

Multi-factor Efficiency Analysis of the Florence University Graduates

Analisi Multi-fattore dell'Efficienza dei Laureati nell'Ateneo fiorentino

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Riassunto: In questo lavoro si propone l'utilizzazione di un modello stocastico per la stima simultanea della misura di efficienza tecnica e delle determinanti delle *performance* dei laureati. Ricorrendo al concetto di meta-frontiera si introducono ulteriori elementi per impostare un confronto di efficienza tra laureati in facoltà diverse.

Keywords: Stochastic frontier, Technical efficiency, Exogenous variables, Meta-frontier

1. Introduction

The recent changes introduced by the reform of the Italian university system have generated increasing attention on issues related to the measurement of productive efficiency and the construction of performance indicators for university institutions, with the aim of increasing the efficiency and the effectiveness of the university system, as well as to improve the quality of graduates. Therefore, it is worth analysing the present situation, in order to better understand the actual condition of Italian university studies, both as such and for the sake of comparing it to that which will be obtained after the above reform produces its first effects. This paper will investigate the issue of identifying the educational production *frontier*. In particular, we will adopt a stochastic frontier production function (pf), which has been adjusted to account for exogenous influences (e.g. student characteristics). The paper is organized as follows. In Section 2, a model of human capital formation as a “production” process with regard to the Italian university is briefly described. In Section 3, the model specification is provided. Empirical results are presented in Section 4, after describing the data. Section 5 contains some concluding comments.

2. The Human Capital Production in the Italian University System

The formation of a graduate in the university is a very complex process, as it involves cultural and intellectual elements, like lectures, tutorials, discussions, seminars, as well as material and non-material goods, such as libraries, class rooms, computers, student assistance services, secretarial offices, tutorship. As such, this formation can be viewed as a production process, whose analysis can be effectively performed in the framework of the neoclassical production theory. Nevertheless, it is evident that the education

production process is characterized by specific features which distinguish it from the “classical” productive processes (Ferrari and Laureti, 2002).

Among these peculiarities, emphasis should be placed upon the heterogeneity of the students who differ from each other in a number of *exogenous* dimensions, such as gender, age, school leaving certificates, individual psychological, social, and household characteristics. Furthermore, the student plays both active and passive roles in the production process. Thus, it seems reasonable to consider him/her as the basic production unit who, by using factors supplied by the faculty he/she attends (e.g. professors and seats in a lecture hall), as well as factors that are peculiar to the individual student (e.g., pre-university training), *produces him/herself as a graduate*.

Given that the Italian universities are for more than 90% publicly-owned, our analysis is put in a *technical efficiency* framework.

Since the characteristics of the students strongly affect the results, in this paper we will use a reasonable and sustainable model that allows to capture the peculiar characteristics of the process and the description of the intrinsic meaning of the university training activity, while fulfilling all the basic conditions of neoclassical theory.

3. Incorporating Student Characteristics on Efficiency

We assume that the exogenous factors do influence the degree of technical inefficiency and hence that these factors should be modelled so that they directly influence the inefficiency term. In this context, sometimes a two-stage estimation approach is used, where the first stage involves the specification and estimation of a stochastic frontier pf and the prediction of the technical efficiency scores of the units and the second one the specification of a regression model where the technical efficiencies are regressed on explanatory factors relevant to the analysis. In this paper, we consider a single stage approach where the technical inefficiency effects are a function of students’ characteristics, to avoid the inconsistency in the above two-stage method pointed out by Kumbhakar and Lovell (2000). Models of this form have been proposed by a number of authors (see, for example, Battese and Coelli, 1995).

Since the mix of resources (e.g., human resources, physical plant, intellectual and technological materials) and the internal organization varies from faculty to faculty, and as the educational products are “delivered” in highly different ways, we will estimate a frontier model for each faculty, separately. Then, starting from the concept of *meta-frontier* function (M), recently employed by Battese e Rao (2002) and still under discussion, we will be able to give additional explanation for the graduate ability in a faculty to compete with other graduates from other faculties within the university. Thus, for the j th faculty, the stochastic frontier model (Aigner, Lovell and Schmidt, 1977) is defined by $y_{ij} = \exp(\mathbf{x}_{ij}\boldsymbol{\beta} + v_{ij} - u_{ij})$, $i = 1, 2, \dots, N_j$; $j = 1, 2, \dots, k$, where, for the i th graduate in the j th faculty, y_{ij} denotes the output and $\mathbf{x}_{ij}$ represents a vector of inputs; $\boldsymbol{\beta}$ is a vector of unknown parameters to be estimated; the v_{ij} s are assumed to be i.i.d. random errors $\sim N(0, \sigma_v^2)$; the u_{ij} s are non-negative unobservable random variables associated with the technical inefficiency of production, such that, for the given technology and levels of inputs, the observed output falls short of its potential output. These effects are defined by a regression model $u_{ij} = \mathbf{z}_{ij}\boldsymbol{\delta} + w_{ij}$, where $\mathbf{z}_{ij}$ is a vector of explanatory

variables (i.e., student characteristics); δ is a vector of unknown parameters to be estimated; w_{ij} s are unobservable random variables, which are assumed to be i.i.d. obtained by truncation of the normal distribution with zero mean and unknown variance, such that u_{ij} is non-negative (i.e. $w_{ij} \geq -\mathbf{z}_{ij}\delta$). The technical efficiency of the i th graduate in the j th faculty is defined by $TE_{ij} = \exp(-u_{ij}) = \exp(-\mathbf{z}_{ij}\delta - w_{ij})$. The stochastic meta-frontier model, defined by the above stochastic frontier and regression models, is estimated using data from graduates from all faculties simultaneously. The stochastic meta-frontier may not envelop the separate frontiers for the different faculties involved.

4. Empirical Results

The production frontiers, specified by the two above models, are estimated by using individual data taken from several sources coming from a comprehensive survey on the job opportunities of nearly 2,500 graduates from the University of Florence in 1988. Additional data on the didactic inputs of faculties was collected from the administrative archives and the Central Library. The production technology is specified, for each faculty, by a Cobb Douglas pf with five inputs: (i) average number of professors and researchers per graduate; (ii) average number of seats in lecture halls per student; (iii) average number of books in the library per student; (iv) average number of journals in the library per student; (v) final high-school mark. We have defined an output measure as the ratio of average grade of the exams related to the effective length of study compared to the obligatory length. Among potential explanatory variables in the regression model, we have considered gender, macro-region of residence, working status while attending university, type of diploma and any repeated year at high school.

The maximum likelihood estimates of the parameters in the stochastic frontier model, given the specifications for the technical inefficiency effects defined by the regression model, are obtained using the program Frontier 4.1. The prediction of the technical efficiencies for each graduate is based on its conditional expectation, given the model assumption.

Using generalised likelihood ratio (LR) tests, the null hypothesis that the technical inefficiency effects were not present in a given faculty, given the specifications of the stochastic frontier model, was rejected for all faculties at a level of significant $\alpha=0.05$.

In Table 1 we present some selected results. According to the LR test, the null hypothesis that the technical inefficiency effects are not influenced by the level of the explanatory variables in the regression model is rejected by the data at a level of significant $\alpha=0.05$.

It can be argued that the graduates of Economics coming from School of Commerce and Technical School have a relatively higher efficiency score compared to the graduates coming from “Liceo Scientifico”. The positive estimate for graduates in Architecture with a technical high school certificate, along with the above result, could suggest a positive effect on efficiency due to continuity in the studied subject. The female coefficient is negative for all the faculties considered (with the exception of Biology and Mathematics), which shows that the female graduates are more inefficient than the males. Graduates of Biology and Mathematics and Law, who worked during their academic career, are relatively less efficient than those who didn’t work. The negative estimate for graduates who repeated a year at high school (statistically significant for graduates of Economics

and Laws) implies that students with a non-regular pre-university career tend to be less efficient.

Table 1: *Technical Efficiency Variables*

	Economics		Architecture		Law		Biology and Mathematics	
	Coef	t-ratio	Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio
Constant	-2.210	-3.640	-0.298	-4.015	-1.660	-3.839	-0.013	-0.152
“Liceo classico”	-0.025	-0.100	0.204	3.289	0.129	2.127	0.093	0.968
“Liceo linguistico”	-0.161	-0.950	0.322	2.934	0.827	4.189	0.075	0.606
School of Commerce	0.278	3.060	-0.081	-0.393	0.567	4.390	0.208	2.112
Technical College	0.503	3.099	0.203	4.340	0.298	3.345	0.063	0.912
Female	-0.141	-2.808	-0.094	-2.218	-1.014	-4.521	-0.052	-1.011
Working	-0.03	-0.641	-0.002	-0.046	0.310	3.257	-0.302	-3.057
Residence near Florence	0.393	3.878	0.049	0.989	-0.226	-3.400	0.193	2.744
Residence far from Florence	1.514	3.979	-0.009	-0.150	0.543	4.385	0.115	0.973
Repeating a year at school	-0.501	-3.815	-0.081	-1.360	-0.293	-3.662	-0.258	-1.143

5. Some Concluding Remarks

The above rough analysis shows that the joint effects of the selected explanatory variables on the inefficiencies of production are significant, although the individual effects of one or more of the variables may not be statistically significant. Moreover, there is evidence that student characteristics cannot be neglected without introducing a bias in the estimation of pfs for educational production process. In order to give a better overview of the comparability of technical efficiency scores across faculties, we can use a decomposition result involving both the faculty frontiers and the meta-frontier. The mean values of the *technology gap ratio*, obtained for each graduate from $TGR_{ij} = e^{x_{ij}\beta} / e^{x_{iM}\beta}$ vary from about 0.71 (Economics) to 0.82 (Law). These results imply that, for Economics, the graduates produce, on average, about 71% of the potential output given the technology available to the university as a whole. Whereas, graduates of Law produce, on average, 82% of the potential output. Further investigation is in progress; in addition, empirical analyses with alternative pfs (e.g., translog pf) and technical inefficiency models will be carried out.

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