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Efficiency measurement and cross-country differences among schools: A robust conditional nonparametric analysis☆

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ABSTRACT

Analyzing the efficiency of educational systems is one of the main focuses of the policy debate to promote national competitiveness and future economic growth. In this paper, we assess the performance of secondary schools from 36 countries (26 OECD countries and 10 partners) participating in PISA 2012. For this purpose, we apply a robust conditional nonparametric approach that allows us to incorporate the effect of contextual factors at both school and country level in the estimation of efficiency measures. Our results suggest that there is a greater heterogeneity across countries than across schools. Particularly, we find that differences in efficiency estimates are mainly explained by economic indicators and cultural values. In contrast, some factors previously identified as potential determinants of student achievement, like the existence of tracking or central examinations, do not seem to significantly affect the efficiency of secondary schools.

1. Introduction

Thanks to the participation of an extensive group of countries in international large-scale assessments like PISA (*Programme for International Student Assessment*) or TIMSS (*Trends in International Mathematics and Science Study*), researchers have access to rich and extensive cross-national databases that they can use to assess education system performance internationally (Gustafsson, 2008; Kamens, 2009). Researchers can use this information to analyze differences in achievement between and within countries and investigate why and how some schools and teachers are more effective than others in promoting student learning or assess the impact of skills on economic and social outcomes (Creemers and Kyriakides, 2008; Hanushek and Woessmann, 2011). Likewise, international comparisons are especially useful for evaluating the effects of some institutional features of education systems that cannot be estimated without access to data on different countries (Hanushek and Woessmann, 2014; Strietholt et al., 2014). Conclusions and results from these analyses provide valuable decision-making guidelines for policy makers to reorient the national education system based on what is currently working in other countries.

Most cross-country studies analyze educational effectiveness, i.e. they estimate an educational production function by means of an equation linking resource inputs with educational outcomes after controlling for various contextual characteristics to investigate the main factors influencing educational attainment (see Hanushek, 1979; Todd and Wolpin, 2003). However, resource utilization is also a key matter of concern in science and technology management (Teddlie and Reynolds, 2000). Indeed, education system efficiency is now a hot topic among educational stakeholders because of the size of public spending on education and the shortage of resources raised from taxation that most countries are now facing. In particular, policy makers and researchers alike are concerned with developing guidelines for educational institutions to encourage improvements in school outcomes given their school factors. As a result, the literature on school performance assessment is growing, although most empirical studies address schools from the same country or region.[1]

This study proposes an international comparison of education production efficiency using cross-country data on secondary schools from different countries participating in PISA 2012. In this sense, it is worth mentioning that international comparisons are extremely challenging, since countries might differ significantly with regard to multiple cultural and institutional features as well as the education system structure. These differences may pose an obstacle to the comparison of schools operating

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[1] See Worthington (2001) for an early review of this literature and Johnes (2015) or De Witte and López-Torres (2017) for updated revisions.

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in diverse frameworks. Some studies have addressed this problem by limiting the comparison group to similar countries (e.g. Bogetoft et al., 2015; Cordero et al., 2017b; Dufrechou, 2016). In this paper, however, our dataset includes a large sample of thirty-six heterogeneous countries, thus we have gone one step further and taken into account data about the diverse educational contexts in which schools are operating when estimating the efficiency measures of school performance. In this way, each unit can be benchmarked with other units from different countries provided that their operational environment is similar.

To do this, we adopt the robust conditional nonparametric approach developed by Daraio and Simar (2005, 2007a, 2007b). These authors extend the probabilistic formulation of the production process proposed by Cazals et al. (2002) to account for heterogeneous contextual factors without imposing the restrictive separability assumption required by traditional second-stage models in order to provide meaningful results.[2] Using this approach, we can also test the significance of the contextual factors included in the model at both school and country level. Then, by exploiting the relationship between the conditional and unconditional measures, we can investigate the direction of their effect (favorable or unfavorable) on the production process. Furthermore, we can obtain clean efficiency scores by applying the second-stage approach suggested by Badin et al. (2012) to eliminate the effects of contextual conditions.

The country-level contextual factors addressed in this study include variables representing the economic, cultural and social context. This is an interesting contribution because most comparative studies based on data from large-scale international assessments overlook these variables (Thät and Must, 2013; Zhao et al., 2008). In particular, we retrieve data from the World Bank's Indicators database about some key economic indicators and approximate each country's cultural background by collecting data from the respondents of the World Values Survey (WVS) with regard to qualities that children are encouraged to learn at home.[3] To the best of our knowledge, this data source has seldom been used in previous comparative studies. Some exceptions are represented by Coco and Lagravinese (2014), who use this information to derive a measure of cronyism as a potential determinant of educational performance in their evaluation of OECD countries using PISA data, and Mendez (2015), who examines the role of the above qualities in explaining country differences with respect to student performance in PISA. In our case, these variables are included as contextual factors influencing the performance of schools from one country compared with schools from other countries.

The remainder of the paper is structured as follows. Section 2 reviews previous literature on cross-country studies using data from international large-scale assessments that focus especially on efficiency measures. Section 3 describes the methodology applied in our empirical analysis. Section 4 explains the main characteristics of the data and variables selected for the empirical analysis. Section 5 discusses the main results compared with the existing literature. Finally, Section 6 outlines some concluding remarks.

2. Literature review

Since the publication of the pioneering work by Woessmann (2003) combining international student- and school-level microdata with several country-level indicators, multiple studies have adopted a cross-country approach to explore the main determinants of educational achievement from different perspectives (Ammermüller et al., 2005; Hanushek and Woessmann, 2011; Le Donné, 2014). These studies mainly address the use of econometric techniques to identify significant causal relationships between student background, school-related variables and educational outcomes (typically represented by test scores).[4]

The above empirical studies usually focus on some specific school factors, such as the class size (West and Woessmann, 2006; Woessmann and West, 2006), instructional time (Rivkin and Schiman, 2015) or divergences in performance between public and private schools (Vandenberghe and Robin, 2004; West and Woessmann, 2010). Likewise, these approaches have also been employed in a growing body of literature analyzing the impact of specific institutional features of education systems on educational attainment (Braga et al., 2013). These features include the existence of central examinations, which has been identified as a factor associated with better student performance in international tests (Bol et al., 2014; Woessmann, 2003, 2005); the practice of tracking,[5] which appears to have a negative impact on average student performance (Hanushek and Woessmann, 2006) and promote educational inequality (Bol et al., 2014; Brunello and Checchi, 2007); or the length of preschooling, which has a positive effect on student performance (Schuetz et al., 2008).

As already mentioned, however, none of the above studies take into account the possibility of there being an unexpected level of inefficiency in student, school or country performance (Levin, 1974). Thus, over the last few years, interest in applying frontier methods to data from large-scale international assessments to evaluate the efficiency of education systems in a cross-country framework has grown notably. This parallel branch of research is valuable for monitoring efficiency differences across countries and the determinants that influence education system performance. Among those works, the most common ones are those using cross-sectional data aggregated at a country level (Afonso and St Aubyn, 2006; Agasisti, 2014; Aristovnik and Obadic, 2014; Bogetoft et al., 2015; Clements, 2002; Coco and Lagravinese, 2014; Giambona et al., 2011; Gimenez et al., 2007, 2017; Thieme et al., 2012; Verhoeven et al., 2007). Nevertheless, we can also find studies comparing the performance of education systems in different countries using school level data. For instance, Sutherland et al. (2009) study the performance of schools from 30 OECD countries participating in PISA 2003; Agasisti and Zoido (2015) derive efficiency measures for more than 8600 schools in 30 countries using PISA 2012 data comparing efficiency scores and measures of equity; Aparicio et al. (2018b) assess schools operating in the 34 OECD countries participating in PISA 2012 and identify different levels of inefficiency for reading and mathematics. Finally, De Jorge and Santín (2010) and Deutsch et al. (2013) use student-level PISA data to estimate the efficiency of European Union and Latin American countries, respectively.

Most of the above studies use nonparametric techniques like DEA or FDH to estimate performance efficiency measures since they are flexible enough to adapt to the characteristics of public services provision,[6] especially to their multi-input multi-output nature. Moreover, in some cases, a two-stage procedure is also applied to examine the potential influence of contextual variables on efficiency estimates (e.g. Afonso and St Aubyn, 2006; Agasisti, 2014; Agasisti and Zoido, 2015; Aparicio et al., 2018b; De Jorge and Santín, 2010; Verhoeven et al., 2007). The main problem with this procedure is that it assumes that environmental factors affect the shape of the distribution of inefficiencies (i.e. mean, variance, etc.) but not the attainable set or the estimated frontier. This is often

[2] Second-stage models rely on the often-unrealistic assumption that contextual variables only affect the shape of the distribution of inefficiencies, but not the attainable set or the estimated frontier (see Simar and Wilson, 2007, 2011 for details).

[3] Our definition of culture is based on the idea suggested by Fernandez and Fogli (2009), i.e. the set of beliefs and preferences that condition individuals' actions, vary systematically across either socially or geographically defined groups and are transmitted to successive generations.

[4] See Cordero et al. (2017a) for a detailed review of this literature.

[5] This is a form of stratification where students are placed in different schools or classes based on observed past or expected future achievement. This process differs widely across countries in terms of the age at which the selection takes place, as well as in the degree of differentiation between different tracks (generally distinguishing between academic or vocational education).

[6] Nevertheless, some several studies (e.g. Deutsch et al., 2013; Sutherland et al., 2009) use parametric methods.