Performance-based resource allocation for higher education institutions in China

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ABSTRACT

How to allocate limited resource to higher education institutions has always been a critical problem with significant social and economic relevance. Researchers and educational administrators have long proposed that resource allocation should be linked to performance. In this paper, we develop a performance-based method for a central planner to allocate research funding to different universities to better stimulate the research output. The method builds on existing works on resource allocation via efficiency analysis. The method takes multiple dimensions of research performance into account, including number of publications, number of patents, and revenue from knowledge transfer. We apply the method to a set of 64 major universities in China based on performance in 2014–2016. The application is particularly pertinent at the moment, since the Chinese government is developing a new funding program called the "double first-class" plan, which features performance-based funding as a central pillar of government funding.

1. Introduction

In the past several decades, many countries have increasingly embraced the performance-based funding (PBF) method to allocate resources to higher education institutions [1–4], in response to mounting public pressure on efficient use of taxpayers' money and escalating demand for accountability. In the United States (US), PBF is steadily gaining ground at the state level with 22 states adopting or in the process of adopting it as of 2013 [5]. In the European Union (EU), PBF has become a well-established standard practice in many countries. The United Kingdom (UK) has been disbursing block research funds to universities based on periodic assessment of academic performance since 1980s [6]. Some other EU countries (Belgium, Denmark, Finland, Norway and Portugal) have followed the "Norwegian Model" to allocate a proportion of government fund based on publication outputs [7].

Although the effectiveness of PBF has been validated in many countries, its use in China is limited. Like most of the countries where public universities play a dominant role in higher education, the government in China has a strong control on resource allocation to higher education institutions. Financial allocation from the government is the most important source of funding for Chinese universities, accounting for 55% of a university's total funding on average [8]. A significant portion of government fund is distributed through special funding programs targeting at a small set of universities. The most notable funding programs are the "211 Project" and the "985 Project". The 211 Project, initiated in 1995 by Ministry of Education of China, is a multi-year funding program designed to support selected universities to attain world-class research and teaching quality. As of 2011, there are 116 universities admitted into the program. The 985 Project, launched in 1998, is a similar but more selective and well-funded program compared to the 211 Project. The program only involves nine top universities at the beginning and gradually expands to 39 universities by 2011. Despite that special funding programs like the 211 Project and the 985 Project are credited with greatly enhancing the research capability of Chinese universities, there is widespread criticism on those programs [9]. The criticism focuses on three aspects, i.e., disparity, inefficiency, and lack of performance assessment for participating universities. From 2009 to 2013, more than 72% of government research fund is given to the 116 universities in 211 Project and 985 Project, while the remaining around 2000 universities share the rest 28% [10]. There is also great disparity within the participating universities. The president of Guizhou University, a university in the 211 Project, complains that financial support to his university in the past thirty years is less than the fund allocated to the two most prestigious universities Tsinghua and Peking in a single year [11]. Meanwhile, efficiency of the programs is also under attack. Among the universities involved in the 985 Project, there is evidence that lower tier universities which received less financial support, improved faster in research output than the most prestigious universities, which received the biggest support [9]. It is also found that [11], "some universities that are enlisted in these projects do not make good use of the research funds they receive and that some even misappropriate research money."

Finally, while the programs generally request performance assessment for participating universities, in practice the assessment results do not carry much weight in fund allocation.

Realizing the predicament of the existing funding programs, Chinese government has decided to pursue a major reform and institute a new funding system. Officially designated as the "double first-class" plan and unveiled in 2015, the new funding system aims to build both world-class universities and world-class disciplines. It is widely believed that in the future, the plan will assume a dominant role in government funding for higher education in China, and will have a profound and lasting impact on Chinese universities. In response to the criticism on 211 and 985 Projects, the double first-class plan introduces PBF as one of the central pillars of the reform. The plan asserts that government funding for selected universities will be dynamically adjusted conditional on performance. It emphasizes that bad performers should be penalized with reduced support and even kicked out of the program. The implementation details on performance criteria and fund allocation method have not been disclosed yet.

In light of the transition of the Chinese higher education system, we develop a performance-based resource allocation model based on efficiency analysis. As one of the first steps to meet the challenges, administrators and policymakers need to measure the performance of the universities. For this purpose, efficiency assessment by data envelopment analysis (DEA) has proven to be a useful approach. DEA is a mathematical programming approach to benchmark the performance of a group of production units, dubbed as the decision making units (DMUs) in the DEA nomenclature [12]. The application of DEA to university assessment has become an important and appealing research topic over the years in fields such as management, education economics, and public policy [10,13,14]. The strengths of DEA lie in two aspects. First, DEA is a non-parametric method and thus does not assume any functional forms for the production process of the universities. Second, the capability of handling multiple inputs and outputs makes DEA an appealing assessment tool, because a university naturally transforms multiple inputs such as R&D staffs, faculties, postgraduates and research funding, into multiple outputs such as research papers, patents, and knowledge transfer. DEA identifies the bad performers which should be targeted for further improvement, and the good performers which should serve as role models for other institutions. The efficiency assessment results are employed as the basis for resource allocation. The central planner maximizes the total outputs of all universities by adjusting the distribution of research fund, subject to constraints on availability of resource, range of input and output adjustment, and change of individual university's efficiency. We demonstrate the effectiveness of the method by applying it to a group of 64 Chinese universities based on their performance over 2014–2016.

The rest of the paper is structured as follows. Section 2 reviews relevant literature. Section 3 presents the models. Section 4 describes the data and variables. Section 5 presents the results. Section 6 discusses policy implications and potential extensions.

2. Literature review

Conceptually, our study builds on the intersection of three streams of literature, i.e., assessment of university performance, the relationship between funding and performance, and performance-based resource allocation. Method-wise, our study is related to the literature about application of DEA to university assessment.

Performance assessment constitutes the foundation of resource allocation in our paper. A great amount of research has been devoted to the study of university assessment [13,15–21], which generally falls into the domain of education economics. These assessment studies have proposed various university performance measures from different perspectives, including teaching [13,15,16,21], research [15–19] and sustainability [20]. The most commonly used measures to capture the research output include the number of research publications [3,20],

research capability rating [16], citation or impact of publications [17,22], number of patents [23], and knowledge transfer activities [23–25]. The generation of research output requires various inputs such as professors, graduate students and funding. Our paper uses the DEA method to integrate multiple inputs and multiple outputs into consideration simultaneously to construct holistic performance measures. The application of DEA to the assessment of higher education institutions has already received considerable attention in prior research. For example, Ahn et al. [26] demonstrate the effectiveness of DEA assessment and discuss its advantage over traditional approaches. Flegg et al. [27] apply the method to British universities, and analyze the causes of efficiency change by developing and decomposing the DEA-based Malmquist index. Thanassoulis et al. [28] use DEA to study the cost structure, efficiency and productivity of universities in England, and estimate the expansion potential of the universities. Johnes and Johnes [29] extend DEA approach to assess the research performance of UK economics departments. De Witte and López-Torres [30] and Johnes [31] provide detailed reviews on the topic. While a substantial bulk of studies have employed DEA to analyze university performance, to the best of our knowledge, no prior research has gone further to study the resource allocation problem. Our research contributes to the literature by demonstrating the applicability of DEA-based resource allocation to higher education institutions.

Resource allocation in the public sector is always a problem of great importance and has been studied extensively [14,32,33]. The problem is especially relevant when a central planner exists and is charged with the allocation decision for a group of organizations. Various methods have been proposed, such as dynamic programming [34], goal programming [35], simulation [36], and of particular relevance to this study, DEA efficiency analysis [37–39]. The objective of these methods is either to minimize the total quantity of certain inputs or to maximize the total quantity of certain outputs over all the production units. The allocation decision may be constrained by capacity, budget and requirement of the distribution of inputs/outputs [37]. Within the literature on DEA-based resource allocation, there are two popular types of approaches. The first type of approach solves a single linear programming problem to determine the distribution of inputs and outputs without explicitly computing the efficiency for each organization [38]. The second type of approach follows a two-step procedure, where the efficiencies are derived in the first step and used as the basis of allocation in the second step [37]. Both approaches have been extensively applied in various situations [40–42]. Our research follows the two-step procedure as in Ref. [37].

A lot of empirical studies have investigated the impact of funding on research performance among Chinese universities [3,9,10,43,44]. For example, Yaisawarng and Ng [10] find that the 211 Project, a prominent funding program in China, has successfully boosted the research capabilities of universities admitted into the program. Further, Zhang et al. [9] find the impact of funding may not be homogeneous. Specifically, after the launch of the 985 Project, the most significant funding program in China, publications from lower tier universities in the program grow at a faster rate than the top universities. These studies are generally descriptive in nature, aiming at identifying the effect of funding on research. Our research is prescriptive in the sense that we aim to optimize the resource allocation scheme such that the most desirable research performance can be achieved.

3. Models

We develop the method in the spirit of [37], where the performance-based funding problem can be divided into two sub-problems, performance assessment and resource allocation. The latter model draws on the result of the first model. The two models are described below.