



Centralized allocation of human resources. An application to public schools



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ABSTRACT

Centralized resource allocation requires planning how to implement changes in order to adapt resources to the allocated budget without losing outputs. This paper presents an alternative model to reallocate human resources in a public education network based on the so-called centralized data envelopment analysis. This stream has received less attention in the efficiency literature and evaluates the overall efficiency of a set of decision making units controlled by a central authority. In this study, an extended centralized data envelopment analysis dealing with non-transferable inputs and environmental factors is proposed to assess the global efficiency of a centralized education network. We then design an iterative procedure capable of reallocating resources without jeopardizing the level of efficiency. The proposed model is applied in a real case of public schools from Catalonia (north-east Spain). The results indicate the network could be improved to optimally redistribute educational resources without falls in the level of aggregated outputs. The study also provides useful information for accountability and decision making when implementing improvement programs in public schools.

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1. Introduction

In recent decades, interest in efficiency in education has increased from both practitioner and academic points of view [50]. One of the reasons for the emergence of studies in this field is the increasing importance of the education sector in the economy since it provides intellectual training for the population, better quality human capital, and increased labor productivity [15]. In addition, education is considered essential to enhance a country's economic growth [74]. In the wake of the current global economic crisis, countries face the challenges of making public finances sustainable. Publicly funded sectors are under pressure to deliver more for less and none more so than the education sector. This environment requires an education system that is efficient in translating resources into educational outcomes [69]. In Spain, the economic reality is currently undergoing social and political debate. In the public sector, the pressure to increase performance implies that any action to improve efficiency becomes an economic policy priority. Under the current budget constraints the continuity of any public entity is a decision variable [10].

Performance measurement is important not only in the private sector, but also in the public sector since it can highlight strengths and weaknesses in current practices, reveal directions for improvement, and ultimately may lead to better use of the resources spent on providing public services [5]. In the Spanish case, the government rationalized education spending through an 11% budget cut to save 3,000 million euros by implementing certain measures at the regional level, such as increasing the student-teacher ratio, expanding the range of increases in university fees, delaying teacher replacements, and even forcing the closure of several schools. For instance, in Catalonia more than seven schools have been closed in recent academic years and the regional government is planning to eliminate several elementary education groups due to lack of resources. In this environment, schools are forced to make additional savings in personnel budgets to keep expenditure low. These budgetary restrictions have provoked growing interest in rationalizing the allocation of available resources [108].

Nevertheless, in spite of these global budget cutbacks, the current education system does not encourage schools to work effectively. For this to occur, reorganization is needed that will motivate education institutions to achieve good results efficiently. In the scenario of cutbacks and closures, it appears that one suggestion for increasing efficiency is to merge education institutions [52,69]. From a theoretical perspective, a merger may accrue

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efficiency benefits from returns to scale, as a consequence of increased administrative, economic and academic efficiency, or returns to scope if the merging institutions have complementary activities [104,51,61]. Previous quantitative studies on the empirical effect of merging on efficiency demonstrate that the impact is positive [64,69,87].

Consequently, the approach proposed in this paper consists of creating an internal performance-based scheme that stimulates an effective level of performance in public schools while complying with the budget constraints imposed by the government without losing quality. The introduction of incentives can help schools to be more efficient and sustain efficiencies over time [18,63]. The main purpose of this paper is to propose a method to assess and re-design a group of schools in a public education network to make additional savings in the education budget. We also aim to reallocate resources through a new education network to optimize overall efficiency without jeopardizing the level of educational quality.

To develop the approach we extend a specific nonparametric frontier technique known as Centralized Data Envelopment Analysis (CDEA), initially proposed by Lozano and Villa [79] and modified by Mar-Molinero et al. [88]. We extend the CDEA model in several ways. First, we include a specific constraint to deal with the inclusion of non-discretionary factors (environmental variables) in a centralized scenario. We need to bear in mind that the performance of public schools can also be affected by exogenous or environmental factors, which in the context of our study are represented mainly by the characteristics of the students, families and the nearest school environment [91]. As these variables are not under the control of either the decision making units (DMUs, in our case schools) or the decision maker (i.e., the Department of Education), we need to include them in our efficiency analysis in a different way.

Second, we incorporate additional constraints referring to transferable and non-transferable inputs. To do so, we design an efficiency model that encourages good educational practices and penalizes unsatisfactory results. Following Yu et al. [112] the actions to improve results are determined by three main policies that regulate government powers. The first is a short-term policy under which the decision maker cannot dismiss any teachers (permanent or non-permanent) but can transfer non-permanent teachers from one school to another, while maintaining the status of permanent teachers in all schools, and the original number of schools. Secondly, the middle-term policy grants the government restricted power to dismiss only non-permanent teachers, but it can transfer permanent teachers between schools and change the original number of them. This is the alternative we propose in this paper. Thirdly, the long-term policy refers to the possibility of dismissing any permanent or non-permanent teacher from any school. This most extreme policy is not taken into account in this paper.

After designing the extended CDEA, we propose an iterative method capable of re-designing the public education network by reallocating resources among schools with reception capacity, taking into account environmental conditions. To that end, we apply a conditional nonparametric efficiency approach to better know which schools were the worst performers (i.e., the candidates to be merged). The conditional model is known to be a better approach than traditional models, such as two-stage models, to account for environmental factors (see [101,27] for an overview). The validity of these traditional models is limited because they assume the separability condition between the input-output space and the space of environmental factors. Therefore, we use the so-called conditional nonparametric approach [19,30–32] which avoids this restrictive separability assumption.

Previous studies on resource allocation in schools have rarely

considered the issue of centralized human resource adjustment scenarios (e.g., [99,57,88,53]). In addition, prior empirical papers have revealed a significant and positive relationship between human resources practices and performance (e.g., [65,24,112]). According to Chen and Huang [24], the appropriate allocation of human resources has a positive effect on organizational performance. Yu et al. [112] also argue that periodic organizational change is necessary to improve organizational performance. A new model is therefore needed to resize the education network in order to provide objective solutions to the general cutbacks proposed by the government (which affect all schools regardless of their performance); in other words, to create a computational model capable of determining the poorly performing schools overall, and to design a mechanism to resize the network without penalizing the best performers.

The results show that overall efficiency can be improved without losing outputs and quality, but this improvement depends on the objectives of the Department of Education. First, 12.7% of resources can be saved without changing the current network. Second, it would be possible to save 17.2% of resources if the network composition was changed by resizing the number of schools operating.

Our work supplements previous research in several ways. First, the extended CDEA we propose overcomes the problem of including non-transferable inputs and non-discretionary factors that were not included in previous research. Second, our analysis may be particularly relevant from a policy perspective because it establishes the actions needed to optimize the network through budget reallocation in a real case study. Third, the implementation of the proposed model in a real application provides valuable information for public authorities and facilitates the implementation of improvement programs in schools, which contributes to higher levels of quality, motivation, and fairness within the system.

Following this introduction, Section 2 reviews the related research on the CDEA model and resource allocation. Section 3 explains the methodology, and Section 4 details the data and variables we use. Section 5 summarizes and discusses the results, and finally, Section 6 concludes.

2. Empirical evidence on efficiency and resource allocation

Schools are multidimensional in nature, consisting of different functions that are difficult to quantify. The education sector is non-for-profit, there is an absence of output and input prices, and schools produce multiple outputs from multiple inputs. It is therefore a complex task to define and estimate the production technology that students use to acquire knowledge [109].

Several methodological approaches have been employed to solve the problem of efficiency measurement in the education context (see [68,70], and references therein). However, the efficiency in education literature has mainly used frontier methods in two variants: nonparametric models (such as Data Envelopment Analysis (DEA) [22], Free Disposal Hull (FDH) [38], order- m frontiers [19] and parametric models like Stochastic Frontier Analysis (SFA) [3]. A review of the advantages and shortcomings of different frontier analysis techniques can be found in Fried, Lovell and Schmidt [46].

In this environment, DEA has become very popular in empirical studies on the efficiency in education, since it can easily handle multiple dimensions of performance and is less vulnerable to the misspecification problems that can affect econometric models [109,78]. This method can also handle multiple inputs and outputs without requiring the specification of an ungranted functional form of the input-output relationship [102]. Hence, DEA is presented as a method of competitive benchmarking in terms of

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