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Assessing national strengths and weaknesses in research fields

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ABSTRACT

National policies aimed at fostering the effectiveness of scientific systems should be based on reliable strategic analysis identifying strengths and weaknesses at field level. Approaches and indicators thus far proposed in the literature have not been completely satisfactory, since they fail to distinguish the effect of the size of production factors from that of their quality, particularly the quality of labor. The current work proposes an innovative "input-oriented" approach, which permits: (i) estimation of national research performance in a field and comparison to that of other nations, independent of the size of their respective research staffs; and, for fields of comparable intensity of publication, (ii) identification of the strong and weak research fields within a national research system on the basis of international comparison. In reference to the second objective, the proposed approach is applied to the Italian case, through the analysis of the 2006–2010 scientific production of the Italian academic system, in the 200 research fields where bibliometric analysis is meaningful.

1. Introduction

Research activity conducted in universities and research institutions is a crucial driver for innovation, competitiveness and the socio-economic progress of nations (Adams, 1990; Griliches, 1998; Henderson, Jaffe, & Trajtenberg, 1998; Mansfield, 1995; Rosenberg & Nelson, 1994). Universities and research institutions provide the life-blood of the knowledge-based economy, through the formation of human capital, the advancement of knowledge in the different fields of science, the development of new technologies and applications, and in licensing and creation of high-tech spinoff firms (Etzkowitz, Webster, Gebhardt, & Cantisano Terra, 2000; Mansfield, 1991; Martin et al., 1996). Awareness of these roles underlies the growing numbers of convinced supporters for policies aimed at reinforcing higher education and research systems, through investments and added funding programs. Many governments have remained faithful to such strategies in spite of the budgetary effects of the global economic crisis, as seen in recent years. However the limitations on public resources, coupled with simultaneous increases in social needs, have forced governments to pay more attention to the efficiency and effectiveness of their interventions. In the research sphere this translates into more attentive and rational allocation of resources. Policy-makers ideally seek effectiveness through identification of the scientific sectors with the highest potential of socio-economic returns, and efficiency through award of competitive funding to the most productive researchers and research institutions.

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In cases where national research funds are primarily allocated through calls for proposals, it is possible to pursue both objectives at once. Effectiveness is sought through the identification of so-called strategic sectors and the division of available funds among different sectors according to degrees of priority. Efficiency is pursued through allocation of resources to the best projects in each sector. However in nations where the largest share of funding is allocated directly to the overall research institutions, with greater or lesser levels of competition, the options for strategic allocation of resources are limited and the effectiveness of interventions is jeopardized. Many nations offering direct institutional funding have thus determined to adopt national research assessment exercises,[1] and allocate resources to their institutions on the basis of the results. This approach is indeed functional for pursuing efficiency in public interventions, but not necessarily for effectiveness: regardless of any alteration in the funds awarded, the top research institutions could, in part or in whole, conduct their research in sectors of little or no strategic priority; meanwhile, the worst research institutions could be the ones dealing in sectors of highest priority.

In the formulation of the national research assessment exercises, especially those using bibliometric indicators, it is actually possible to observe choices with undesirable strategic implications. This is the case with the most recent Italian national evaluation exercise, the VQR (Research Quality Evaluation), completed in July 2013. Here the quality of the hard sciences research products submitted by institutions was evaluated by number of citations (and in some cases impact factor) standardized with respect to an international benchmark, rather than a national one. In this manner the institutions with greater concentration in research fields where Italy is a follower or late follower are penalized compared to those with a greater concentration of research in fields where Italy is at the frontier. This penalization not only appears unjust, but could in fact be counterproductive for the national system, in the case of strategic motivations for fostering catch-up research in the "follower" fields rather than the frontier research in "world-class" fields.

In any case, prior to the formulation of any policy intended to improve the effectiveness of a national research system, governments would obviously be well advised to conduct strategic analysis to identify the strong and weak research fields of their respective national systems. However the analytical methods for this task as thus far proposed in the literature present a number of limitations, and it is to this theme that the authors now direct their attention.

The next two sections of our paper provide a brief review of the literature on measuring the scientific standing of nations and an examination of the methodological shortcomings of the current approaches. Section 4 presents the methodology proposed by the current authors and the bibliometric dataset used to test it, referring to the Italian academic system. Section 5 presents the results of the analyses conducted at the aggregate level of the disciplines, and Section 6 provides a deeper investigation at the level of scientific fields. The concluding section summarizes the work, indicates potential applications for the proposed method, and offers the authors' suggestions for future directions on the theme.

2. Measuring scientific standing: literature review

Defining, measuring and comparing the "scientific standing" of institutions or nations in the different scientific fields is a difficult and challenging responsibility for scholars in the field, given the multidimensional and highly complex character of the tasks (Hauser & Zettelmeyer, 1997; Werner & Souder, 1997). For Tijssen (2003), scientific standing has a comparative character, implying "surpassing something or someone in quality", and for him the most important drivers are: (i) the creation of new scientific and technical knowledge; (ii) its transmission to user communities; (iii) the commercial exploitation of that knowledge.

In fact there is no unanimous opinion on the meaning of "research standing", much less on the relative indicators for its measure. However there is a certain agreement on the fact that standing has a strong link with "research quality" and "research impact", even though some scholars hold that impact is a part of research quality (Boaz & Ashby, 2003; OECD, 1997), the other parts being importance and accuracy of research (Martin & Irvine, 1983), while others hold that quality and impact are two different elements of research standing (Grant, Brutscher, Kirk, Butler, & Wooding, 2010).

Recent progress in techniques of bibliometric measurement has certainly provided a significant push to studies on the measurement of research standing, conducted both at the level of institutions and national systems. May (1997) provides a first definition of research standing: "For many purposes, most notably overall advance in our understanding of nature, it is total output that matters. For other purposes – for example, in producing trained people or for underpinning industrial advances – output relative to country size is more relevant". He then measured the relative international standing of 15 countries in science, medicine and engineering, by their shares of ISI-indexed publications and citations as well as by citations per unit of spending, over a 14-year period. May also calculated the comparative advantage of countries in each of 20 disciplines, by the fraction of a country's citations in a discipline relative to the world's fraction. A year later, Adams (1998) presented a study sponsored by the Higher Education Funding Council of England, aimed at identifying England's relative strengths and weaknesses in performance when comparing between fields. Impact measures for England in 47 disciplines were compared over a nine-year period to those of six other nations, against a world baseline. King (2004) updated May's original 1997 work to 2002, covering a 10-year period. The new study increased the number of nations analyzed (31),

[1] According to a recent study by Hicks (2012), there are currently 15 nations (China, Australia, New Zealand, 12 EU countries) that conduct regular comparative performance evaluations of universities and link the results to public financing. The shares of overall public funding and the criteria for assigning funds vary from nation to nation.