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The geographical efficiency of education and research: The ranking of U.S. universities

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ABSTRACT

This paper proposes to study the American efficiency of educational diffusion and research productivity following two distinctions: urban vs. rural areas and public vs. private universities. Following this geographical consideration, knowledge diffusion seems to be homogeneous over the American territory, whereas research productivity is more heterogeneous: American research efficiency decreased of 7% points, due to some rural university localizations. Universities in urban areas favor educational quality through high student selection criteria, contrary to those located in more rural areas. Third, public universities present higher educational efficiency, in favoring educational quality over research productivity: the lesser research efficiency of public institutions comes from difficulties in the management of several campuses, by comparison with the private institutions which are all single-campus.

1. Introduction

The links between higher education and economic growth are, today, a major research topic [1]. In particular, the number of frameworks analyzing institutions of higher education has increased recently, since the publication in 2003 of the Academic Ranking of World Universities (ARWU), also known as Shanghai Ranking. Such ranking has greatly influenced educational policies at university levels: in terms of tenure promotions, earnings, and financial aids. Furthermore, such ranking has had major implications at national level: several countries (including China, Denmark, France, and Russia) have decided to merge some of their higher education institutions in order to improve their relative positions in international ranking. These major reforms of higher education systems have been implemented for one main reason: to enhance the international reputations of the higher education institutions, and thus their capacities to attract a greater number—and probably, caliber—of national and international students and teachers. If we consider the self-perpetuating nature of such ranking, the universities ranked highly would be expected to increase or reinforce their initial relative good position, because they can attract better students and teachers.

A large part of the literature has been concerned primarily with assessing the research productivity of universities (e.g. Refs. [2,3]. These frameworks have mainly tried to identify better empirical measurement methods, based on data availability, in order to produce more representative indicators for benchmarking analysis. ARWU ranking uses, for example, Nobel Prizes, Field Medals, the Science Citation Index (SCIE), and the Social Citation Index (SSCI). Citations and publications, in particular, are among the indicators most commonly used to assess journals' reputations and research productivity at department, faculty, or at more aggregate levels [4]. In this framework, the unit of analysis is the university level. The advantage of such a choice—to include all departments of a higher education institution—is that it takes multidisciplinary research into account.

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More recently, however, several papers have criticized this approach. First, the ARWU ranking uses arbitrarily fixed weights for different variables to calculate a global score. Second, a research indicator is not sufficient to provide a complete evaluation of a university's achievements. For example, students would probably be better informed in their choice of university by an indicator about the educational quality and not only by a research indicator [5]. With the aim of addressing these deficiencies, a new ranking has been published since 2004: the Times Higher Education World Rankings (THEWR). This ranking proposes a number of extended indicators with new fixed weights: it incorporates the degree of internationalization, the link between research and economy, and the quality of schooling. In line with the THEWR framework, our study proposes an indicator for research and knowledge diffusion. Data Envelopment Analysis (DEA), which is a popular method in this literature (e.g. Refs. [6–12] have, notably, showed that the current existing rankings are highly correlated with the efficiency scores calculated from DEA model. Such approach has, furthermore, the advantage of avoiding arbitrary assumptions in the weights system between the variables used in the indicator. They are determined by the DEA maximization program as discussed in the sections devoted to the findings. Furthermore, our approach considers also that a part of university heterogeneities in assessing efficiencies comes from the geographical locations [13]. For this purpose, we use a hierarchical DEA model proposed by Ref. [14] which allows to consider if universities operate in either urban or rural areas.

According to the ARWU results, the performance of American universities seems to be ahead of that of the European system. The higher education system in the United States provides a particularly interesting case for the geographical issue, since the American system is highly decentralized. There is no minister of national education in the United States: education provision is managed by each state and not at national level. Our framework, therefore, proposes a benchmarking analysis between state management and its associated regional performance, which can provide more robust recommendations for policy makers than more microeconomic levels [15].

The problems and solutions of universities situated in a large city are probably very different to those situated in more rural areas and they should be distinguished. In a first step, we seek to understand how location can influence educational or research attainment. In a second step, we assume that the higher education system covers the whole of the US territory to facilitate access to education for all young residents. In this context, we assess the impact on efficiency of university location (a factor over which universities have no control), specifically the effects of differences between rural and urban areas in terms of population density and their appeal as places to live. Such an approach allows, then, specific analysis and distinct recommendations, based on university location in either rural or urban areas. The results are, furthermore, discussed in respect to the university status: public or private management.

This framework uses data produced and made available by the Integrated Postsecondary Education System (IPEDS) and the Global Research Benchmarking System (GRBS) websites (see the next section for a complete description of the data). Based on these precise data sets, we have performed several tests to assess whether institutional factors (e.g. university governance, public or private status, different religious affiliations, etc.) might influence the productivity of US universities [16].

The paper is structured as follows: The second section discusses the data and some statistics derived from the final sample; the third section presents the hierarchical categorical DEA model; then, to conclude, section four presents a geographical discussion of our empirical results for educational attainment, the research indicator, and an aggregate of both.

2. Data and descriptive statistics

This section presents the inputs and outputs used for both educational and research productivity indicators.

2.1. Educational data

Data for educational assessment have been extracted from the IPEDS website. They consist of nine interrelated survey components that are collected over three time periods (fall, winter, and spring) for each year. Of these surveys, five in particular have been used: (a) an institutional characteristics survey which provides information about student charges and control of the institutions; (b) a completions survey which indicates the degree of completion by level, program, race/ethnicity and gender; (c) an enrollment survey for graduate and undergraduate levels, with the same detailed breakdown of categories as the completions survey; (d) a survey of undergraduate financial aid, collected with regards to federal, state, local government, and institutional grants and loans; (e) a human resources survey which details full-time instructional staff by academic rank, gender, and contract length. All these data were collected in 2012–2013 for 7735 college and universities. From these samples, two outputs and fourteen inputs are used for the indicator of knowledge production:

Educational Output: (a) the number of undergraduates who have successfully completed their degrees, (b) the number of graduates who have successfully completed this level of schooling.

The first output is interpreted in this paper as a proxy for the quantity of educational attainment, whereas the second refers to a higher quality of educational production. At the level of higher education, the quality of education is more difficult to appraise than it is at lower levels.[1] We assume, here, that these two outputs differ in terms of quality: with higher quality and skill attainment associated with graduates, as argued by Ref. [7]. Adjustment for quality is rare, given the lack of qualitative measures at higher education level and, furthermore, such an approach should assume an arbitrary system of weights to provide a measure of quality (e.g. Ref. [17].[2] These outputs are usual in educational literature (see Table A1 in appendix).

Educational Inputs: (a) The percentage of undergraduate students receiving federal, state, local, institutional, or other grants (for the fall cohort); (b) the average amount of these grants; (c) the percentage of undergraduate students receiving federal loans; (d) the average amount of these loans; (e) undergraduates' fees; (f) graduates' fees; (g) total dormitory capacity; (h) the ratio of admitted students divided by the number of applicants (i.e. the admittance ratio); (i) the number of graduated students; (j) the number of graduated aliens[3]; (k) the number of undergraduate students; (l) the number of undergraduate aliens; (m) the number

[1] For lower educational levels, some surveys provide some quality scores for students, like PISA survey for the European countries and the SAT scores for the United States.

[2] Another output that could be considered is the matching of the supply of skill production at university level to the skill demand of the labor market. For that purpose, it would be necessary to analyze the professional progression of graduates from higher education, for example, through the levels of wages obtained after graduation (as used by Ref. [35]. Unfortunately, such information is not available, to our knowledge.

[3] Individuals who are not citizens or nationals of the United States and who are in the country on a visa or other temporary basis. They do not have the right to remain indefinitely in the country.