creativity itself has not been a specific area of coverage for DG research in terms of developing indicators.

This paper presents some first elements of reflection about creativity in relation to indicators that have been used or are being developed in science and technology.

Measurable components

It is clear that we do not have adequate measures of creativity. As the title of this monograph shows, it is still an open question if creativity can or not be measured. From our point of view, creativity is a black box that we cannot look into. We need, therefore, to define proxies for creativity. That is to say, we have to look for its measurable components. It seems clear, however, that the scientific process embeds an element of creativity, and, thus, science and technology indicators might provide useful insights into the measurement of creativity.

In this way, it is possible to see creativity in relation to the cycle Input, Framework conditions, Output (see figure 1). In the case of scientific creativity, the indicators that are used for the monitoring progress towards creating a European Research Area can serve as a point of departure. Input indicators refer to both quantity and quality of human and financial resources. It is important to note that in addition to quantitative measures of input we need measures that can tell us something about the quality of

the input. Combining, both quality and quantity indicators, we will be able to have a better picture of the effectiveness of the research cycle.

Framework conditions refer to the aspects in the systems that are in place to foster scientific creativity. There are several aspects that could be interesting and that, potentially, could influence the appearance of scientific creativity. In here I will propose two areas of indicators: diversity of perspectives and the balance stimulus-security in research activities. Finally, output measures refer to the results of the scientific process. In here there are two aspects that we believe are crucial to look at, and that are related to the use-reuse of scientific creativity: Quality assurance and Open access to research results.

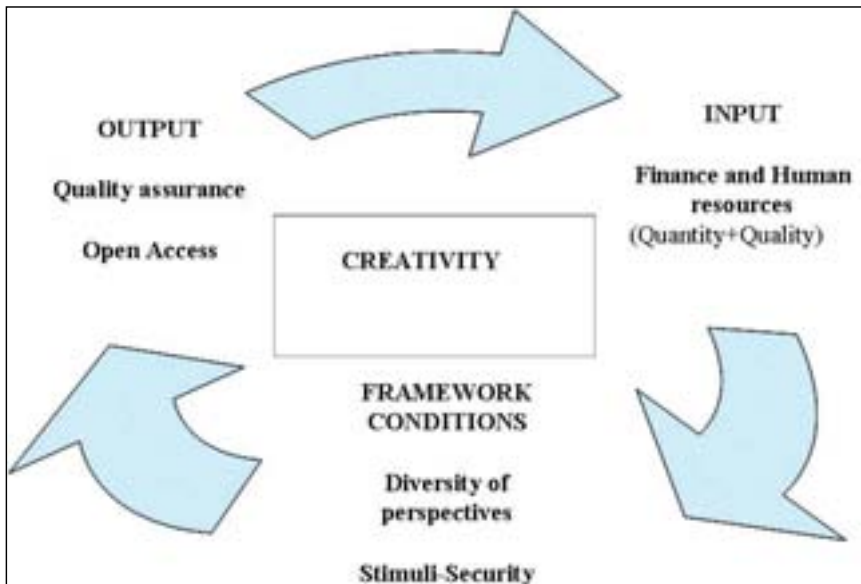


Figure 1: An illustration of some measurable aspects

These different components would have to be looked in a comprehensive manner. It will be necessary to understand how the three parts of the model relate to each other. In this way, it would be possible to identify the relationship between input and output and the mediating effect of framework conditions, which would allow us to understand one specific dimension of the efficiency of the research investment. The three components (input-framework conditions-output) compound a circle, where research outputs constitute, in fact, new research inputs.

The present article outlines some examples of the framework presented in figure 1. It provides some examples of indicators and show figures related to some of them,

taken mainly from the European Commission, DG Research work on the Science, Technology and Competitiveness key figures report 2008/2009.

Input measures

It is possible to find indicators which provide us with information on the potential input to creativity, at least for specific professional areas. For quite some time now, one of the most common indicators referring to input measures into research is the R&D intensity, measured as the Gross Domestic Expenditure on R&D (GERD) as a percentage of the GDP. Figure 2 shows this indicator for 2007. This indicator points at financial resources which are necessary but not sufficient to enhance research-based creativity in Europe.

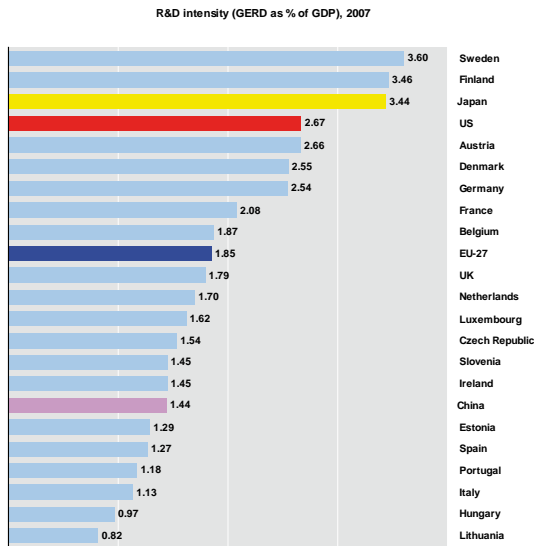


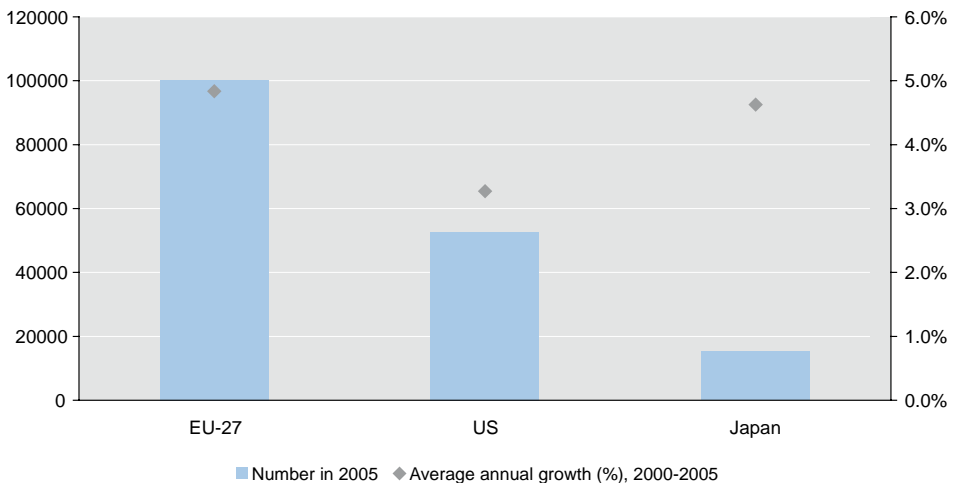
Figure 2: R&D Intensity

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

Creativity is always embodied in people, in this case researchers. Therefore, another relevant indicator for inputs, related to human resources, is the number of doctoral graduates. Figure 3 shows this indicator for 2005 and the average annual growth from 2000-2005. It seems that in terms of graduates, the EU is as prepared, at least, as the US or Japan.

However, these indicators tell us little on the quality of the financial and human resource inputs in terms of creativity. We need to develop better indicators to assess quality. But quality can, in many instances, only be assessed in an ad-hoc manner, af-

ter scientific results are provided, thus, the need of understanding the framework in a circular manner, where output indicators relate to input indicators.



Source: DG Research
Data: Eurostat

Key Figures 2008

Figure 3: Number of doctoral graduates in 2005 and average annual growth 2000-2005

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

Input indicators, are thus, important but they need to be combined with other indicators. For example, we know that R&D intensity depends heavily on the sector structure of a country. In the context of measuring creativity: Which are the framework conditions under which financial and human resources are more likely to form part of a creative activity?

Framework Condition

Under this heading, it should be possible to establish a number of indicators that provide information on the conditions where research as creative activity is taking place. One avenue could be to explore the “diversity of perspectives” in science. Diversity may be associated with more creative potential. A system that welcomes different points of views, allows for researchers to have exposure to other points of views, and is a source for new ideas, will most likely be more creative. Creativity in science, as in other domains, is also fertilised by cross-cutting boundaries and multi-disciplinary approaches (see Chapter XX in this volume).

Measuring diversity is not an easy task. From the S&T indicators, one possible interesting indicator would be the proportion of female researchers, since this provides a picture of the diversity of the system in terms of gender.

The number of doctoral candidates with citizenship of another Member State could be another of the indicators showing diversity of perspectives. Attractiveness and openness of the European Universities, in this case, plays a crucial role. Also in terms of diversity and connectivity of research universities, it would be possible to use the web-based hyperlinks between universities as a proxy of diversity of information-based perspectives. This indicator would show how much universities are connected with other universities, at least from a theoretical point of view (see figure 4). Other indicators on this direction, showing the connection between business and universities could provide additional information on diversity of perspectives.

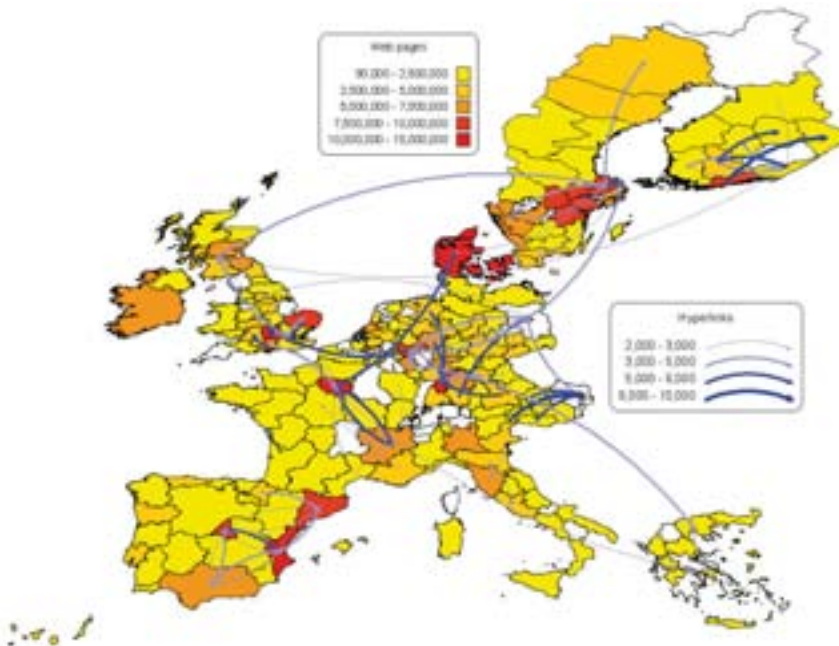


Figure 4: web-based hyperlinks between universities in EU 15

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

Another aspect of the framework conditions is the extent to which the system provides a balance between stimuli and security for research-based creativity. Figure 5 shows the different funding models for universities in the Member States. It shows the structure of different financing schemes.

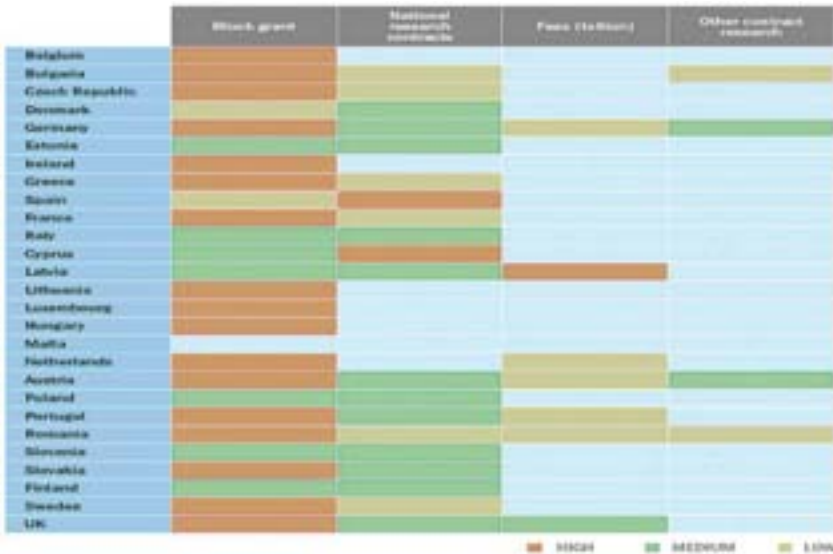


Figure 5: Funding models for universities

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

From the perspective of creativity, a right balance between external stimuli and internal security contributes to the creative process. In the field of research, external stimuli can among other aspects be enhanced by the attention to competitive funding, to outlook in society-responsive thinking; internal security and stability in time is just as important for creativity, enhanced by institutional funding and long term free-mind research.

Output

The measurement of scientific output is more and more an important area for research. As indicated above, the output is one way in which we can assess the quality of a scientific production. One of the indicators that is used, and that could be related to scientific creative outputs is the "citation impact".

Figure 6 shows the most active research universities by country from 1997-2004. This can provide a general picture of how much research from specific universities in each country is cited in scientific journals. From the perspective of creativity, an article is cited, among other reasons, because it represents a step forward, a result of a creative process.

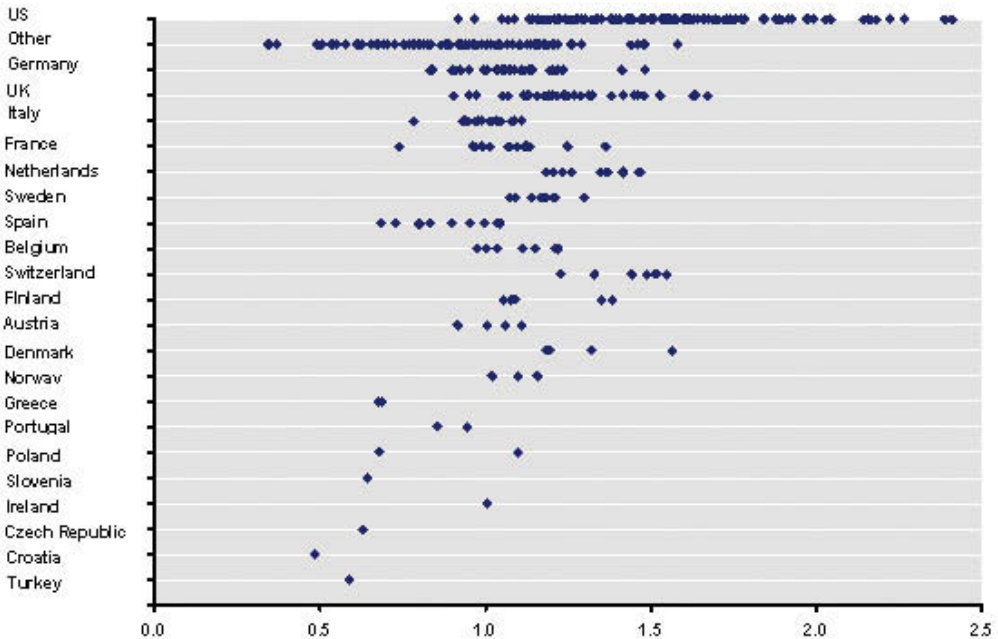


Figure 6: The most active research universities – normalised citation impact by country, 1997-2004

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

Finally, in finding information referring to the connection between scientific output and input, it might be interesting explore data related to “open access to research results”. Figure 7 shows the worldwide open access repositories, where almost half of the repositories belong to the EU 27. This is an area to explore, since there is an increasing number of research outcomes that are more and more available for other researchers to use. Creativity based on knowledge is in part self-generating: knowledge triggers creative processes that may result in new knowledge, given appropriate input in financial and human resources as well as optimal framework conditions for creativity.

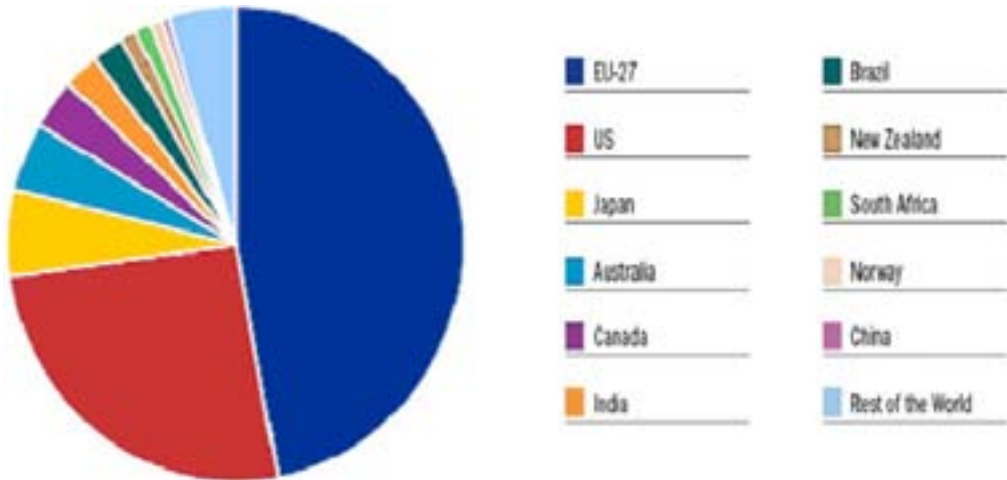


Figure 7: Worldwide open access repositories

SOURCE: Science, Technology and Competitiveness key figures report 2008/2009

Conclusion

It is very difficult both conceptually and empirically to quantify scientific creativity in itself. However, we do dispose of some indicators that could contribute to our understanding and we could imagine a framework measuring the conditions that stimulate creativity. This article has provided a brief, general overview and some specific example of possible data that could be used. Measuring creativity is a new field of work that will most probably expand in the years to come.

References

Research Directorate General (2009). *Science, Technology and Competitiveness key figures report 2008/2009*. Brussels: Research Directorate General.http://ec.europa.eu/invest-in-research/monitoring/statistical01_en.htm