What is wrong with the EU Science-Technology-Industry links: a note on the scientific impact of Europe[1]

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resumen

Este artículo evalúa el impacto científico de Europa. En primer lugar, revisa de forma selectiva la evidencia disponible sobre las fortalezas y debilidades europeas en materia de producción científica. A continuación compara el sistema europeo de educación superior con uno de sus principales competidores. Para concluir se sugieren algunas implicaciones con respecto a las políticas públicas.

abstract

This article assesses the scientific impact of Europe. First, it selectively reviews the evidence concerning the European strengths and weaknesses in science production. Second, it compares the European system of higher education with the one of its major competitor. To conclude, a few policy implications are suggested.

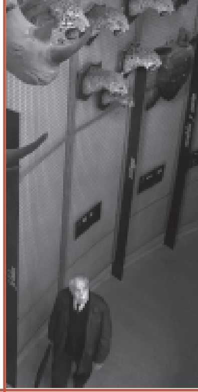
palabras clave

Política científica de la Unión Europea
Ciencia-Tecnología-Industria
Indicadores de ciencia e innovación
Universidades de la Unión Europea

keywords

European Union research policy
Science-Technology-Industry
Science and Innovation indicators
EU universities

[1] Acknowledgements: This article draws upon other works co-authored with Giovanni Dosi and PatrickLlerena —in particular Dosi et al. (2006)— to which the reader is referred for more detailed discussions.



1. Introduction

Since the beginning of the nineteens, despite some variance across countries, the economic performance of the EU original member states has been dismal. Over the last decade, as shown in Table 1, on average the annual growth of per capita GDP has been more than half percentage point lower than in the US. Although it might not seem as a big difference, in the long run small gaps end up producing large differences and EU policymakers are rightly concerned with their slow economic growth.

To propose sound policy measures, one wants first to understand what went wrong with the European economy. How can the poor performance be explained? Classical economic growth theory stresses the importance of capital accumulation and saving rates. Unfortunately, however, this approach is not very helpful here, since both the capital-labor ratio and the investment rates are still higher in Europe then in the US. On a different ground, an often mentioned explanation relies on the European failure to reform its product, service, and labor markets. As important as these reforms can be, differences in markets' regulation between the two sides of the Atlantic are not new and were already there when Europe was growing much faster than the US.

An additional and very popular interpretation of the EU-US widening gap is the one that inspired the so-called Lisbon Agenda. A version of this story can be summarized as follows: by the late 1980s Europe, after a long phase of catching up, could not rely anymore on capital accumulation and technological imitation as its principal sources of economic growth. At the same time, the Information Technology revolution was finally producing its positive effects on the US economy. Nevertheless, European countries' institutions and policies did to allow them to fully benefit from this new technological breakthrough. In other words, the same institutions and policies that did a good job in fostering economic development through catching up and imitation, were unfit to foster economic growth stemming from the complex relationship between new scientific discoveries, novel technical innovation, and their industrial exploitation.

The above explanation is plausible but incomplete. In fact, it is indisputable that Europe does not invest enough in research and development (R&D) and that its knowledge economy — however defined — is weak. Nevertheless, the R&D dismal figure is likely to be the consequence of something else, rather than an explanation. I venture that the important question here is why in Europe the science-technology-industry links have not worked properly in the last decade. One conventional answer — especially popular among Brussels' bureaucrats and policy makers — is that Europe plays a leading worldwide role in terms of top- level scientific output, but lags behind in the ability of converting this strength into wealth-generating innovations (EC, 1995). Elsewhere, together with Giovanni Dosi and Patrick Llerena, I critically reviewed this hypothesis, known as the 'European paradox' (Dosi et al., 2006). We concluded that the existing pieces of evidence do not support the 'paradox' conjecture; conversely, what a number of indicators do show is that European weaknesses reside both in the European system of scientific research and in a relatively weak industry.

Table 1. Real GDP growth rate - percentage change on previous year

	1998	1999	2000	2001	2002	2003	2004	2005	2006
EU - 15	2.9	3.0	3.8	1.9	1.1	1.2	2.3	1.6	2.8
Euro area	2.8	3.0	3.8	1.9	0.9	0.8	2.0	1.5	2.8
United States	4.2	4.4	3.7	0.8	1.6	2.5	3.6	3.1	2.9

Source : Eurostat.

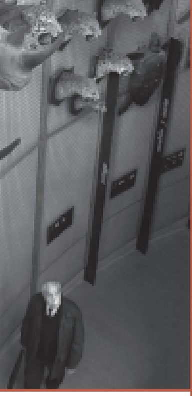
The present essay concentrates on the scientific impact of Europe and it, first, selectively reviews the evidence concerning the European strengths and weaknesses and, second, suggests a few policy implications.

2. The myth of the European leadership in science

A central part of the notion that Europe's major weakness stems from its difficulties in transforming the findings of its excellent research system into innovations and competitive advantages concerns the width, depth and originality of European Science.

The stage was set by the 1995 EU Green Paper on Innovation that measured the scientific impact of Europe using the number of publications per euro spent in non-business enterprise R&D as the main indicator (EC, 1995). Such number was slightly higher in Europe and relying on this evidence the document concluded that "[c]ompared with the scientific performance of its principal competitors, that of the EU is excellent" (EC, 1995, p.5). More recently, advocates of the paradox notion have emphasized that Europe has overtaken the US in the total number of published research papers during the second half of the nineties (EC, 2003).

The above measures are largely inaccurate and do not take into account that only a small number of total publications has an effect on the advancement of knowledge. This is suggested by the fact that solely a few articles are cited, while the overwhelming majority receives zero citations. In science, what really matter are the



originality and the impact of scientific output upon the relevant research communities. Two among the most used proxies of such an impact are articles[2] citations and the shares in the top 1% most cited publications. As shown in Table 2, once one controls for population, the US is well ahead with respect to both indicators. In particular, the outstanding EU scientific output is still less than half than the US one.

In the second and third column of the same table, numbers of publications, citations, and top 1% publications are decomposed into two components: a measure of university researchers productivity (i.e. output per university researcher) and a ratio of university researchers to population.1 The table clearly shows that US leadership is due to the quality of research published rather than to the sheer number of university researchers.

Table 2. Publications and Citations weighted by Population and University Researchers

	Publications / Population	=	Publications / Researchers	x	Researchers / Population
US	4.64		6.80		0.68
EU-15	3.60		4.30		0.84

	Citations / Population	=	Citations / Researchers	x	Researchers / Population
US	39.75		58.33		0.68
EU-15	23.03		27.52		0.84

	Top1%publication / Population	=	Top1%publications / Researchers	x	Researchers / Population
US	0.09		0.13		0.68
EU-15	0.04		0.04		0.84

Notes : Our calculations based on numbers reported by King (2004) and OECD (2004). Number of publications, citations and top 1% publications refers to 1997-2001. Population (measured in thousands) and number of university researchers (measured in full time equivalent) refer to 1999.

The unsatisfactory state of European Science is confirmed by the data on the highly cited researchers (HCRs), recently made freely available by Thomson Scientific and analyzed by Bauwens at al. (2007). More specifically, Thomson identifies those researchers whose collected publications have received the highest number of citations across the past two decades in 21 scientific disciplines. Their names, affiliations and countries of residence are freely available on-line[3]. Of the 5,790 researchers identified, 3,829 (about 66%) are currently affiliated to a US institution and only 1,177 (about 20%) in an EU15 one. Of course, as shown in Table 3, one observes large disparities within European countries. For example, Switzerland — that incidentally is not a EU member — ranks remarkably well and, once the total number of his HCRs is normalized for inhabitants, its scientific impact is similar to the US one. On the other hand, overall European performance is extremely poor. In particular, Germany, France and Italy have a normalized number of HCRs which is less than one fifth of the one of the US.

Table 3. Highly cited researchers (HCRs)

	Number of HCRs	HCRs per million inhabitants
United States	3,829	16.82
Switzerland	103	16.28
EU 15	1,177	3.01
United Kingdom	439	7.79
Sweden	59	7.09
Netherland	92	6.50
Belgium	35	3.55
Germany	240	3.12
France	155	2.88
Italy	72	1.28

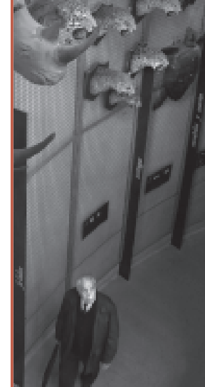
Source : Bauwens at al. (2007).

Of course, there is a substantial inter-disciplinary variation in the revealed quality of European research. Nevertheless, applying different classifications of scientific disciplines, one gets different results. According to King (2004), US superiority is remarkable in life and medical sciences, while Europe performs slightly better in physical sciences and engineering. However, if one adopts ISI narrower classification, a less diversified picture emerge from data on HCRs[4]. First, as shown in Table 4, the European leadership in physical sciences and engineering found by King (2004) vanishes. Second, the only field in which EU17 has an higher research impact is Pharmacology. Third, Chemistry and Physics are the only important disciplines where the US number of HCRs is not more than double. Finally, note the very poor EU performance in Economics and Social Sciences. Bauwens at

[2] The figure relies on the assumption of equal research production of non academia researchers.

[3] See www.ISIHighlyCited.com

[4] Data on HCRS are also likely to reflect a smaller number of research output with respect to the top 1% cited articles and overall citations.



al. (2007) observe that this is probably due to the use of English as lingua franca.

The general message stemming from the above pieces of evidence is therefore far from suggesting any European leadership. On the contrary, one observes a structural lag in top level research output. This basic fact suggests that one of the likely causes of the dismal performance of the so-called "science, technology, innovation and growth systems" is precisely the weak European scientific impact.

Table 4. HCRs in EU17 and US by fields: numbers and ratio

Discipline	*US*	*EU17*	*Ratio*
Pharmacology	93	121	0.77
Agricultural Sciences	113	84	1.35
Plant and Animal Science	147	100	1.47
Chemistry	143	72	1.99
Physics	148	74	2.00
Microbiology	159	71	2.24
Immunology	201	81	2.48
Neuroscience	182	73	2.49
Ecology-Environment	192	73	2.63
Space Sciences	206	74	2.78
Mathematics	221	75	2.95
Molecular Biology and Genetics	197	63	3.13
Geosciences	219	70	3.13
Materials Science	159	50	3.18
Biology and Biochemistry	138	40	3.45
Engineering	138	32	4.31
Clinical Medicine	161	36	4.47
Computer Science	226	45	5.02
Psychology-Psychiatry	228	23	9.91
Economics-Business	263	24	10.96
Social Sciences	295	11	26.82

Source : Bauwens at al. (2007) and my elaboration.

3. EU universities in comparative perspective

European research universities are the obvious candidate for explaining the EU weaknesses in scientific productivity. To be sure, comparing the European system of higher education with the ones of its major competitors is a difficult task for a number of reasons. First, notwithstanding the recent attempts to converge towards a common model, European countries still have different and idiosyncratic academic institutions. Second, reliable cross-country indicators are surprisingly scarce, even for industrial economies. Nevertheless, important insights can be found in the huge case study literature together with few quantitative indicators.

To begin with, although research universities emerged for the first time in the mid 19th century Prussia — with the so-called Humbolt model —, universities seem to occupy a less significant position among research producers in today's Europe. For instance, German basic research is mainly concentrated in the Max Plank institutes, as suggested by the fact that — as a whole — they are the only continental Europe institutions that stand among the top 25 research producers, as measured by the number of HCRs (Bauwens at al., 2007). Similarly, in France public non-university institutions such the CNRS (National Center for Scientific Research), the INSERM (National Institute for Health and Medical Research), and the Institute Pasteur play a central role as basic research performers. On the contrary, after the Second World War, also influenced by the Vannevar Bush (1945) report, US universities have been picked as the most appropriate institutional locus for basic research. This difference is likely to be important, given the strong complementarities between basic research and teaching activities.

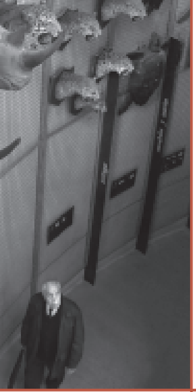
Second, data on enrolment reveal that, since the beginning of the twentieth century, the EU higher education institutions have constantly absorbed smaller shares of the relevant cohorts of population than the US ones. For instance, European universities enrollment exceeded 10% only in the sixties, when US rates by the same time were reaching 50% (Burn et al., 1971). Of course, this partly stems from a sharp US distinction between research-cum-graduate teaching universities, undergraduate liberal art colleges, and technical colleges. Conversely, Europe (especially Continental Europe) offers in most universities a confused blend of the three. Anecdotal evidence suggests that this is neither good for research nor for mass-level training.

Third, partly related to the above, according to OECD, US outstrips EU in expenditure on tertiary education. As displayed in Table 5, in 2004 total (public and private) spending on higher education in EU19 accounted for barely 1.3 percent of GDP, against 2.9 percent in the US. This means that every year Europe spends almost two percent of GDP less than the US. The gap is similar if one observes expenditure per student, with an annual spend of $ 7,192 dollars in EU19 versus $ 19,842 in the US (OECD, 2007).

Table 5. Expenditure on tertiary education as a percentage of GDP

	Private	*Public*	*Total*
United States	1.0	1.9	2.9
EU 19 average	1.1	0.2	1.3
United Kingdom	0.8	0.3	1.1
Germany	1.0	0.1	1.1
France	1.2	0.3	1.3
Italy	0.7	0.3	0.9
Spain	0.9	0.3	1.2

Source : OECD (2007).



Fourth, university systems in most European countries are characterized by centralized control and important functions remains under the authority of national governments. This is likely to prevent US style competition that stems from greater student mobilities across states and regions. In a recent policy brief, Aghion at al. (2007) find that universities' autonomy in budgets, hiring and remuneration increases the efficiency of both public and private spending. The process of creating greater compatibility within European higher education presents a clear opportunities to achieve a common playground for European universities, but one wants to be sure that, first, competition occurs for the right reasons and, second, harmonization would not be a deceptive mask for overregulation (Mas-Colell, 2003).

Fifth, according to the Shanghai Jiao Tong University Academic Ranking of World Universities, the United States completely dominates all European countries in the Top 50 universities. Only Switzerland and the United Kingdom rival the US once one adjusts the figure for country population, while large continental Europe countries score much lower. On the other hand, performance gaps reduce as one moves from considering only top 50 institutions to consider top 500 (Aghion at al., 2007).

Finally, at a complementary level, as reported by Dosi et al. (2006), the evidence that university-industry links are stronger in the U.S. than in Europe is at least mixed: if, on the one hand, qualitative evidence on labor mobility between university and industry supports to some extent the common wisdom, data concerning industry support to higher education R&D point to the opposite direction.

4. Some policy implications

In the picture presented above, Europe shows worrying signs of weakness with respect to the production of scientific knowledge and the institutions devoted to its generation. Some straightforward implications of the above analysis are the following.

First, increase support to high quality science, through agile institutions much alike the American National Science Foundation (NSF) relying on world-class peerreview, as suggested by May (2004). In that direction the recent constitution of the European Science Council is a welcome development.

Second, invest more in higher education institutions. On average, European countries should increase funding for universities by at least 1 percentage point over the next decade to close the gap with the US. It is an open question, however, whether this increase should come from public budgets or conversely from private funding, including tuition fees. Moreover, for this effort to pay off, universities should become more autonomous, in particular with regard to their budgets, but also in hiring, course design and student selection. Together with money, what matter for the good performance of education institutions is good governance.

Third, fully acknowledge the difference within the higher education system between research-cum-graduate teaching universities and other forms of tertiary education discussed above. The well placed emphasis of the role of the first type of institutions comes often under the heading of "Humbold model" as pioneered by Germany more than a century ago. However, nowadays the practice is mostly American, while the confused bland of the functions nowadays offered in Europe — especially Continental Europe — is neither good for research nor for mass-level training.

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