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RESEARCH INFRASTRUCTURE FOR SCIENCE
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A COMPARISON OF US AND EUROPEAN UNIVERSITIES: THE STRONG RELATIONSHIP BETWEEN REVENUES AND INTERNATIONAL VISIBILITY

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By integrating data on scientific publications from the CWTS Publication Database with data on European Universities from RISIS-ETER (European Tertiary Education Register) and data on US universities, researchers from USI, Lugano, and from the University of Turin present a new study published on *PlosOne*, and titled “Scientific output scales with resources. A comparison of US and European universities”.

The study shows a strong relationship between universities’ revenues and their volume of publications and citations, and it is also focused on the association between university incomes and international visibility. This relationship implies that international rankings are largely measures of wealth.

Further, the study shows that three characteristics differentiate the US system, i.e. a) a significantly higher level of resources, b) a clearer distinction between education-oriented institutions and doctoral universities, and c) a higher concentration of resources among doctoral universities.

Accordingly, a group of US universities receive a much larger amount of resources and have a far higher number of publications and citations when compared to their European counterparts. These results demonstrate that the ‘transatlantic gap’ in research excellence is largely associated with differences in resources. Implications for public policies and institutional evaluation are discussed.

1. INTRODUCTION

Defining excellence is not a simple job, especially when it comes to research, and when the excellence of research systems should be related to revenues. Researchers of USI (Università della Svizzera italiana), Lugano, in collaboration with University of Turin, have revealed a strong relationship between university revenues and their volume of publications and citations, sweeping away some conceptions on university rankings.

“The European Commission has further expanded the information available on European universities, with particular emphasis on organizing the data and increasing the number of countries involved”, said Benedetto Lepori, of Università della Svizzera italiana and corresponding author. “This allowed an interesting comparison between the United States and Europe in order to deepen the modalities and the functioning of the competition between universities and to investigate the type of impact that this phenomenon has on the research outputs at system level”.

Providing input and output data for nearly all doctoral universities in the US and in Europe, researchers revealed that the number of publications and citations at the university level scales in respect to revenues, and that these relationships are similar in the US and in Europe. This implies that the richest universities will systematically show up at the top of bibliometric indicators and of international rankings. Scientist mapped more than 3,000 Higher Education Institutions in the US and over 2,000 in Europe. Data derived from RISIS-ETER, the European Tertiary Education Register database and from Integrated Postsecondary Education Data System for the US (IPEDS), as well as from the CWTS Publication Database maintained by the University of Leiden.

“Though often criticized for their intrinsic limitations, rankings have been used to provide so-called ‘excellence’ signals. Across countries, one model of research intensive institution, inspired by the US research university, has become the aspirational archetype for all universities that are increasingly involved in the battle for international ‘excellence’, with university managers keenly scrutinizing their position in international rankings. At the political level, the observation of a ‘transatlantic gap’ in bibliometric indicators between US and Europe has led to a wide debate on whether stronger policies rewarding ‘excellence’ would be needed”, said Lepori. Thus, investment in research by universities plays an important role in attracting academics from abroad, and generates self-reinforcing cumulative mechanisms where the rich is becoming richer.

Specifically, funding needs to be considered if we want to properly understand productivity of individuals and organizations.

“Beyond the obvious assumption that more resources translate into more output, we know little about the relationship at the institutional level between the amount of available resources on the one hand and scientific output and visibility on the other hand. All evaluation efforts have been directed toward measuring output rather than productivity”, said Lepori. “The focus of the study is to examine the relationship between resources and standard bibliometric indicators that are widely used to compare universities for their ‘excellence’, for example, in international rankings. The aim is to understand whether such indicators depict wealth rather than anything else”.

2. METHODOLOGY AND DATA: IPEDS AND ETER

For this study, researchers have created a dataset including the full population of HEIs delivering at least a bachelor degree in the two systems (excluding associate colleges in the US), i.e. 3,287 HEIs in the US and 2,243 HEIs in Europe. Data have been derived from the Integrated Postsecondary Education Data System for the US (IPEDS) and the European Tertiary Education Register database (ETER). When compared with international student statistics from EUROSTAT, the coverage of the dataset is 100% of student enrolments at bachelor, master and PhD level in the US and 96% in Europe.

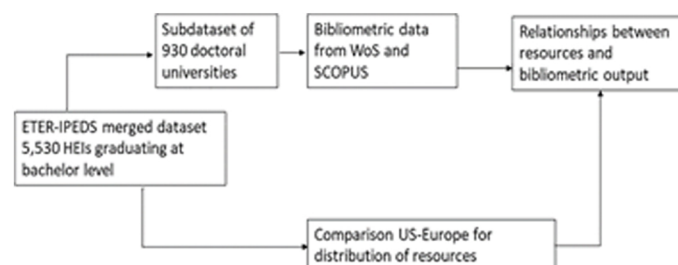
This dataset has been used to compare the volume and distribution of revenues within the two systems and to examine to which extent this accounts for differences in resourcing of doctoral universities between US and Europe.

Second, from this dataset, the subpopulation of doctoral universities, defined as the HEIs awarding more than 20 PhD degrees in the reference year 2013 and excluding universities focused on a single topic such as medical schools (the criteria adopted by the US Carnegie classification), has been extracted. This subpopulation is composed of 564 universities in Europe and 366 universities in the US. It includes 22 out of the top-25 and 77 out of the top-100 universities in the ARWU ranking (2017 edition), the remaining being in other regions worldwide, and is therefore highly representative of what is considered as international research ‘excellence’. This subpopulation was used to analyze the relationship between the volume of research and bibliometric outputs (publications and field normalized citations). Bibliometric data were extracted from the Web of Science copy at CWTS,

Leiden University, and from Scopus-SCIMAGO in a robustness check.

Further, given their strong correlation, the study analyzes whether the budget is associated with bibliometric output directly or through an increase in the number of staff through a so-called mediation model (Figure 1).

Figure 1. Empirical strategy



3. ANALYZING SCIENTIFIC PRODUCTION

Scaling properties of bibliometric output

The key result of this study is that there is a very strong relationship between budget and bibliometric output and that the relationship is super-linear, i.e. when by doubling the university budget publication and citation output more than doubles, implying that university size primes in terms of output.

These findings have important implications for the use of bibliometric indicators for evaluation purposes. On the one hand, the coupling between revenues and bibliometric indicators is really tight. On the other hand, super-linear scaling implies that bibliometric indicators increase more rapidly than revenues and so-called scale-free indicators, such as Mean Normalized Citation Score, become size-dependent. Such a relationship implies that the position in international rankings is strongly associated with university revenues—16 out of the top-25 US and European universities in the 2017 ARWU-Shanghai ranking are among the top-25 HEIs in our dataset for revenues, and Harvard and Stanford top both lists.

Behind international excellence: revenues, staff and output

There are two ways increasing budget can lead to larger research output. On the one hand, universities might invest additional resources to hire more people, which in turn produce more outputs. On the other hand, universities could also provide more resources per unit of staff, for example in the form of higher salaries or of starting packages for newly hired professors.

resources per unit of staff, as this allows the richer universities to compete for the most talented researchers. As expected, student enrolments have a positive association with the number of staff, implying that, with increasing number of students, revenues are used to a larger extent to hire staff, generating some increase in output. However, increasing student enrolments push universities to expand their staff to manage educational activities and, in turn, this lowers scientific output. Therefore, for international 'excellence', not only the amount of resources matters, but also the extent to which revenues are decoupled from the number of students.

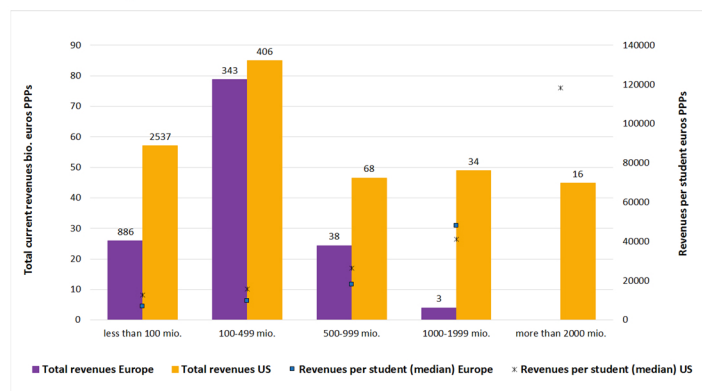
US vs. Europe differences in resource distribution

To inquire on the origin of the so-called 'transatlantic gap', i.e. US universities consistently showing up at the top of international rankings despite Europe having more output at the system's level, we compare the distribution of revenues within the two systems.

Fig. 2 shows that the US system includes a larger number of small HEIs and a group of HEIs with extremely large revenues, while in Europe the largest portion of resources are directed to middle-size HEIs. On the top of the pile, the US system includes 16 HEIs with total revenues above 2 billion euros in PPPs, while the 50 HEIs with revenues above 1 billion constitutes one-third of all resources. On the contrary, in Europe there are only 3 HEIs with revenues above 1 billion, while half of the resources are accounted for by middle-sized HEIs below 500 million Euros.

All top-25 HEIs by revenues in the dataset are in the US, with the list being topped by Harvard and Stanford, the first European universities are Cambridge (place 26) and Oxford (place 41), i.e. the highest ranked European HEIs in the 2017 ARWU-Shanghai ranking. Interestingly, HEIs in the same revenue class have similar levels of funding per student in the two systems, showing that the main difference lies in the distribution of revenues and, particularly, in the presence in the US of a group of about two dozens of universities with extremely high revenues.

Figure 2. HEI revenue classes. Number of HEIs by region and class. Left axis: sum of revenues by class. Right axis: revenues per student



Institutional differences

A deeper analysis shows that a combination of institutional factors accounts for the observed difference in the distribution of revenues:

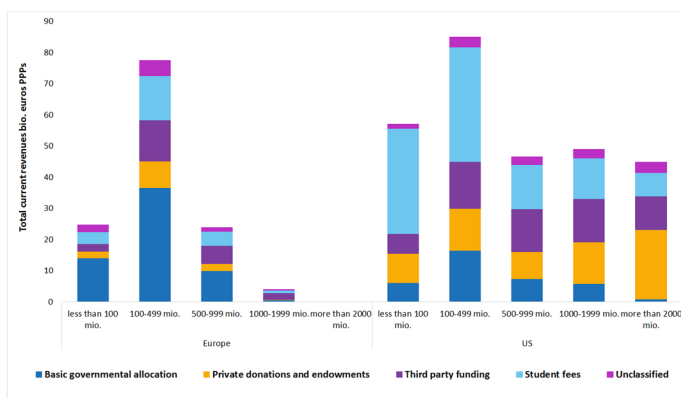
1) The US higher education system is endowed with more resources. The numbers of staff, students, publications and citations are similar in both systems, while the total amount of revenues is 282 billion euros PPS in the US and 133 billion euros in Europe, showing how the transatlantic 'excellence' gap is essentially a resource gap.

2) We observe a difference in the extent of institutional differentiation between the two systems. Although the European system comprises a large number of colleges and specialized HEIs, doctoral universities account for nearly 70% of academic staff and students at the bachelor and master level, when compared to 55% of staff and 45% of the enrolled students for US doctoral universities. Since colleges receive fewer resources per student, a higher share of students attending colleges translates into more resources for doctoral universities.

3) the US system is characterized by a stronger differentiation of revenue sources in the aggregate and between HEIs. As demonstrated in Fig 3, most European HEIs have a funding model where the basic government allocation represents the largest share of funds, while other sources are complementary. On the contrary, US universities have a differentiated funding model, where private revenues and student funding play a central role—the latter being largely indirect state support through student loans and subsidies.

Moreover, in the US, private donations and endowments are the main source for the largest institutions and are heavily concentrated at the top of the pile (Fig 3). The 16 universities with revenues above 2 billion euros receive 53% of the private donations that constitute 49% of their revenues. On the contrary, in Europe, the universities with the highest revenues are funded by a combination of state allocation and third-party funds.

Figure 3. Revenue sources by revenue class. The numbers on the top of the bar are the number of HEIs in each group



4) European HEIs “scale up” with student enrolments, with the distribution of staff and revenues closely following students and with research outputs only moderately more concentrated. On the contrary, revenues are more concentrated than students (and staff) in the US, while publications are far more concentrated. This indicates that the funding mechanisms in the US allows top-ranked universities to receive more resources per unit of staff, without a parallel increase in the number of students. As suggested by our statistical models, this is a powerful driver for achieving international research ‘excellence’.

4. POLICY IMPLICATIONS: US AND EUROPEAN STRATEGIES

Investigating the connection between publication output and international visibility, including a measure of resourcing is critical for policy evaluation purposes as performance-based allocation of resources represents a core element of the new ‘academic capitalism’ paradigm.

Beyond the obvious assumption that more resources produce more output, we have shown that this relationship is tight across a wide range of size and across the two main scientific systems worldwide. These findings add a further worrisome dimension to the evaluation debate. By and large and especially on the top of the pile, bibliometric indicators and rankings are a richness measure and is questionable whether by orienting their decisions to these indicators policy-makers and stakeholders would do more than enriching the richer, under the presumption of promoting international ‘excellence’. A key component of this process is the existence of a universal (context-free) and measurable definition of ‘excellence’ that might differ from (context-related) quality. Such a measure, like the one conveyed by international rankings, is not necessarily ‘objective’, but nevertheless drives the behavior of the actors, including policy-makers, university managers and scientists themselves.

Bibliometric indicators indeed provide valuable information for evaluation purposes at the policy and institutional level. However, the study rejoins previous critiques against their de-contextualized usage without taking into account local situations and specificities of scientific fields, countries and institutions.

Moreover, the study demonstrates that the strongest association between resources and bibliometric outputs is via additional resources per staff, rather than an increase in the number of faculty. This suggests that a key underlying mechanism explaining the observed patterns is academic mobility, where highly productive scientists move towards the ‘best’ places in terms of ‘excellence’, while in their

hiring behavior universities attempt at maximizing ‘excellence’ by investing more resources in few highly productive people.

Fighting for the top-positions in international rankings must be associated with the concentration of large amounts of resources in a few places. In the US, this was achieved through institutional differentiation and a large amount of resources provided discretionally by private donors, while in Europe, this was achieved only by two countries, i.e. UK with its longstanding tradition of concentrating resources, and Switzerland through the creation of two ‘national’ universities in a federal system. Such processes concern only a tiny minority of institutions and, once established, become self-sustaining thanks to the coupling between ‘excellence’ and resources.

Policy implications are therefore different for the US and for Europe. In the US, promoting international excellence should not be a major focus of public policies as private capital already ensures it; instead, public policies should continue to be focused on widening access and ensuring good quality of education and research throughout the country, following the longstanding tradition of support to colleges and state universities. The increasing privatization of US higher education represents, in this respect, a worrisome tendency. On the contrary, for some (large) European countries currently lacking internationally ‘excellent’ universities, dedicated policies should be designed that trigger the kind of cumulative mechanisms observed in the US, for example by attributing long-term institutional funding. Of course, if this is deemed an important policy objective. To this goal, additional resources would be required as our data show that higher education investment in most European countries is well below the US level. At the same time, European countries would be well advised to keep their focus on delivery of good quality university education and research at regional level that represents a strength of the European system.

In turn, at the institutional level, the battle for international rankings should not be the main concern of most university managers for two reasons: first, this process is driven by largely endogenous mechanisms and, at the least in the short and medium term, there is important inertia that makes it difficult to substantially change the amount and distribution of resources. Second, even in a well-funded system like the US one, this concerns only a handful of universities that account for a tiny proportion of higher education activities, particularly for what concerns education and the contribution to society and economy.

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