



Innovative Application of O.R.

On the potential balance among compulsory education outcomes through econometric and multiobjective programming analysis

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ABSTRACT

This paper sheds new light on the relationship between inputs and outputs in the framework of the educational production function. In particular, it is geared at gaining a better understanding of which factors may be affected in order to achieve an optimal educational output level. With this objective in mind, we analyze teacher-based assessments (actual marks) in three different subjects using a multiobjective schema. For much of the analysis we use data from a recent (2010) Survey – ESOC10, linked with the results from an educational assessment program conducted among 11 and 15 year-old students and with the administrative records on teacher-based scores. Following the statistical and econometric analysis of these data, they are used to build a multiobjective mixed integer model. A reference point approach is used to determine the profile of, potentially, the most “successful and balanced” students in terms of educational outcomes. This kind of methodology in multiobjective programming allows generating “very balanced” solutions in terms of the objective values (subjects). Finally, a sensitivity analysis is used to determine policies that can be carried out in order to improve the performance levels of primary and secondary education students. Particularly, policy makers should be more concerned with the need to promote some cultural habits – such as reading –, from both the students' and parents' side. Additionally, policy efforts should be focused on making the vocational pathways available to Spanish youth more appealing, with the aim of taking advantage of the particular skills of students not succeeding in the academic track.

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1. Introduction

Education is a cornerstone of the welfare state and has been under evaluation at the microeconomic level particularly since 1997, when the OECD launched the Program for International Students Assessment (PISA), designed to evaluate education systems worldwide every three years by assessing 15-year-olds' competencies in key subjects (reading, mathematics and science). One of the main conclusions of these studies with regard to Spain is the relatively low performance of Spanish teenagers as compared to most of the students from the EU-15. Within Spain, Andalusia – the region for which we are conducting the research in this paper – is of special interest since pupils in this region are among the lowest achievers compared to the rest of Spain (e.g. it is one of the three worst regions in Spain in terms of reading and mathematics, as measured by test scores from PISA).¹

The policy background of this work relies on the fact that youth educational failure is a major problem in Andalusia and, in general, in Spain (together with the rest of the Mediterranean countries). In fact, leaving school early² is higher in Spain than in other UE-27 countries, and this trend has been maintained during the last two decades, reaching a rate of 28.4 percent by 2010 (23.2 percent for female students and 33.5 percent for male students),³ only surpassed by Turkey⁴; the figures for Andalusia are even worse, as 40.3 percent of male and 28.7 percent of female youngsters leave school with, at most, a lower secondary education.

Despite the dramatic size of these figures, they have shown a decreasing trend during the last five years, particularly since 2008,

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E-mail addresses: mLuque@uma.es (M. Luque), odmarcenaro@uma.es (O. D. Marcenaro-Gutiérrez), luisalej90@gmail.com (L. A. López-Agudo).¹ According to this program, Spain is placed in the thirtieth position in reading (mean score of 481), thirty-first position in mathematics (483) and thirty-third in sciences (488), slightly under the mean of the OECD countries (score of 493).² Defined as the percentage of the population aged 18–24 with at most lower secondary education and not in further education or training.³ From Eurostat (2013): “Early leavers from education and training by sex”, http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=T2020_40.⁴ The rate of early school leavers in Turkey is 47.9 percent for female students and 37.8 percent for male students (2010). On the contrary Slovenia is the country which exhibits the lowest percentage, with only 3.3 percent for female students and 6.4 percent for male students.

mainly because the economic crisis has drastically limited employment opportunities, reducing the opportunity cost of staying within the educational system. Consequently, there is a high degree of concern about the relatively low performance of students and the difficulties faced by young people in securing a good quality job as a consequence of the lack of an appropriate mix of skills required for the labor market.

It should be noted that given the high cost of education investments made by families, firms and the government, there exists a special policy interest in the extent to which different factors may affect the educational performance exhibited by students at different stages of their compulsory education and the degree to which these outcomes might be affected to achieve an “optimal” performance level.

Most of the previous literature on educational production functions has been mainly concerned with the difficulties to measure educational inputs and outputs, particularly in connection with the effect of some students’ socio-economic background, and the impact of some specific factors, such as study time, gender or parents’ highest formal education level (or social class),⁵ on some measure of educational output (mainly test based assessment),⁶ such as exam scores in a particular subject (or the mean of the scores for the whole set of subjects) controlling personal characteristics, thus failing to consider the joint balance in performance among different subjects. The latter is the main issue under scrutiny in this paper which focuses on investigating which factors, among a wide set, might be affected to achieve that optimum balance, assessing first of all the extent to which some of these factors are clearly correlated with educational performance in “reading”, “mathematics” and “English” of primary and secondary education students and, secondly, analyzing how these inputs should be combined to achieve an “optimally balanced” performance of students in the three subjects mentioned, no neglecting any of the three subjects and obtaining similar values for the three subjects. This means that we conceptualize education as a process in which a variety of inputs are used to determine a multidimensional output since we are considering the three subjects at the same time and not the global score.

Additionally, this paper aims to provide new methodological tools, combining econometric and multiobjective programming techniques, to help researchers and politicians to have a more precise view of how to improve the efficiency of the educational system. To the best of our knowledge this is the first time this methodology is deployed to evaluate the distance to an “optimal” performance level among Spanish students, although there is some previous evidence of this mixed methodology. Particularly, Wallenius, Wallenius, and Vartiainen (1978) proposed a multiobjective optimization model for formulating macroeconomics policy decisions in Finland through econometric models. Recently, in Marcenaro, Luque, and Rúa (2010) a multiobjective approach is used as a supplement to an econometric study regarding the satisfaction levels of Spanish workers.

In brief, we propose analyzing this problem with a two-step procedure. Firstly, we will proceed with econometric estimates to obtain a causal relationship between students’ performance and an individual/contextual set of features. In order to address this issue we use survey and administrative data containing records on a rich set of variables – potentially-closely related to students’ performance: immigrant condition, type of school, holding or not a grant, the educational level of the father and the mother, living or not with their parents, family events, parents control of manners, parents control of time devoted to internet, videogames and homework, attending private lessons/academies, days absent from school, students’ and par-

ents’ reading habits, assessment of teaching methods and whether or not the student is repeating a school year. These are all argued to be key correlates of a good student’s performance. At a second stage, we will make use of multiobjective programming techniques to disentangle the extent to which those correlations may be affected in order to achieve a satisfactory solution to the problem.

Multiobjective programming problems involve several multiple criteria to be optimized (maximized in our case) simultaneously. In such problems, the criteria and the constraints that determine the feasible set of alternatives can be mathematically expressed by functions. Since the criteria, also known as objective functions, are usually conflicting, there is no solution where all the objectives can reach their individual optima. Instead, it is possible to identify some compromise solutions, known as Pareto optimal solutions, non-dominated objective vectors or efficient solutions, where none of the objectives can improve without deteriorating at least another one.

In the last decades, many methods have been proposed to generate efficient solutions in multiobjective programming problems. One group of techniques is based on the reference point methodology, where some reference values (reference point) constitute the preferential information considered in the multiobjective programming model. Minimizing the achievement scalarizing function allows us to generate efficient solutions taking into account the reference point considered (Wierzbicki, 1980). The popularity of this methodology in recent years is unquestionable: Steuer and Choo (1983), Steuer (1986), Korhonen and Laakso (1986), Korhonen and Wallenius (1988), Sun, Stam, and Steuer (2000), Buchanan and Gardiner (2003), Miettinen and Mäkelä (2002, 2006), Luque, Miettinen, Eskelinen, and Ruiz (2009), Luque, Ruiz, and Steuer (2010), Marcenaro, Luque, and Rúa (2010). In our case, this methodology will be used to describe the profile of the highest performance of an Andalusian student in the current educational system, according to the survey data.

The paper thus offers a new and crucial contribution to the debate on education policies, particularly relevant in a context of economic crisis when cuts have been made to the budget assigned to education.

The rest of the paper is organized as follows. Section 2 describes the data used in our analysis, provides some descriptive statistics of the sample under scrutiny and presents information on the key outcome measures, namely exam scores at ages 11 and 15 in three different subjects. Additionally, in Section 2 we also report the results of the econometric analysis. The multiobjective programming models are formulated and solved in Section 3. Finally, the main conclusions are drawn in Section 4.

2. Data and methodology

The final model of this problem has been built following a series of steps. First, a set of data concerning Andalusian students’ performance levels, as well as some of their personal characteristics, was collected from the ESOC10-SEN survey. Then, an econometric analysis was carried out in order to find a set of variables significantly affecting the students’ educational outcomes in primary and secondary education in three different subjects; several conclusions were obtained from this econometric analysis. Based on these results, the significant decision variables of the problem were identified, and the objective functions and constraints built. Finally, a reference point scheme was used to work out the resulting multiobjective problem.

2.1. Data

The information analyzed in this paper comes largely from the Andalusian Social Survey, Education and Households (ESOC10) for 2010, in which families and students provide information on a wide range of personal characteristics, parents–school interactions and learning attributes. This survey was conducted by the Statistical and

⁵ See, e.g. Dolton, Marcenaro, and Navarro (2003).

⁶ Predominantly those reported by the International Assessment Programs (PISA, TIMSS, PIRSL, etc.).

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