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University efficiency and public funding for higher education in Bulgaria

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The recent pressure on public finances in Bulgaria has exposed the need for a performance-based system of public funding for higher education. This article estimates the relative technical and cost efficiency of Bulgarian universities and explores the correlation between public funding and efficiency levels. In particular, a recent government proposal to use university rankings for the allocation of funds is evaluated with regard to efficiency. The results indicate that public universities are less efficient than private institutions, especially in teaching-related aspects. A larger share of the education market, fewer fields of study and more science-related majors result in efficiency gains. Efficiency is not a significant determinant of the amounts of subsidy allocated to a university, while the rankings of efficiency and funding are found to be negatively correlated. However, the rankings to be used under the proposed policy are positively related to cost efficiency, suggesting that the reform effort is a step in the right direction.

The outflow of academics and students from Bulgaria over the past two decades has been detrimental to the growth and development of one of the poorest countries in Europe. Low-quality teaching and research, ill-adapted and obsolete curricula, scant resources, lack of modern technology, low pay and the absence of job opportunities for graduates have all contributed to the brain drain. These are symptoms of an inadequate and dysfunctional system of public funding for higher education, which is the focus of this article. Despite numerous reforms since the start of the market transition in the early 1990s, public universities remain dependent on a government subsidy that is determined solely on the basis of quantitative indicators such as student enrolment. This has created a perverse incentive for public universities facing a chronic shortage of funds and pressure from private and foreign competitors to expand student enrolment in order to secure financial resources irrespective of efficiency and quality concerns. The drastic budgetary cuts in the wake of the global economic crisis and the ensuing recession have increased the urgency for the government to reform the system of public funding for higher education by taking into account how universities manage their financial resources. In late 2010 the government unveiled a new ranking of universities which is supposed to serve as a benchmark in the allocation of budgetary funds in the future. However, this ranking, described in more detail in the next section, has focused on the outcomes of the teaching and research process while ignoring the costs involved in obtaining them.

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The goals of this article are threefold. First, we estimate the relative efficiency of public and private institutions of higher education in Bulgaria using a number of quantitative and qualitative indicators from a unique data set. In particular, we employ a non-parametric methodology to estimate the extent to which colleges and universities minimise their input costs in the process of obtaining a certain level of educational outputs. The efficiency levels are ranked relative to a benchmark composed of the best-performing institutions. Second, we examine the correlation between the estimated efficiency levels and the corresponding amount of government subsidies to test whether the current system of public funding rewards efficiency.[1] We hypothesise that this is not the case given the fact that subsidies are based mostly on student enrolment rather than on performance. We also explore the correlation between our efficiency-based ranking and the recent official university ranking that could shape the new mechanism for disbursing budgetary funds for higher education. Third, we identify the determinants of efficiency and the government subsidy using regression analysis, which allows us to formulate policy recommendations aimed at reforming the system of public funding for tertiary education in Bulgaria.

Numerous studies have estimated the efficiency of universities in different countries around the world using various parametric and non-parametric methods (for an overview see Worthington (2001) and Johnes (2006)). Empirical research has focused mostly on universities in English-speaking countries, including the United States (Kokkelenberg *et al.* 2008), the United Kingdom (Izadi *et al.* 2002, Flegg *et al.* 2004, Glass *et al.* 2006), Canada (McMillan and Chan 2006) and Australia (Abbott and Doucouliagos 2003, Worthington and Lee 2008). Several studies have examined the relative performance of universities in Italy (Agasisti and Salerno 2007, Agasisti and Johnes 2010), Germany (Fandel 2007, Kempkes and Pohl 2010) and China (Ng and Li 2009). Another group of papers has estimated the efficiency of departments within a university (Johnes and Johnes 1993, Tauer *et al.* 2007, Kao and Hung 2008) and of a given academic programme across universities (Colbert *et al.* 2000).

The present article differs from previous studies in two major respects. First, the existing literature is limited almost exclusively to the estimation of efficiency levels and robustness tests of the resulting scores across various specifications of the model and variables. The major contribution of this study is that it goes a step further and links the performance of public universities to the levels of government funding they receive. The few studies that explore the relationship between efficiency and funding for higher education focus only on technical efficiency within a single university. Caballero *et al.* (2004) show that the allocation of budgetary funds for hiring teaching staff among departments at the University of Malaga in Spain improved the average technical efficiency with respect to teaching. In contrast, Tajnikar and Debevec (2008) report that inefficient departments within the University of Ljubljana in Slovenia received disproportionately more funds than efficient ones.

In comparison with these studies, our analysis is more comprehensive in that it estimates technical as well as cost efficiency for various groups of Bulgarian universities, correlates performance with funding levels, and investigates the factors that influence efficiency and the amount of government subsidy. Moreover, the proposed change in the mechanism of public funding for higher education in Bulgaria represents a natural experiment that allows us to test whether the new criteria for subsidy allocation reward efficient management of financial resources more than the existing system.

The second difference is that with the exception of Tajnikar and Debevec (2008) all previous works have evaluated universities in the developed countries of North

America, Australia and Western Europe, where public funding for higher education is relatively smooth even during economic downturns or where public universities have enough flexibility to compensate for decline in government subsidies by other means. In contrast, this study assesses the performance of institutions of higher learning in a transition economy in Eastern Europe which is also the poorest member state of the European Union. The requirements of strict fiscal discipline and the associated austerity measures have led to deep cuts in the subsidy to public universities and have exposed the need to introduce a performance-based system of public funding for higher education. The article evaluates the reform efforts in Bulgaria, which could provide important lessons for other countries in Central and Eastern Europe facing similar problems.

The article is organised as follows: the first section provides a brief overview of higher education in Bulgaria. The next two sections describe the methodology and the specification of input and output variables respectively. The results of the analysis are then presented and the final section concludes.

Higher education in Bulgaria

Until the breakdown of the communist system in 1989–90 all institutions of higher education were controlled by the state and relied exclusively on government funding. The introduction of democracy and market reforms in the early 1990s brought major changes. Universities were given academic autonomy, enabling them to overhaul their curricula and introduce new programmes. Although public funding remained the major source of income, universities were now allowed to admit fee-paying students alongside those who qualified for a free education through entrance exams. Moreover, private universities were founded which were quick to introduce Western-style degree structures and relied entirely on tuition fees and private donations.

Despite many positive developments, higher education also faced a myriad of challenges. Between 1990 and 2001 the number of university students increased by almost 50% while the number of academic staff rose by only 3% (Georgieva *et al.* 2002). Government funding for higher education as a share of GDP fell from 6% in 1992 to 3.6% in 2000 and had risen to only 4% in 2006. The share allocated to research funding was under 0.5% in the late 1990s, and research spending comprised less than 1% of university budgets (Middlehurst and Woodfield 2004). The worsening quality of higher education due to a boom in enrolments, scant resources and archaic curricula, as well as the lack of research funding and career prospects, have caused a large number of students and academics to leave Bulgaria and seek better opportunities abroad. Tens of thousands of Bulgarian students have enrolled in universities around the world, and since Bulgaria joined the EU in 2007 the possibilities to study and work abroad have widened considerably.[2]

Since 2001 the single most important source of income for public universities in Bulgaria has been the allocation of funds from the government budget based largely on the number of enrolled students in six broad fields of study. In response, public universities have been eager to admit as many students as possible and open new departments in as many fields as possible in order to maximise the amounts of government subsidy they receive. When the global financial and economic crisis reached Bulgaria in 2009 a newly elected government faced with fiscal problems severely reduced the disbursement of budgetary funds to universities and vowed to reform the system of public funding for higher education by focusing on efficiency improvements.[3]

In November 2010 the Bulgarian Ministry of Education, Youth and Science (MEYS) unveiled a new ranking system of all accredited public and private institutions of higher education in the country based on a large number of quantitative and qualitative indicators across all fields of study offered in each institution. The primary objective of the rankings was to provide prospective students and their parents with more information for selecting a college or university. Moreover, it allowed institutions of higher learning to identify their strengths and weaknesses in a comparative context and evaluate their position on the market for educational services. More importantly, the MEYS planned to use the rankings for determining the amounts of the subsidy allocated to public universities in the future. Shortly after the introduction of the new rankings, the minister of education announced a gradual decrease by 10% in the level of budgetary funding for public universities that were at the bottom of the rankings.

The new rankings are doubtless a major step toward a more competitive educational system in Bulgaria based on informed choice and quality of education. However, using them as the basis for determining the levels of public funding for institutions of higher education is problematic because they focus almost exclusively on the outputs of the educational process. The cost at which these outputs were obtained is not addressed by the rankings but should be taken into account if efficiency improvements are to be achieved. In other words, government funding should reward those public institutions that manage their resources most efficiently relative to their competitors for budgetary funds. This is particularly relevant given the fact that public colleges and universities are ranked together with their private counterparts, which are much more flexible in their financing.

Methodology

Estimating the efficiency of universities requires that tertiary institutions be treated as production units that generate outputs by employing inputs at a certain cost. From this perspective, universities employ labour (academic and other staff) and use capital (lecture halls, laboratories, libraries, equipment) to produce and disseminate knowledge by teaching students and conducting research, which is published in academic journals and books. Technical efficiency is defined as the attempt to produce the maximum levels of outputs given a certain level of inputs. Alternatively, universities can seek to achieve efficiency by minimising the amount of inputs for a given level of outputs. In the case of Bulgaria, the output-maximising behaviour is more realistic because the public universities that dominate tertiary education cannot easily dispose of academic or other staff and physical capital without government approval. Furthermore, given that government subsidies depend on the number of students enrolled, one of the few options for public universities to maximise their revenue is to admit as many students as possible. While technical efficiency focuses on the quantitative aspects of inputs and outputs, cost efficiency also takes into account the costs associated with the production process. In particular, universities could achieve cost efficiency if they found a combination of inputs and their corresponding input prices that would minimise the overall cost of running an institution of higher learning. Cost efficiency is thus a more comprehensive measure than technical efficiency.

In practice, the efficiency of a university is evaluated relative to a reference point on a benchmark production frontier. The efficiency level is a radial measure of the distance between a given university and the best-practice frontier calculated as the ratio of actual to potential performance (Farrell 1957). Accordingly, a university is considered efficient if its performance corresponds to a point on the best-practice frontier. This approach allows us to identify the most technically and cost-efficient universities within Bulgaria, even if they might be inefficient in international comparison, and estimate the extent of inefficiency of all other universities relative to the best-performing institutions.

The radial measure of efficiency relies on the existence of a benchmark production frontier which is not observed in practice. In this study, we employ data envelopment analysis (DEA), a non-parametric method that uses mathematical programming to construct a piecewise linear production frontier which envelops the observed data points and treats all deviations from the frontier as inefficiency. This methodology allows the data to determine the form of the frontier without imposing any restriction that might misspecify the production technology. The alternative methodology used in the literature, the stochastic frontier approach (SFA), requires, in contrast, *a priori* specification of the functional form of the frontier. The major drawback of the DEA approach is the sensitivity of efficiency measures to outliers and sampling variation.[4] For this reason we use the bootstrapping method of Simar and Wilson (1998) to test the robustness of our DEA estimates. The bootstrapping produces bias estimates which are then used to correct for the bias of the original DEA estimates.

First, we estimate the technical efficiency of Bulgarian universities by solving the following output-oriented linear programming model developed by Banker *et al.* (1984):

$$\begin{aligned} \theta^* &= \max_{\theta,\lambda} \theta \\ s.t. \quad \theta x_{io} &\leq \textstyle\sum_{j=1}^{n} \lambda_j x_{ij} \quad i = 1, \ldots, m \\ y_{ro} &\geq \textstyle\sum_{j=1}^{n} \lambda_j y_{rj} \quad r = 1, \ldots, s \\ \textstyle\sum_{j=1}^{n} \lambda_j &= 1 \\ \lambda_j &\geq 0 \quad \forall j \end{aligned} \tag{1}$$

where x_{ij} and y_{rj} denote the levels of the ith input and rth output of the jth university, $j = 1, \ldots, n$. The first two constraints require that the performance of a given university o in terms of its inputs x_{io} and outputs y_{ro} is located within a production possibility set defined by the envelopment of all data points. The last two constraints, where λ is an $N \times 1$ vector, allow for variable returns to scale by imposing a convexity restriction which generates a frontier in the form of a convex hull of intersecting planes. The scalar $\theta*$ which is the optimal solution of the maximisation problem in Equation (1) represents the efficiency score of a given university. If $\theta* = 1$, the university is located on the best-practice frontier and is thus efficient, whereas $0 < \theta* < 1$ indicates inefficiency.

Next, we make use of the data on input prices and estimate the cost efficiency by solving the following linear programming model based on Farrell (1957):

$$\begin{aligned} c_{io}x_{io}^{*} &= \min_{x,\lambda} \textstyle\sum_{i=1}^{m} \sum c_{io}x_{io} \\ s.t.\, x_{io} &\geq \textstyle\sum_{j=1}^{n} \lambda_j x_{ij} \quad i = 1, \ldots, m \\ y_{ro} &\leq \textstyle\sum_{j=1}^{n} \lambda_j y_{rj} \quad r = 1, \ldots, s \\ \textstyle\sum_{j=1}^{n} \lambda_j &= 1 \\ \lambda_j &\geq 0 \end{aligned} \tag{2}$$

where the constraints, including variable returns to scale, are identical to the model in Equation (1) but the goal is to minimise the production cost represented by the product of the input x_{io} and its corresponding price c_{io}. The optimal solution is the input vector $x*$ which when multiplied by the input-price vector c determines the minimum cost. The cost efficiency (*CE*) score for each university is then obtained by evaluating the minimum cost $cx*$ relative to the observed cost cx as follows:

$$CE = \frac{cx^*}{cx} \tag{3}$$

where $0 < CE \leq 1$ and the university is cost-efficient only if $CE = 1$. Technical efficiency is a necessary condition for cost efficiency on the best practice frontier but not vice versa.

With regard to technical efficiency, the input variables we use focus on the employment of labour and physical and financial capital to achieve teaching and research goals. In particular, we include the number of academic staff, the size of the area used for teaching and research, the number of library items and the amount of research funds. In the cost efficiency models we also add the price of labour and capital, defined as the average annual academic salary and the non-salary operating costs per square metre of floor area respectively. The output variables assess teaching and research from a quantitative as well as a qualitative perspective. In terms of teaching outputs, we choose the number of domestic and foreign students along with the mean salary after graduation and the (reciprocal of the) unemployment rate, which reflect the quality of the education.[5] The share of foreign students is a quality indicator, as foreigners choose to attend a Bulgarian university either because they believe that the education they get is better or the tuition fees they have to pay for a degree of equivalent quality are lower than in their home countries. Unemployment and salary of graduates, which have been used as performance indicators in previous studies (Smith *et al.* 2000, Belfield and Fielding 2001, Bratti *et al.* 2004), provide a gauge of the potential job opportunities associated with the completed education and the monetary value of the degree on the market respectively. Obviously, employment and salary also depend on economic factors that fall outside the control of universities. Nevertheless, the narrow focus of higher education in Bulgaria on preparing graduates for certain occupations makes it imperative to take into consideration job market factors.[6] In addition, given the small size of the country, the universities operate in more or less the same macroeconomic environment.[7] As for the research output, we opt for the number of peer-reviewed publications and a citation index that reflects the quality of published work by academic staff.

Data

Our data come from 46 of the 50 accredited tertiary institutions in Bulgaria.[8] These are classified as public if they are financed by MEYS or private if they rely on tuition fees and private donations. Institutions of higher learning are further grouped into three categories depending on their academic focus. Universities typically offer degrees across a broad spectrum of academic disciplines, which may include life sciences, social sciences, humanities, arts and often even some professional degrees such as law, medicine and engineering. Professional schools offer degrees in a specific field that usually qualify graduates to work in a particular profession. Beside traditional schools in medicine, arts, finance and engineering, there are a number of institutions in this category that focus on a particular agricultural or industrial sector (e.g. University of Forestry, University of Food Technology, University of Mining and Geology).[9] The third category encompasses colleges which, in contrast to most universities and professional schools, are exclusively private institutions that were founded after the start of the transition in 1990. Colleges, most of which specialise in business and finance, share in general the narrow focus of professional schools.

The data on input and output variables are for 2009 unless otherwise noted, and were obtained from an on-line database provided by MEYS in connection with the release of the official ranking of institutions of higher learning.[10] The input variables used in the efficiency analysis include academic staff, area, library items and research funds. The number of academic staff include all staff who are under contract with the university and teach in at least one academic field. The area measures the square meterage of all rooms in university buildings used for teaching and research purposes. Library items are defined as books, periodicals, microfilms, compact disks and other materials available in the library or in storage at a given university with the exception of electronic databases. Research funds represent the sum of government subsidies, external grants and donations assigned for research purposes.

In the cost efficiency models we focus only on public universities and employ only two inputs owing to limitations of the data. Labour and its price are measured as the number of academic staff and their average annual salary respectively. We use the floor area of university buildings utilised for research and teaching as a proxy for capital. The price of capital is calculated as the ratio of operating costs to floor area. Operating costs include maintenance and repairs, utilities and work by external contractors. Alternatively, we measure the price of capital as the ratio of capital expenditure to floor area, taking into account spending on equipment and materials for teaching and research purposes, library items and new buildings and infrastructure.

The teaching output is evaluated with regard to the number of domestic and foreign students as well as the starting salary and unemployment rate of graduates. The number of students counts all individuals enrolled in an undergraduate or a graduate programme. Using enrolled students rather than graduates is due to the lack of data but also reflects the fact that students acquire knowledge by taking classes even if they do not eventually graduate. The salary is measured as the average monthly income that is subject to social security tax earned by individuals who graduated from a given university in the previous three academic years. The unemployment rate is the percentage of individuals who graduated from a given university in the past three years and are officially registered as unemployed. The data on salary and unemployment were obtained from the Bulgarian National Social Security Institute and reflect the average monthly income and unemployment rate in March 2010.

The research output is assessed with regard to the number of publications and citations. The publications encompass only articles published in refereed journals by academic staff over the period 2005–09. The data were collected from the SCOPUS database, which covers a very large number of international refereed publications, including 53 Bulgarian titles.[11] The quality of the publications is measured by the h-index reported in SCOPUS, which takes into account the number of publications and the number of citations per publication over the period 2005–09.

The descriptive statistics reported in Table 1 indicate that tertiary education in Bulgaria is dominated by public institutions, which represent more than two-thirds of all institutions of higher learning. Government-funded institutions are much larger than their private counterparts across almost all categories and are more productive in research. Graduates of private institutions have a slightly higher average monthly income (albeit with a higher standard deviation) but also a higher unemployment rate. Furthermore, the substantial number of professional schools and colleges indicates that tertiary education in Bulgaria is focused on preparing students for a specific occupation rather than providing a broad liberal arts education. While universities are about twice as large as professional schools in terms of students, academic staff, research funds and publications, their graduates have the lowest salaries and the highest unemployment of all

Table 1. Descriptive statistics of Bulgarian universities.

	Total	Public	Private	University	Professional school	College
Number of institutions	46	33	13	12	25	9
Number of students	5814 (5443)	6350 (5826)	4455 (4220)	10523 (5915)	4633 (4579)	2821 (2817)
Foreign students (%)	4.6 (7.2)	5.1 (6.1)	3.3 (9.8)	5.0 (9.8)	5.8 (6.8)	0.5 (0.6)
Number of academic staff	322 (338)	411 (354)	95 (126)	511 (410)	333 (297)	36 (16)
Area per student (m^2)	9.0 (9.3)	10.6 (10.2)	4.9 (4.5)	7.2 (8.7)	11.1 (10.3)	5.6 (5.3)
Library items per student	36.6 (31.2)	43.8 (29.2)	18.9 (29.6)	46.8 (33.7)	41.9 (30.6)	9.6 (9.0)
Research funds[a]	1687 (2607)	2129 (2918)	563 (935)	3123 (3910)	1522 (3910)	229 (209)
Number of publications[b]	163.3 (398.9)	223.8 (458.6)	9.7 (19.9)	299.2 (659.3)	156.7 (282.7)	0.4 (1.3)
Citation index[c]	5.1 (6.5)	6.6 (7.0)	1.3 (2.3)	8.3 (7.7)	5.2 (6.1)	0.2 (0.7)
Mean monthly salary[d]	1016.9 (179.5)	1000.5 (143.1)	1058.5 (252.2)	969.4 (282.6)	1029.6 (141.5)	1044.7 (81.8)
Unemployment rate	3.2 (1.6)	3.1 (1.6)	3.4 (1.6)	4.0 (1.8)	2.7 (1.4)	3.7 (1.4)
Price of labour[e]	–	10121 (2630)	–	10297 (1711)	10065 (2891)	–
Price of capital[f]	–	145 (181)	–	132 (205)	148 (177)	–

Notes: The reported numbers are averages with standard deviations in parenthesis. For comparison purposes, 1 Euro = 1.96 Bulgarian leva.
[a] in thousands of Bulgarian leva.
[b] over the period 2005–09.
[c] h-index of citations over the period 2005–09.
[d] In Bulgarian leva as of March 2010 for individuals who graduated in the previous three years.
[e] mean annual salary of academic staff in Bulgarian leva.
[f] operating costs in Bulgarian leva per square metre of floor area.

three categories. In comparison, colleges have small student bodies and only a minimal amount of research but their graduates earn the highest average starting salaries.

Results

Efficiency levels

We estimate three groups of DEA models measuring different aspects of technical efficiency. The corresponding combinations of input and output variables are summarised in Table 2. The first specification of the model focuses on the teaching-related outputs of a tertiary institution, while the second deals only with outputs associated with research. The data do not allow us to separate the inputs according to their teaching and research use, which certainly introduces a bias in the results for these two models. However, we believe that it is crucial to examine teaching and research aspects separately owing to the different emphasis placed on these outputs by the three categories of institutions in the sample. The third specification combines various teaching and research outputs to produce comprehensive measures of technical efficiency.[12]

The efficiency levels from the teaching-oriented models are presented in the first two columns of Table 3 and indicate that the estimated inefficiency ranges between 15% and 25%. On average, efficiency levels increase when starting salary is included in the model instead of the number of foreign students. Private schools are much more efficient than their public counterparts, while universities are found to be better performers than professional schools. As is evident from the third column of Table 3, Bulgarian institutions of tertiary education are far from using their resources for research optimally. In this model, public schools exhibit a much higher efficiency than private ones, while universities perform better than professional schools, with colleges a distant third.

The comprehensive measures in columns 4 to 6 of Table 3 suggest that private schools exhibit overall less than 10% inefficiency, while the inefficiency levels of institutions relying on public funding range between 16% and 28%. The difference in efficiency levels

Table 2. Input and output variables of the estimated DEA models.

	Technical efficiency						Cost efficiency		
	Teaching		Research	Comprehensive					
	T(1)	T(2)	R	C(1)	C(2)	C(3)	(1)	(2)	(3)
Input variables									
Academic staff	x	x	x	x	x	x	x	x	x
Floor area	x	x	x	x	x	x	x	x	x
Library items	x	x							
Research funds			x	x	x	x			
Output variables									
All students		x		x	x	x	x	x	x
Domestic students	x								
Foreign students	x								
Unemployment	x	x			x		x		
Starting salary		x				x		x	
Publications			x	x	x	x	x	x	x
Citation index			x	x					x
Prices									
Academic salary							x	x	x
Operating costs							x	x	x

Table 3. Levels of technical and cost efficiency of Bulgarian institutions of tertiary education.

	Technical efficiency						Cost efficiency		
Focus[a]	T(1)	T(2)	R	C(1)	C(2)	C(3)	(1)	(2)	(3)
Total	0.75 (0.27)	0.85 (0.17)	0.44 (0.41)	0.77 (0.31)	0.78 (0.24)	0.87 (0.14)	–	–	–
	0.78 (0.25)	*0.90 (0.14)*	*0.45 (0.42)*	*0.81 (0.27)*	*0.83 (0.21)*	*0.90 (0.12)*			
Public	0.68 (0.27)	0.80 (0.17)	0.49 (0.39)	0.72 (0.34)	0.72 (0.24)	0.84 (0.15)	0.69 (0.23)	0.65 (0.24)	0.68 (0.23)
	0.71 (0.25)	*0.86 (0.15)*	*0.50 (0.40)*	*0.75 (0.30)*	*0.77 (0.21)*	*0.88 (0.12)*	*0.73 (0.24)*	*0.68 (0.27)*	*0.74 (0.22)*
Private	0.93 (0.17)	0.99 (0.01)	0.30 (0.42)	0.91 (0.17)	0.93 (0.19)	0.96 (0.10)			
	0.95 (0.12)	*1.00 (0.00)*	*0.32 (0.45)*	*0.95 (0.10)*	*0.95 (0.15)*	*0.96 (0.09)*	–	–	–
University	0.78 (0.28)	0.85 (0.19)	0.55 (0.31)	0.88 (0.12)	0.83 (0.19)	0.86 (0.14)	0.69 (0.23)	0.69 (0.23)	0.75 (0.21)
	0.79 (0.27)	*0.87 (0.17)*	*0.57 (0.32)*	*0.90 (0.12)*	*0.85 (0.19)*	*0.89 (0.14)*	*0.71 (0.22)*	*0.71 (0.22)*	*0.77 (0.20)*
Professional school	0.69 (0.27)	0.80 (0.16)	0.47 (0.43)	0.67 (0.37)	0.71 (0.25)	0.84 (0.15)	0.69 (0.24)	0.63 (0.25)	0.65 (0.24)
	0.72 (0.25)	*0.83 (0.14)*	*0.48 (0.44)*	*0.71 (0.33)*	*0.76 (0.21)*	*0.88 (0.12)*	*0.74 (0.25)*	*0.65 (0.28)*	*0.70 (0.23)*
College	0.90 (0.20)	0.99 (0.02)	0.20 (0.39)	0.91 (0.19)	0.92 (0.23)	0.98 (0.07)	–	–	–
	0.93 (0.14)	*1.00 (0.00)*	*0.21 (0.41)*	*0.96 (0.09)*	*0.94 (0.18)*	*0.98 (0.07)*			

Notes: The reported numbers are average levels of efficiency with standard deviation in parenthesis. The bootstrap estimates and their standard deviations are in italics.
[a] T = teaching, R = research, C = comprehensive.

between universities and professional schools is large when research quality is included in the model but almost negligible when salary is used instead.

The three cost efficiency models are estimated only for public schools owing to lack of expenditure data for private institutions. The input/output combinations are reported in Table 2, while the results are presented in the last three columns of Table 3.[13] The fact that efficiency deteriorates when input prices are taken into account suggests the presence of allocative inefficiencies. The levels of cost inefficiency exceed 30% and are quite robust across the three specifications of the model. The differences between universities and professional schools are negligible except when research quality is introduced as output, in which case the former are more efficient than the latter.

Given the deterministic nature of DEA estimation, we test the robustness of the estimates using the bootstrapping procedure of Simar and Wilson (1998). The bias-corrected efficiency scores are reported in italics under the corresponding raw scores in Table 3. The bootstrap estimates are generally higher than the raw scores, but none of the differences between the two measures is statistically significant. Nevertheless, we use the bias-corrected scores in the rest of the article.

Rankings

The estimated efficiency levels allow us to examine whether the current system of public funding for tertiary education in Bulgaria rewards the best-performing institutions. For this purpose we investigate the correlations between official and financial rankings, on the one hand, and the technical and cost efficiency rankings on the other.

The official ranking of Bulgarian universities released by MEYS in 2010 is based on six groups of criteria: teaching, research, student resources, career opportunities after graduation, campus life and prestige. In the overall score the greatest weight is assigned to professional success after graduation (30%), followed by teaching and research (20% each) and prestige (15%).[14] The official ranking assigns a total of 100 to the institution with the maximum scores across all criteria. In practice, the highest score in any field is 72 and the lowest 10. To make comparisons with efficiency rankings possible, we convert these scores into a relative scale with the top-ranked institution receiving a score of 100.

In addition, we design a financial ranking for the public institutions based on the amount of government funding they receive. The government subsidy for tertiary institutions contains funding for teaching, research, capital expenditure, financial aid and health insurance for students. The teaching subsidy is by far the largest component, accounting for about three-quarters of the total funds allocated to a university. The amount of the teaching subsidy is determined by the number of domestic students across six broad fields of study.[15] The amount of financial aid and health insurance also depends on the number of enrolled students. We divide the total amount of government subsidies each public institution received in 2009 by the number of its students and convert the largest subsidy per student into a score of 100. Given that the nominal level of the teaching subsidy per student is the same across all universities, institutions that have larger numbers of doctoral students and fields of study, and larger allocated amounts of research and capital funds per student, are ranked higher on this scale.

For the technical efficiency ranking of the public schools we use the average of the three bias-corrected comprehensive estimates from the previous section. Similarly, we use the average of the three bias-corrected measures of cost efficiency to create a second efficiency ranking of public institutions of higher learning. The descriptive statistics of the four rankings, displayed in the upper part of Table 4, suggest that the average scores on the

Table 4. Average scores and correlations of public university rankings.

	Official ranking	Financial ranking	Technical efficiency	Cost efficiency
Average scores				
Public (*n* = *33*)	76.3 (9.6)	34.3 (23.4)	80.5 (18.4)	72.2 (21.7)
University (*n* = *8*)	74.2 (10.5)	21.5 (10.2)	85.7 (15.6)	73.1 (22.1)
Professional school	77.0 (9.5)	38.4 (25.0)	78.1 (19.3)	68.2 (23.0)
– Medicine (*n* = *4*)	80.9	70.1	97.4	71.0
– Engineering (*n* = *3*)	80.8	27.4	79.2	62.9
– Business (*n* = *3*)	79.5	12.7	100.0	91.1
– Arts (*n* = 5)	75.0	64.0	47.8	50.4
– Sectoral (*n* = *10*)	74.5	24.0	68.5	65.7
Correlations				
Financial ranking	0.27 (0.29*)	–	–	–
Technical efficiency	0.25 (0.26)	−0.20 (−0.25)	–	–
Cost efficiency	0.37** (0.36**)	−0.25 (−0.43***)	0.60*** (0.61***)	–

Notes: the standard deviations of the average scores are in parenthesis; the Pearson correlation coefficients are reported along with the corresponding Spearman's rank correlation coefficients in parenthesis. *$p < 0.10$; **$p < 0.05$; ***$p < 0.01$.

official ranking are lower than technical efficiency levels but only marginally higher than cost efficiency. The average score in terms of funding is quite low, indicating that a few institutions received larger subsidies per student than the rest.[16] Universities achieved higher technical and cost efficiency than professional schools, but this is not reflected in the official and especially financial rankings, where the latter received almost twice as much funding on average as the former. Within the group of professional schools, medical schools and art academies appear to be the major beneficiaries of government funding. In the case of medical schools, this seems appropriate, as these institutions exhibit almost perfect technical efficiency and above-average cost efficiency levels. In contrast, arts academies are at the bottom of the efficiency rankings but have enjoyed almost twice the average funding per student. Obviously, the poor performance is associated with the fact that research is not an integral part of fine arts and that art school graduates command lower starting salaries and have fewer job opportunities. The largest discrepancy is found for professional schools with a focus on business and economics, which have the highest efficiency scores but receive on average only 12% of the highest subsidy allocated per student.

The lower part of Table 4 shows the Pearson and the Spearman's rank correlation coefficients of the four rankings. The correlation between financial and efficiency scores and ranks is negative, but it is significant only for the cost efficiency ranks. In other words, the government subsidies are currently allocated, at best, without taking efficiency into account. At worst, government funding rewards the least efficient institutions of higher learning and puts the best-performing institutions at a financial disadvantage. In contrast, the new official rankings are positively and significantly (albeit weakly) correlated with cost efficiency, offering hope that university performance may be better reflected if government funding is revised according to the new rankings.

Determinants of efficiency and funding

The variation in efficiency levels across Bulgarian universities and the inefficient allocation of government funds for higher education call for policy measures that would improve the performance of public institutions and reform the distribution of the budgetary subsidy. For this purpose we attempt to identify the determinants of efficiency and public funding for tertiary education using regression analysis.

First we focus on efficiency and use a regression model with the following specification:

$$EFF_i = \beta_0 + \beta_1 FUND + \beta_2 SHARE_i + \beta_3 FIELD_i + \beta_4 SCI_i + \beta_5 DOC_i + \beta_6 REV_i + \beta_7 SUB_i + u_i \quad (4)$$

where EFF_i stands for the technical or cost efficiency levels estimated above.[17] For estimations involving the entire sample we include as an independent variable the source of funding (*FUND*), which is a dummy variable assuming the value of 1 for public institutions financed from the government budget and zero for the ones relying on private funding. The relative size of an institution enters the right-hand side of the equation in the form of the share of the educational market (*SHARE*) measured as the ratio of its students to the total number of students across all institutions. Furthermore, we examine the effects of academic variables, including the number of fields of study (*FIELD*), the share of science-related fields of study (*SCI*) and the number of accredited doctoral degree programmes (*DOC*).[18] Lastly, for the sample of public universities we also explore the impact of revenue per student (*REV)* and the government subsidy per student (*SUB*) on efficiency. Revenue consists of income from tuition and other fees, rent, dividends and interest for 2009, but excludes public funds.

Since efficiency scores are limited to values between 0 and 1, estimation via ordinary least squares would result in inconsistent estimates. Therefore we employ a censored regression specification which captures the lower and upper censoring of the dependent variable and produces consistent maximum likelihood estimates. The coefficients are estimated for three different measures of technical efficiency using the entire sample of institutions of higher learning. The results presented in the first three columns of Table 5 indicate that public funding is negatively associated with efficiency levels. Private universities are significantly more efficient overall than their public counterparts. In particular, their performance in the area of teaching separates them from institutions relying on public funding. Given that private colleges and universities rely on revenue from tuition and alumni donations, they have to offer a higher quality of teaching, which is reflected in better chances on the job market and higher salaries after graduation. In research, the difference in efficiency between public and private institutions is not statistically significant.

The market share is another important determinant of efficiency. Larger universities perform better in teaching and overall, which is most probably due to scale efficiencies. In contrast, the number of doctoral programmes is not correlated with efficiency. This result seems counterintuitive since an advanced degree generally improves chances on the job market and results in a larger number of publications for the university. One possible explanation could be the fact that entry-level academic positions in Bulgaria are associated with low prestige and pay, making them unattractive for graduates, which in turn is reflected in the unemployment rate. Moreover, doctoral candidates are usually expected to produce a dissertation in the form of a large scholarly monograph rather than a series of

Table 5. Determinants of efficiency and funding for institutions of higher learning.

	All institutions (technical efficiency)			Public institutions		
	Teaching	Research	Total	Technical efficiency	Cost efficiency	Subsidy
Constant	1.031*** (0.079)	−0.190 (0.264)	0.952*** (0.082)	0.534*** (0.109)	0.692*** (0.116)	548.8 (885.5)
Funding source	−0.443*** (0.093)	−0.159 (0.282)	−0.392*** (0.094)	–	–	–
Market share	0.138*** (0.029)	0.032 (0.084)	0.148*** (0.037)	0.155*** (0.039)	0.097*** (0.032)	443.1*** (159.6)
Number of fields	−0.022*** (0.008)	−0.011 (0.023)	−0.022** (0.009)	−0.015* (0.009)	−0.015* (0.009)	18.6 (43.4)
Science share	0.209 (0.128)	1.618*** (0.504)	0.382*** (0.140)	0.445*** (0.164)	0.241 (0.172)	1897.4** (820.1)
Doctoral programmes	−0.002 (0.003)	0.003 (0.009)	−0.003 (0.003)	−0.005* (0.002)	−0.003 (0.003)	28.3* (14.0)
Cost efficiency	–	–	–	–	–	1026.4 (1027.1)
Revenue	–	–	–	−0.001 (0.001)	−0.002** (0.001)	1.7*** (0.3)
Subsidy	–	–	–	0.000 (0.000)	0.003 (0.003)	–
Observations	46	46	46	33	33	33
Censoring	[0;1]	[0;1]	[0;1]	[0;1]	[0;1]	[0;∞)
Log likelihood	−3.81	−38.02	−5.28	0.62	−1.40	−275.7

Notes: Standard errors in parenthesis. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

papers that could be published more quickly in academic journals. This may have an adverse effect on the quantitative aspects of the research output.

The results further suggest that the more fields of study a university offers, the lower the overall and teaching-related technical efficiencies. With the exception of the smaller colleges that generally focus on a very few academic disciplines, all other institutions, public and private, have been expanding their course offerings. Private universities attempt to attract more students with new (and often exotic) courses that are not offered at other schools. Public universities can maximise the amount of the government subsidy by broadening the number of fields they offer. Accordingly, efficiency deteriorates as a result of curriculum expansion because it is difficult to sustain high-quality performance across a large number of disciplines. A broad spectrum of programmes requires additional resources and expertise that might not be easily obtainable. Yet the composition of the curriculum seems to matter as well. A higher share of science-related classes has a positive and significant effect on research-related and overall efficiencies. Natural sciences, engineering and medicine have a strong research component, and graduates from these programmes have better chances on the job market due to the applied nature of these disciplines. This also concurs with the above-average levels of technical efficiency for professional schools in medicine and engineering reported in Table 4.

The regression in Equation (4) is also estimated for the sub-sample of public institutions of tertiary education. The results for technical and cost efficiency are displayed in the fourth and fifth columns of Table 5 respectively. Most of the estimates have the same sign and significance levels as those for the overall sample, except for the coefficient of the share of science-related fields of study, which has no significant effect on cost efficiency. Teaching and research in science and engineering require laboratory space, equipment and other resources, which impose higher costs and make cost minimisation more difficult than for institutions with a larger share of humanities and social sciences. This is also in line with the below-average levels of cost efficiency for sectoral and engineering schools shown in Table 4.

The sub-sample of public universities allows us to include the two financial variables, revenue and the government subsidy per student, in the regression. In general, better funding per student is expected to have a positive effect on efficiency as it can help improve the quality of teaching and research. However, Bulgarian public universities earning higher revenue per student exhibit lower levels of efficiency, with a significant coefficient in the case of the more comprehensive measure of cost efficiency. The amount of government subsidy per student was not significantly related to efficiency, which concurs with the results above. These findings indicate that the amounts of public funds obtained by public universities and their revenue earned beyond the government subsidy are detached from their performance. Restrictions on the sources and amounts of funding that universities can earn beside the government subsidy translate into a distorted system that does not reward cost minimisation.

Lastly, the regression model in Equation (4) is estimated with the government subsidy per student as the dependent variable and cost efficiency as independent variable.[19] The results in the last column of Table 5 again indicate the lack of a significant relationship between subsidy and cost efficiency. In addition, the size of the university is positively related to the amount of the subsidy per student. Larger universities have more doctoral programmes and fields of study, but since we control for these variables in the regression it means that these institutions receive larger amounts of funds for research and capital expenditure per student. Given that doctoral students count twice as much as undergraduate students in the calculation of the government subsidy, it is not surprising to see a positive and significant coefficient for doctoral programmes. Similarly, the number of fields of study is also positively associated with the amount of the subsidy.[20] Furthermore, our results indicate that the allocation of the government subsidy not only does not encourage efficiency but also exacerbates the financial inequality across public universities. Institutions that earn more revenue per student benefit from larger amounts of government funds, even though they exhibit lower average levels of cost efficiency.

Conclusions

The system of higher education in Bulgaria is beset by a myriad of problems which include overcrowded classrooms, lack of modern equipment, scant resources, low-quality research and ill-prepared graduates. To evaluate the performance of Bulgarian universities and colleges, this article estimates their relative efficiency in managing resources with the goal of obtaining the maximum amount and quality of teaching and research outputs at minimum cost. The results indicate that private institutions exhibit significantly higher efficiency than public schools, which is mostly due to their teaching-related performance. In the area of research, even though public universities perform better, the extent of inefficiency is staggering. Furthermore, overall efficiency levels are lower when the cost of inputs is taken into account. Our findings also indicate that efficient universities focus on fewer fields of study, offer a larger number of degrees in natural sciences, medicine and engineering, and claim a larger share of the market for higher education.

The inefficiency of public universities coupled with their dependency on public funding compelled us to examine whether efficiency is factored into the allocation of the government subsidy for higher education. Our results show that a better performance in terms of cost minimisation and output maximisation fails to attract larger amounts of public funds. Instead, there are some indications that institutions with lower efficiency rankings are also the recipients of a larger subsidy. But the subsidy, in turn, does not contribute to any significant efficiency gains. These findings suggest that public funding for tertiary education in Bulgaria is in dire need of reforms that would create incentives for universities to manage their resources efficiently. The task of introducing a performance-based system of public funding for higher education takes on a greater urgency during the economic downturn. In this context, the proposal by the government to disburse funds based on a recently released official university ranking is a step in the right direction, as it is positively and significantly (albeit weakly) correlated with our efficiency ranking.

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Notes

1. We also test the possibility that efficiency results from (rather than being the determinant of) the funding provided but the results indicate that this is not the case.
2. According to the Bulgarian Ministry of Education, Youth and Science, about 10% of all graduates from secondary school left the country to study at foreign universities in 2009–10. This information is based on the number of school diplomas notarised by the Ministry for admission to institutions of higher education abroad.

3. Bulgaria has a currency board, which pegs the Bulgarian currency (leva) to the euro. This arrangement drastically limits the scope of monetary policy and imposes requirements for strict fiscal discipline, which has led to painful cuts in public spending during the recent global crisis.
4. The advantage of SFA over DEA in this regard is that it takes into account stochastic noise; however, it also makes assumptions about the distributional properties of the components of the stochastic term which are often violated (Greene 1999).
5. In the output-oriented DEA model, inputs have to be positively related with outputs, and therefore the unemployment rate, which is a negative quality indicator, is included in the model in the form of its reciprocal.
6. It is of little use for a university to churn out graduates who cannot secure jobs. In a competitive market, the reputation of the institution suffers, leading to a decrease in its share of the education market. However, Bulgarian universities are generally not involved in job placement, and career services on campuses have been slow to emerge.
7. In fact, we initially included two variables to control for the impact of macroeconomic factors on efficiency in the regression model below. However, neither economic growth nor the general unemployment rate in the cities where the universities were located had a significant impact. Therefore, these two variables were dropped from the final regression analysis.
8. We chose to drop the Academy of the Ministry of the Interior, the Naval Academy, the National Defence Academy and the National Military University from the sample owing to incomplete data. Furthermore, these institutions are financed by the Ministry of Defence and the Ministry of the Interior, in contrast to all other public institutions of higher learning in Bulgaria, which receive funding from MEYS.
9. Professional schools in Bulgaria are labeled either ‘academy’ (especially in the arts) or ‘institution of higher learning’ (*vishe uchilishte*). But many also carry the word ‘university’ in their names, which is misleading owing to their narrow academic focus, and should not be confused with the university category we use in this article.
10. The data were released in November 2010 and are available at http://rsvu.mon.bg/.
11. SCOPUS includes journals in languages other than English only if the articles they contain have an abstract in English.
12. We estimated all possible combinations of the outputs listed, but the resulting efficiency levels are very similar to those reported in the article, which prompted us to exclude them from the analysis to save space. These results are available from the authors upon request.
13. The alternative specification of the price of capital as capital expenditure per square metre of floor area produced very similar estimates of the levels of cost efficiency which are not reported here and are available from the authors upon request.
14. The various specifications of our DEA model take into account several variables from each category of criteria except for campus life and prestige, which are based on surveys and are thus less preferable than qualitative measures such as citations of published work or income after graduation. Moreover, campus life and prestige represent only 20% of the overall rank.
15. Regular Bulgarian students and ethnic Bulgarian students from abroad enter the calculation in absolute numbers, while doctoral students are assigned a weight of 2 and long-distance students a weight of 1/3.
16. Art academies and medical schools benefit from larger subsidies per student compared with most other institutions. Treating these as outliers and dropping them from the sample did not alter the correlations with the efficiency rankings significantly.
17. The three measures of technical efficiency include the average of the two teaching-related estimates, the research-related estimate and the average of the three comprehensive estimates from Table 3.
18. Science-related fields are defined as those in the realm of natural sciences, engineering and technology and medicine.
19. In this case the regression is censored from below at zero, which corresponds to the Tobit model specification.
20. The only reason for the coefficient to lack significance is that the government uses only six broader categories of academic fields while we include 51 possible fields of study.

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