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COST EFFICIENCY ANALYSIS OF PUBLIC HIGHER EDUCATION INSTITUTIONS IN UZBEKISTAN

BY

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Cost Efficiency Analysis of Public Higher Education Institutions in Uzbekistan

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Abstract: Over the last decade, the revenue structure of public higher education institutions (HEIs) in Uzbekistan has changed from full government funding to mostly tuition funding. In this paper, a stochastic cost frontier analysis is used in order to examine whether the institutional financial resources obtained mostly from tuition revenue have been utilised efficiently or inefficiently at 58 public HEIs during the period of 2000 to 2013. The Battese and Coelli (1995) method is applied to measure the influences of institution, staff and student characteristics on cost efficiency of the universities. According to mean efficiency scores, the Uzbek universities are not remarkably cost efficient in producing education and research outputs, although the significant improvements in the efficiency followed throughout the sample period. Findings also reveal that HEIs with a greater share of government allocations are less cost efficient relative to those institutions with a smaller share of government allocations.

Keywords: Stochastic frontier; cost efficiency; higher education; Uzbekistan.

JEL classification: I21, P20

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1. Introduction

In the aftermath of the recent financial crisis, many countries had to considerably reduce their spending on public service sectors, such as health, transportation, education, tourism, in order to balance their budgets (Johnstone and Marcucci, 2010). Education is often among the sectors that lost out as a result of such public cuts (Albrecht and Ziderman, 1995; Sanyal and Johnstone, 2011). Higher education establishments have been struggling to find sufficient financial resources for conducting basic teaching and research activities due to the decline in government allocations (Sam, 2011). In some countries, the processing of reforming the HEIs, in order to make them less dependent on government funding, had already been ongoing by giving more financial autonomy to their public HEIs for obtaining funds from external/private sources (Johnstone, 2004; Salmi and Hauptman, 2006; Sanyal and Johnstone, 2011). These reforms also included the increasing demands on public sector institutions to improve the efficient utilization of available resources and to operate at the optimal level of efficiency (Johnes and Johnes, 2013).

Numerous studies have found that simply introducing or increasing tuition fees at public HEIs are not always sufficient to fill the gap left by the reduced government funding (Barr, 2009; Erkoc, 2013; Horne and Hu, 2008). Therefore, these and many other scholars argue that public higher education establishments should always seek to utilise their resources more efficiently and perform at the best level of cost efficiency in order to achieve financial sustainability. Since the last fifteen years, productivity and efficiency topics have received considerable attention by policy-makers and administrative bodies of universities in many countries, especially in high-income countries. In light of this, many scholars have tried to analyse whether HEIs are utilising their resources productively and efficiently (e.g. Agasisti, 2016; Agasisti and Johnes; 2015; Johnes, and Johnes, 2013; Katharaki and Katharakis, 2010; Kempkes and Pohl, 2010; Kuo ad Ho, 2008; Leitner et. al, 2007; Salerno, 2003; Sav, 2012; Worthington and Lee, 2008; etc.). Having benefited from the studies evaluating the efficiency performance of universities, administrators within governmental institutions and HEIs began to reorient their financing choices (Erkoc, 2013).

Similar to any other forms of organisations, measuring resource efficiency of universities often involves conducting specific analytical procedures that rely on fundamental assumptions of microeconomic theory. One of the key assumptions of the theory is that the goal of a typical entity is to produce maximum amount of outputs through utilising given inputs with minimum cost. Within the framework of free market rules, the microeconomic concept supposes that entities direct input and output efficiently with the objective of minimising total cost or earning maximum revenue/profit (Farrell, 1957). A number of research papers, which examine the economic efficiency level of public universities, have noticeably increased in the frontier analysis literature over the last decade (Agasisti and Johnes, 2015). Some of the main driving forces behind this proliferation could be the evident reduction in government allocations to public HEIs as well as increased institutional costs.

According to our review of literature, most of the recent frontier and efficiency studies were conducted in the case of HEIs located in upper-middle or high income countries. Moreover, majority of those empirical works do not contain reliable variables which measure quality of institutional outputs and inputs. To the best of my knowledge, the previous stochastic frontier and efficiency studies on higher education were limited with very short time periods. For example in the Horne and Hu (2008)'s paper the longest time period relative to the other stochastic frontier studies has been applied, 8 year panel data. Our study aims to contribute to the existing literature through filling all these mentioned research gaps.

This paper is expected to be the first cost efficiency study in the case of public HEIs in low and middle income countries. As the study of Stevens (2005), we use a method that allows us to not only account for inefficiency in HEI provision, but also examine the influences on inefficiency. During the analysis, we also use longer time period, t=14 years, compared to the existing stochastic frontier studies. In addition, two student specific factors are used in this analysis in order to account for the quality of educational outputs produced by the Uzbek HEIs. Also, this study contributes to the existing literature through examining the cost efficiencies of different groups of public HEIs divided according to the percentage of revenue received from government funding. This examination helps to identify whether those Uzbek universities with a smaller share of public allocations are more cost efficient relative to those universities with a greater share of public allocations.

After this brief introductory section, the next section describes the higher education system of Uzbekistan. Section 3 discusses the models, methods and data which are utilised measuring cost efficiency of public HEIs. Section 4 presents the empirical results estimated by applying the method of Battese and Coelli (1995) and at the end of this section, mean inefficiency scores and re-estimated government funding effects are also exposed. The last section reveals a summary of the paper.

2. An overview of the Uzbek higher education system

The higher education system of Uzbekistan is mainly funded from the state budget at three levels: local, regional and central (ADB Evaluation Study, 2011). Institutions of higher education, teacher training institutions and affiliated academic lyceums in the Republic are financed from the central budget. The budget expenditure is calculated based on the student quotas, the costs of government grants for students, fixed assets, equipment and buildings. To evaluate the salary of higher education staff a 9/1 students and a teacher ratio has been used since 1996, but in practice it differs depending on the field of study (EC Tempus, 2010). According to the Decree of the Cabinet of Ministers of Uzbekistan (CMUZB) (1997), before starting of every academic year – all public HEIs make budget bids based on the basis of the last year's allocations to the institutions, which are submitted to and then evaluated by the ministries and agencies. These ministries and agencies aggregate the total budget and thereafter submit to the MFUZB, where a judgement about the total is made and return to those ministries and agencies which then redistribute the final figures between the HEIs (Mirkurbanov, Anoshkina and Danilova, 2009). Furthermore, extra-budgetary funds make up more than half of overall expenditures on the higher education system of Uzbekistan in these days. Main reasons of this situation can be seen the continually raising the number of contract-paid students and the prices of their education (EC Tempus, 2010). The extra-budget funds of Uzbek HEIs are usually generated from the following sources: tuition and other fees, renting the properties and provision of short-term training programs by academic staff of HEIs (MFUZB, 2013).

According to the Resolution of the CMUZB (2001), extra-budget funds which obtained from tuition charges and other private activities do not reduce the amount of funding from the public budget. These extra revenues can be spent for operational expenditures of HEIs, but all financial activities have to be reported to their ministries. For example, the Tashkent Medicine Academy reports about the allocations of its extra-budget funds to the Ministry of Health. Particularly, the extra-budget funds can be spent for further developments of the facilities and infrastructure of universities (NHDR, 2011). According to Figure 1, the amount of extra/off-budget funding has considerably increased relative to the state-budget funding at Uzbek HEIs during the period 2007-2013.

<<<< Figure 1 About Here >>>>

If we rely on the data exposed by the figure above, the off-budget funding rose by over 27 per cent in 2013 compared to 2000. In 2013, the off-budget funds were twice higher than the state-budget funds due to extensively increased tuition fees. It is important to remark that a share of institutional revenue derived from tuition payments has consisted more than 90 per cent of total off-budget revenue at public HEIs – since 2007. Accordingly, shares of institutional revenue from research activities and public services were lower than 10 percent during that period. Moreover, Table 1 illustrates that the total expenditure per student has insignificantly changed between the period 2000 and 2013. A slight trend towards an increase in public expenditure per student is witnessed during the annual adjustment for inflation of teachers' wages and students' scholarships. A decline in the off-budgetary expenditure per student may be a result of the fact that in 2003, the adjustment for inflation of the tuition fee contracts amount was not made (EC Tempus, 2010). In 2013, with respect to the state-budget funding per student and payment per student on a fee-based contract, the amount of the state expenditure reduced from 50 to 25 per cent depending on the academic performance of a student. This residual amount per student does not meet even the minimal needs of the Uzbek HEIs.

<<<< Table 1 and Figure 2 About Here

The data obtained from the MFUZB (2013) suggest that expenditures by the Uzbek government on higher education have increased by 10 per cent from 2007 to 2013. Accordingly, the amount of funds which need to be allocated to the several institutional expenditures, such as wages, stipends, social and other funds, capital costs and other expenses, have also increased year by year. Huge portions of the governmental funds were dedicated to paying stipends of students and salaries of academic staff over the period of 2007 to 2013. Whereas, relatively less amount of funds have been allocated to capital costs and other expenses during the same period. However, this increased expenditure to higher education was sufficient neither to expand the number of academic staff nor to improve financially sustainable operation of the HEIs.

Since the mid-2000s, there has been a reform that was aimed to introduce a high degree of autonomy to the HEIs. Since then, all public HEIs have been allocated a total budget by MFUZB and institutions have had autonomy to determine how this budget should be spent. Public HEIs are free to set their own tuition charges, but within a maximum cap which is determined by CMUZB. The administrators of HEIs can freely decide about the use of tuition revenues, but their ministries should be reported about the management of the private funds in addition to the public funds. Sources of finance at the Uzbek HEIs are now much more heterogeneous compared to the previous decade, with more than 60 per cent of total revenue coming from private sources in 2013 (MFUZB, 2013). Thus, this enhanced autonomy has encouraged institutions to pay heed to the financial performance and cost efficiency of their operations. Despite of the increased autonomy, the public HEIs in Uzbekistan remain very similar in their status and mission.

3. Methodology and Data

3.1 Stochastic cost frontier analysis

Using information on the outputs and the price of the inputs, together with a behavioural assumption that public universities' objective is to minimise costs, the cost frontier and efficiency of the Uzbek HEIs can be estimated (Kumbhakar and Lovell, 2000). This assumption seems a plausible since all public higher education establishments in Uzbekistan are not-for-profit entities, as in many other countries (NHDR, 2011).

<<<< Figure 3 About Here >>>>

The cost frontier shows the best that can be attained economically, and it also describes standards against that the economic efficiency of institutions can be measured

(Kumbhakar and Lovell, 2000). In other words, in a given output level and input prices relying on available technology of production that the stochastic cost frontier model estimates minimum cost. Afterwards, institutional cost efficiency can be defined by dividing the estimated (minimum) cost to actual (observed) cost. The concept of cost frontier analysis and cost inefficiency is presented in Figure 3 in order to give a more intuitive explanation for how SFA works. This figure describes the relationship between total costs (TC) and an output (e.g., a FTE student) of institutions. As an example, the author uses three imaginary HEIs (A, B and C) each with different costs but produce same level of output, S. A typical regression analysis such as OLS characterises the relationship between average costs and output, thus it predicts the behaviour of the average institution (Wooldridge, 2002). In the OLS estimation, contrary to the cost-minimisation assumption, some observations can lay below the regression line as a university C in Figure 3. However, the stochastic frontier predicts a minimum cost at given level of output relative to OLS, therefore there cannot be any institution with observed cost less than the minimum cost.

According to the SFA, the university C is cost efficient and it shows the minimum feasible cost for producing a FTE student. However, universities A and B are less cost efficient in producing output, S. The cost inefficiency for university B with output, S, and total cost, TC_B, is the ratio of the distance between C and S to the distance between B and S. Therefore, the institution A is less efficient than institution B, because the distance AC is longer than distance BC. Since actual total costs, TC_A, TC_B and TC_C, are observable, estimation of cost frontier is required to evaluate cost efficiency level of the HEIs. According to many scholars, universities should be treated as multiproduct organisations, since their activities are aimed to teaching, research and public services (Cohn et al., 1989; Johnes and Johnes 2013; Kumbhakar and Lovell, 2000; Robst, 2001). The traditional multiple-output cost function which examines the impacts of the multiple outputs and input prices on the institutional cost is usually interpreted as:

$$TC = c(y, w; \beta, \gamma) \qquad (1)$$

Where, TC - is the total cost; y - is a vector of output variables; w - is a vector of input prices; and β and γ are parameters to be estimated.

Stochastic frontier cost function (SFCF) following the pioneering works of Aigner, Lowell and Schmidt (1977) and Meeusen and Van den Broeck (1977) is specified as:

$$TC_i = c(y_i, w_i; \beta, \gamma) + v_i + u_i \quad \text{or} \quad TC_i = \beta y_i + \gamma w_i + v_i + u_i \qquad (2)$$

Where, $\beta y_i + \gamma w_i + v_i$ is the optimal, frontier target (e.g., the minimum cost) pursued by institution. $\beta y_i + \gamma w_i$ is the deterministic fraction of the frontier and $v \sim N[0, \sigma_v^2]$ is the stochastic fraction, these two parts together constitute the stochastic frontier (Greene, 2008).

The SFCF was extended to panel data by Battese and Coelli (1993, 1995), and the general form of total cost for university *i* and time *t* can be represented as:

$$TC_{it} = c(y_{it}, w_{it}, z_{it}; \beta, \gamma, \theta) + v_{it} + u_{it} \qquad (3)$$

$$i = 1, 2, \ldots, N; \qquad t = 1, 2, \ldots, T,$$

z_{it} - is a vector of observable explanatory variables that impact costs directly, and θ is a parameter to be estimated.

Also, equation (3) can be interpreted in the following way:

$$TC_{it}^{M} = \beta y_{it} + \gamma w_{it} + \theta z_{it} + v_{it} \le TC_{it}^{O} \qquad (4)$$

$$TC_{it}^{O} = TC_{it}^{M} + u_{it} \qquad (5)$$

Where, $u_{it} \ge 0$.

Combining equations (4) and (5) leads to:

$$TC_{it}^{O} = \beta y_{it} + \gamma w_{it} + \theta z_{it} + \varepsilon_{it} \qquad (6)$$

Where, TC_{it}^{M} - represents university *i*'s minimum potential (estimated) cost at time period *t*; TC_{it}^{O} - the actual (observed) total expenditures for university *i* and time *t*. The institution's actual total cost (TC_{it}^{O}) is normally greater than or equal to the minimum estimated cost (TC_{it}^{M}). Moreover, SFA characteristically assumes that the regression residual consists of two error components ($\varepsilon_{it} = v_{it} + u_{it}$). The first error component, a normally distributed random error (v_{it})[1] captures the factors outside the control of the institutions, measurement errors and the usual statistical noise. The second component (u_{it}) evaluates the causes of cost efficiency such as input characteristics, various environmental factors and managerial decisions. This term can be estimated in the following way:

$$Cost\ efficiency = \frac{\beta y_{it}+\gamma w_{it}+\theta z_{it}+v_{it}}{\beta y_{it}+\gamma w_{it}+\theta z_{it}+v_{it}+u_{it}} = \frac{TC_{it}^{M}}{TC_{it}^{O}} \qquad (7)$$

This cost efficiency term is assumed to have a strictly non-negative distribution ($u_{it} \geq 0$) and A HEI can be interpreted as cost efficient if that institution reaches its minimum cost, where ($\mathrm{u_{it}} = 0$). The u_{it} is usually assumed to be half-normal distribution truncated at zero, or an exponential distribution (Greene, 1993). A researcher selects and imposes the shape of the distribution of the efficiency term.

In the early 1990s, Kumbhakar, Gosh and McGulkin (1991) introduced a method for measuring both frontier and inefficiency term of firms with external factors serving as determinants of inefficiency. Further, Battese and Coelli (1993, 1995) modified the method for panel data with time-varying inefficiency which allows inefficiency to change over time. In this study, we employ the method of *Battese and Coelli (1995)* which can rest upon the assumption that the cost frontier is indirectly influenced by the external factors through influencing the inefficiency term. Therefore, z_{it} are assumed as determinants of cost

[1] The random error is assumed to be independently and identically distributed (i.i.d) with zero mean and variance σ^2. $\mathrm{v_{it}}$ and $\mathrm{u_{it}}$ are distributed independently of each other.

inefficiency and the inefficiency influences in the stochastic cost frontier equation (6) is defined as:

$$u_{it} = \delta_0 + \sum \delta z_{it} + w_{it} \qquad (8)$$

Where w_{it} is the random variable which is defined by the truncation of the normal distribution with zero mean and (σ^2), such that ($w_{it} \geq -\sum \delta z_{it}$). Battese and Coelli (1995) stated that "these assumptions are consistent with u_{it} being a non-negative truncation of the $N(\delta z_{it}, \sigma^2)$ distribution".

The next step is to choose a relevant functional form in order to assess the relationship between the institutional expenditure and explanatory variables. In general, the selection of functional form is mostly motivated by the data character and availability, as well as by sample size. In the context of higher education, the total costs of universities have been estimated using different functional forms in the case of different countries. For example, Izadi et al. (2002) opted for CES functional form for the UK HEIs; McMillan and Chan (2006) used Cobb-Douglas functional form for the Canadian universities; in their recent published papers, Daghbashyan (2011) and Sav (2012) applied Cobb-Douglas cost function for the Swedish and American universities, respectively. However, there are some other scholars who preferred to use the more flexible functional forms: Agasisti (2016), Horne and Hu (2008) and Robst (2001) utilised the trans-log cost function for the HEIs in Australia, Taiwan and America, respectively; Johnes and Johnes (2009) and Agasisti and Johnes (2015) opted for Quadratic cost functional form for the British HEIs.

In many efficiency studies, the trans-log and Cobb-Douglas specifications have been eschewed by many scholars considering the costs of multiproduct entities because the predicted value of costs for HEIs that produce zero values of some outputs are nonsensical. According to Baumol, Panzar, and Willig (1982) that the cost function of a multiproduct entities should meet a number of requirements. Foremost, “cost functions must allow sensible predictions to be made for the costs of institutions that produce zero levels of some outputs" (Agasisti and Johnes, 2015; p. 71). In this study, none of the HEI in the sample produces zero of any of the outputs. Therefore, this research does not violate the desiderata of Baumol et al. (1982). Moreover, the function need not be linear in order to allow for economies of scale or scope. Since the main purpose of this study is to measure efficiency level of HEIs using the determinants of inefficiency rather than issues such as economies of scale and scope, this study does not face this problem and can apply the translog functional form. I specify the following translog cost function, which will be estimated using the SFA:

$$lnTC_{it} = \beta_0 + \beta_1 lnUG_{it} + \beta_2 lnPG_{it} + \beta_3 lnRES_{it} + \gamma_1 \, ln\, SALARY_{it} + 0.5\beta_{11}(lnUG)^2 + 0.5\beta_{22}(lnPG)^2 + 0.5\beta_{33}(lnRES)^2 + 0.5\gamma_{11}(lnSALARY)^2 + \beta_{12} lnUGlnPG + \beta_{13} lnUGlnRES + \beta_{14} lnUGlnSALARY + \beta_{23} lnPGlnRES + \beta_{24} lnPGlnSALARY + \beta_{34} lnRESlnSALARY + \sum_m^8 \theta_m Z_{m,it} + v_{it} + u_{it} \qquad (9)$$

Where UG_{it}, PG_{it} and RES_{it} are outputs produced by institution *i* during time *t*. UG_{it} - is number of full time equivalent undergraduate students, PG_{it} - is number of full time equivalent postgraduate students, and RES_{it} - is total revenue generated from research and other non-tuition activities. The input price in this analysis is average staff expenditures (total staff costs divided by staff FTE), $SALARY_{it}$. Z_{it} - captures the determinants of cost inefficiency which are institution, staff and student specific characteristics, including two revenue sources; the share of government allocations and the share of tuition revenue. Finally, v_{it} – is a symmetric error component reflects the statistical noise and u_{it} – is a non-negative truncated distribution captures the influences of inefficiency. Additional to the outputs, input-price and determinants of efficiency, this flexible functional form contains quadratics for each output and input variable as well as six interaction terms in order to account for possible nonlinearities.

Battese and Coelli (1995) time-variant inefficiency model is narrated as:

$$u_{it} = \delta_o + \delta_1 STIP_{it} + \delta_2 LOAD_{it} + \delta_3 PROF_{it} + \delta_4 FTS_{it} + \delta_5 SIZE_{it} + \delta_6 MED_{it} + \delta_7 GA_{it} + \delta_8 TR_{it} + w_{it} \qquad (10)$$

Through assuming that v_{it} and w_{it} are distributed independently of each other, a simultaneous equations approach that uses one-stage Maximum Likelihood Estimation (MLE) method is applied in this study. The MLE is employed in order to estimate the regressors' parameters of the cost function and the cost inefficiency effect model.

3.2 Data description

For the present study, a major proportion of the data for individual universities are collected from the Main Department for Financing Social Sphere and Science (MDFSS&S) under the MFUZB. All institutional financial data, such as institutions total costs, institutional revenues from research and other private activities, average annual salaries, and average annual stipends, are derived from the Annual Financial Reports (AFR) of public HEIs in Uzbekistan. These reports were originally conducted by the MDFSS&S. Moreover, the share of government allocations and the share of tuition revenue variables are estimated using the data from the AFR of public HEIs. Two output indicators such as the number of FTE undergraduate and postgraduate students, as well as institutional and student characteristics are drawn from the annual reports prepared by the MDFSS&S. The data on staff characteristics are available from the official web-site of the Ministry of higher and secondary specialized education (MHSSE), but not for the all required period. Therefore, the data on staff characteristics for the entire period is collected from the Department of Financing and Accounting under MHSSE. All the financial data, those derived from the MFUZB, are available only in the national currency of Uzbekistan. Accordingly, the nominal

Uzbek Sums data are transferred into the real Uzbek Sums using the CPI inflation measurement for the each study year.[2]

The sample size of this study initially consisted of 62 public HEIs and 14 years. However, data for the majority variables and years are missing for the four institutions of higher education. Moreover, these four HEIs produced zero teaching and research outputs during sample period. Therefore, these institutions are withdrawn from the analysis and a balanced sample consists of 812 institution-year observations representing 58 public HEIs each with 14 year variables. Figure 4 illustrates the evaluation of institutional revenue patterns for the all 58 public HEIs, figured against the considerably increasing tuition prices over the 14 years. The figure also exposes that the reduced allocations from government after 2002 have been offset by an increased reliance on tuition revenue. These increased tuition revenue has been derived mostly in part through raises in tuition charges, although most of the HEIs considerably increased the number of contract-based student enrolments over the sample period. These remarkably increased tuition prices and enrolments have led to the increased institutional revenue from tuition at the HEIs. Moreover, the descriptive statistics of all variables utilised during the empirical estimations are presented in Table 2.

<<<< Table 2 and Figure 4 About Here >>>>

3.3 Selection of variables

The costs measure includes both current and capital expenditures (in the form of depreciation). In addition to the total cost factor, the traditionally required data for estimation of cost frontier and efficiency analysis are the output and input variables as well as the observable explanatory variables which may have impacts on total costs through an inefficiency term. The selections of outputs, which can be the best proxies for outputs of education, have always been subject to significant disagreement among scholars of higher

[2] All financial data are inflated to 2013 UZB Sums [Source: IMF World Economic Outlook Database (2015)].

education. Therefore, majority of the institutional production and cost based studies acknowledge that the estimated coefficients are frequently distorted because of challenges in efficiently accounting for outputs' quality (Dundar and Lewis, 1995; Sav, 2012).

In many efficiency studies, the most frequently utilised measure of higher education outputs are the FTE number of undergraduate and postgraduate students (Cohn et al., 1989; Robst, 2001; Salerno, 2003; Stevens, 2005). These easy identifiable outputs are the most commonly used variables in the efficiency literature despite of their well-documented limitations on accounting for quality of students produced at HEIs. For example, consider two institutions which educating the equal number of students where one provides a "standard" education while another provides an "excellent" education. In efficiency study, if these two institutions are compared based on their FTE student enrolments, the institution that educating more students per (academic) staff can be regarded as more cost efficient, not the one that providing better quality education. The failure to account for this form of quality factors may emerge misleading analysis and comparison. Since *the number of FTE undergraduate and postgraduate students* are the best accessible outputs which can be obtained from the available data, this study employs these two proxies for measuring outputs of education while recognizing the existence of quality limitations.

In the current analysis, *the research income* is used as a proxy for research output of the Uzbek HEIs despite of all the potential drawbacks of this approach. Nevertheless, Cohn et al. (1989) suggest that a weighted measure of all the various research outputs would be the supreme output measure. Unfortunately, the data in our hands are not reach enough for taking weights of all different research outputs produced at the Uzbek universities. In the cost and production estimations, *input prices* are the next category of factors must be included into the model. What form of input measure to use is depends on what form of efficiency is being examined. Physical input units (usually measured by FTE faculty numbers) are used in the technical efficiency analyses, while expenditure-based units are employed in the cost efficiency assessments (Kumbahakar and Lovell, 2000). In the previous cost efficiency studies, inputs are usually measured either by annual faculty salary (Stevens, 2005) or annual capital expenditures (Erkoc, 2013).

The cost efficiency estimation normally has two components. The first is the evaluation of a stochastic cost frontier which serves as a benchmark against that to evaluate the cost efficiency of institutions. The second component is also vital, since it concerns the association of exogenous factors which are neither outputs of production nor inputs to the production process (Robst, 2001). However, the determinants of efficiency influence on total cost either directly through affecting the cost frontier, (TC_{it}), or indirectly through affecting the inefficiency term (Kumbhakar and Lovell, 2000). Examples for the exogenous variables, which characterise the environment in which "production" occurs, can be input and output quality indicators, various staff characteristics, ownership forms and the like. Certainly, the selection of such variables is controlled by data availability (Stevens, 2005). In this study, several determinants of efficiency which may influence on the cost efficiency of public HEIs are separated into several following categories.

Two student characteristics are included to the analysis in order to account for quality of educational outputs (or quality of students). The first variable is *the annual stipends per student* serves to measure quality of students and may work a very-well in the context of public HEIs in Uzbekistan. Every FTE enrolled student of the Uzbek institutions must be provided with the institutional stipends in every month of his/her study period. However, an amount of the monthly stipends depends on a student's average grade from the preceding semester. For example, students receive small, medium or high levels of stipends according to the following grading scale: if a student's average grade lower than 70 per cent (situated between 56-70) receives the smaller stipends, while a student with average rating between

71-85 per cent receives the medium stipends, or one can have the highest stipends with an average grade over 86 per cent (situated between 86-100). In other words, “higher” quality students receive higher monthly stipends relative to "lower" quality students at public HEIs. This leads us to make an assumption that a university with greater number of "excellent" students is more likely to have higher education quality and greater institutional expenditures dedicated to monthly stipends. The second quality measure is *the load per academic staff*, defined as the ratio of FTE students to the number of faculty members. Usually, the increase in this indicator would lead to decline in the institutional cost and to improvement in the cost efficiency, while it may have an opposite impact on the quality of educational outputs.

The current study contains also two staff specific factors such as *the share of professors in academic staff* and *the share of full time working personnel*. The former factor selected as a measure of academic personnel quality which may improve the efficient operation of HEIs by having influence on the education outputs. At the same time, it is more likely to increase institutional expenditures. The latter factor may also have significant impact on total costs of HEIs. For example, an institution with greater number of full-time based staff is more likely to have greater salary expenditures relative to another HEI which employs fewer full-time based personnel. Furthermore, the first institution specific variable is the size of university proxied by *the total number of FTE enrolled students*. This indicator is usually expected to increase institutional expenditures, but it may reduce the costs if a university operates under increasing return to scale (Koshal and Koshal, 1999). The second institution specific factor captures *medical institutes* which can have considerably positive impact on institutional costs. In other words, total expenditures of medicine based institutes are normally much higher than other subjects based HEIs, thus medical institutes are usually less cost efficient (Agasisti, 2016).

The last two determinants of efficiency, *the share of government allocations* and *the share of tuition revenue*, represent the impacts of the main institutional income sources on the cost efficiency of public universities in Uzbekistan. Over the last decade, majority of the HEIs were jointly financed by government funding (43%) and tuition income (55%), the rest generated from other external sources (MFUZB, 2013). Since the higher education sector is not only funded by the government's purse but also financed through the private financial sources, the share of government allocations and the share of tuition revenue vary across the Uzbek HEIs.

4. Results

This section first discusses the outcomes of the stochastic cost frontier and the determinants of efficiency which are estimated using the more flexible translog multiproduct specification.[3] The next sub-section discusses the estimated average inefficiency scores of the public HEIs. The re-estimated influence of government allocations on the cost efficiency of three different groups of HEIs is presented in the last sub-section.

4.1 Cost efficiency estimates

This sub-section presents the estimated parameters conducted through employing Battese and Coelli (1995) time-variant inefficiency model that is shown by the Eq. (10). This model allows us to estimate conditional mean model with several observable external variables as determinants of efficiency. The one-stage MLE is used in order to estimate the parameters of the regressors for both translog cost function after making an assumption that

[3] In this study, we used the Cobb-Douglas functional form as a robustness check and findings are available from the author upon request. According to results of Likelihood Ratio test, all the coefficients of second-order terms equal to zero are statistically rejected. In other words, the trans-log specifications have an obvious superiority over the Cobb-Douglas specifications when the method of Battese and Coelli (1995) is used. Findings are also available from the author upon request.

w_{it} in Eq. (10) and u_i in Eq. (9) are distributed independently of each other (Kumbhakar and Lovell, 2000). Three maximum likelihood regressions are carried out and every regression contains the same number of variables which used to evaluate the cost frontier. Whereas, the selected variables to measure cost inefficiency are not the same for the all models:[4] Model 1 contains only four determinants of efficiency, staff and institution specific factors; Model 2 includes two additional factors which show student specific characteristics in order to account for the quality of outputs produced; and in addition to the institution, staff and student specific characteristics, Model 3 encompasses the two main revenue sources of the Uzbek HEIs.

Table 3 presents the cost frontier and inefficiency estimates of translog cost function pertaining to three different models. The lambda, λ, of all three models are highly significant at 1 per cent level that proves the fact that the divergence from the cost frontier function is to a great extent explained by heterogenous inefficiency. In other words, the cost inefficiency exists in the provision of higher education at the Uzbek HEIs. The total institutional cost positively correlated to UG and these relationships are statistically significant in the all three models. Unsurprisingly, the influence of PG on the total costs is positive and statistically significant in the all models. RES is positively but insignificantly correlated to the institutional expenditures in the first two models. However, the coefficient of this output is statistically significant in 10 per cent level in the third model. The single input factor in the analyses, SALARY, is exposing insignificant values (in Models 1 and 3) and negative sign in the first model only. This variable's coefficient is significantly and positively correlated to the total costs in the third model, and the cost elasticity with respect to the personnel salary is considerably high 1.74.

[4] As it is stated by Battese and Coelli (1995), coefficients of the determinants of efficiency are interpretable in terms of their signs but not magnitudes.

With regards to the interaction terms, Table 3 shows the coefficients of interaction terms between UG and PG as well as PG and RES are significantly negative at 1 per cent level in the all three models. This means that a substitution effect exists between them. The interactions between UG and SALARY is not significant in Model 2, also the coefficients of UG with RES and SALARY are insignificant in the last model. However, the interaction between PG and SALARY are insignificantly positive for the all models. Regarding the findings of exogenous variables, FTS value is negative and insignificant in the all models except the second model. PROF is showing significantly negative correlations to the institutional inefficiencies in every model. Surprisingly, having greater the share of professors or the share of full-time based personnel decreased the cost inefficiency of the Uzbek HEIs. In the first two models, the total FTE enrolment (SIZE) that is used as a proxy variable for the institutions size is one of the statistically significant factors but with negative signs. The increase in the SIZE of universities may decrease the total expenditures and thus may end up with reduced cost inefficiencies. This outcome can be explained by the greatly increased number of FTE enrolled students relative to the number of academic staff at the Uzbek HEIs during the entire sample period. The findings suggest that these institutions are working under the economies of scale. Unexpectedly, the relationships between the institutions providing medicine-oriented education (MED) and the cost inefficiency are negative but highly significant in the all models, suggesting that having MED is diminishing the institutional expenses.

Table 3: Cost function and inefficiency effects

Among the determinants of inefficiency, the coefficients of STIP and LOAD are highly significant for the all three models. STIP has positive but LOAD has negative influence on the total costs as would be anticipated. Perhaps, the positive correlation between the annual average stipends and the institutional spending is signalling for the improving quality of educational outputs produced at the Uzbek HEIs. However, the increase in the ratio of students over faculty personnel may lead to decreased quality of teaching provision, while it may considerably reduce the total institutional expenditures. The results also show that government allocations and tuition revenue coefficients are positive and statistically significant at 5 and 10 per cent levels, respectively. The findings are implying the positive relationships between these factors and inefficiency. In other words, the growth in the share of either GA or TR increased cost inefficiency during the sample period.

4.2 Cost inefficiency estimates by years and HEIs

The purpose of this sub-section is to analyse average inefficiency level of public HEIs in Uzbekistan for the period 2000-2013. Mean inefficiency scores of the all models, where the institution, student and staff based characteristics were captured, are estimated and discussed in this sub-section. The descriptive statistics for the mean inefficiency scores are presented in Table 4. The mean scores are revealed by years for each model in that table.

<<<< Table 4 About Here >>>>

The mean inefficiency estimates are not relatively sensitive to model selection. The first model reveals a continuously inefficiency reduction from the period of 2001 to 2009 and in 2012, but this decreasing rate of inefficiency is slowdown and started to increase in 2010 by 6 per cent, in 2013 by over 8.5 per cent, and by 10 per cent in 2013. A very similar picture emerges in the last model. The second model shows a substantial inefficiency slowdown in the years 2001, 2004, 2005, 2007, 2008, 2009, 2010 and 2013 but the inefficiency increased by 9 per cent in 2002, by 2 per cent in 2003, by 26 per cent in 2006 and by 5 per cent in 2011.

According to Figure 5, the Uzbek HEIs have managed to constantly reduce the inefficiency throughout the sample period. Such as, the inefficiencies of the three models are ranged from 48 to 55 per cent in 2000, but ranged from 20 to 40 per cent in 2013.

<<<< Figure 5 About Here >>>>

A mean inefficiency performance of the public HEIs are not dispersed ranging between 36 to 37 per cent, and it does not vary considerably from one model to another. In other words, the cost efficiency of the 58 public HEIs, on average, ranged from 64 to 63 per cent during the period of 2000 to 2013. Even though there are institutions those mean efficiency scores are corresponding to the values less than 50 per cent, it seems that institutions in Uzbekistan are operating cost efficiently (see Figure 6 and Table 5). Moreover, the number of public universities those operating less efficient than 30 per cent and more efficient than 90 per cent are very scarce. Based on the empirical findings, we suggest that the CMUZB should encourage a new set of policy-making decisions which could "force" less cost efficient HEIs (1) to utilise their existing resources more efficiently as well as (2) to learn how to operate more cost efficient from more efficiently running institutions.

<<<< Table 5 and Figure 6 About Here >>>>

The figure above illustrates the convergence of results from the SFA technique. Although the inefficiency scores of Uzbek HEIs vary across the models, their relative ranking is very similar. It seems that most of the HEIs from the first 29 institutions performed more efficiently relative to the average inefficiency score (37 per cent), while only several institutions in the second set of 29 HEIs exhibit cost inefficiency above than average.

4.3 Re-estimated GA effect and inefficiencies

As it was mentioned earlier, Uzbek HEIs have two main income sources, such as government allocations and tuition revenue. Therefore, it seems plausible to assume that a HEI with a greater share of government funding is more likely to have a smaller share of tuition income, and vice versa. Since one of the main aims of this study is to analyse whether Uzbek HEIs are more cost efficient with the smaller or greater share of government allocations, the public HEIs divided into three different groups according to the percentage of their incomes received from government allocations (GA). Accordingly, the "small" group consist of universities with smaller share of government funding (GA<40%) but with greater share of tuition revenue (TR); the "medium" group has universities with equal proportion of government allocations (40%≤GA<50%) and tuition revenue; finally, the "large" group of institutions with greater share of government allocations (GA≥50%) but with smaller share of tuition income. Table 5 illustrates the re-estimated GA effect on cost inefficiency as well as the mean inefficiency scores which are re-estimated using the method of Battese and Coellli (1995) for each group of HEIs and study years.

For the public HEIs with the state funding lower than 40 per cent, the coefficient of GA effect is negative but statistically significant in 1 per cent level. In the case of institutions in the "medium" group, GA effect becomes inefficiency improving and significant at the 5 per cent level. However, GA effect is negative and statistically insignificant for the institutions with the state funding greater than 50 per cent. These findings suggest that the increase in GA improves cost efficiency of the HEIs with lower level of public funding, but the growth in GA reduces cost efficiency of the group of HEIs with the same percentage of public and private financings. According to the re-estimates, the public HEIs with a smaller percentage of government funding are, on average, more cost efficient than the institutions with a greater share of GA. Uzbek HEIs those heavily dependent on government funding (GA≥50%) for their daily operation are showing 68 per cent average cost inefficiency value, while universities those mostly rely on tuition revenue and receive smaller share of total income from public funding (GA<40%) are having 36 per cent mean inefficiency score.

<<<< Table 6 and Figure 7 About Here >>>>

According to both Table 6 and Figure 7, the average cost inefficiencies for the all bunches of public HEIs have noticeably decreased year by year. The cost inefficiency of the "small" group of HEIs has dramatically decreased during the period of 2003 to 2009, but slightly increased between 2009 and 2013. Those universities with the greater share of government funding have experienced less cost inefficiency reductions than the institutions with smaller percentage of GA during the entire sample period. All these estimated results suggest that Uzbek universities with smaller percentage of GA but with greater share of TR are more cost efficient than the universities with "medium" or "large" percentage of public allocations.

5. Concluding Remarks

A few but growing empirical evidences reveal that the increased educational expenditures do not always lead to successful long-term student outcomes (Coupet, 2013; Pike et al., 2006). To some extent, the current study answers to this question through examining the efficient utilisation of fiscal resources at the 58 public HEIs using SFA technique and the methods of Battese and Coelli (1995). The results show that the Uzbek universities mostly focused on producing teaching-based outputs, while paying less attention to conduct research-based activities. Relative to the other institutional outputs, the number of undergraduate students can have a greater influence on the total expenditure as anticipated. These findings can be interpreted as; Uzbek HEIs have increased production of undergraduate students through increasing institutional expenditures, whereas the increases in enrolments of postgraduate students and research activities have not been significantly supported from the institutional expenditures. Therefore, it seems plausible to expect that public institutions with a greater share of undergraduate enrolments were less cost efficient than institutions with a smaller share of undergraduate students.

In the majority of efficiency studies, measuring the quality of outputs produced by higher education establishments was one of the challenging tasks. In this study, we used the "brand-new" STIP factor (developed based on the context of Uzbek HES) and more often utilised the students/staff ratio factor in order to examine whether or not the increased production of education-based outputs are associated with improved quality of students at public HEIs. According to Table 3, the increase in LOAD led to reduction in the institutional cost inefficiency but the growth in STIP increased the cost inefficiency. However, education quality is more likely to decline in the case of increased LOAD and decreased institutional STIP. In practice, all the findings of this study should serve for improving cost efficiency of Uzbek HEIs. If a main objective of the Uzbek HEIs is not necessarily to reduce institutional expenditures, but to improve quality of education, then the shares of both professors and full-time staff should be increased. In addition, the number of FTE enrolled students should be increased to reduce cost inefficiency and decrease institutional cost. In most of the cases, however, the expanding SIZE of HEIs increases the student and staff ratio and therefore the education quality is more likely to shrink. Surprisingly, Uzbek HEIs those provide medical instructions have not experienced the growth in the total expenditures and cost inefficiencies during the sample period. Since HEIs with medical schools are both labour and cost intensive, these institutions were expected to have greater cost inefficiency compared to the institutions without medical instruction. Perhaps, one of the explanations for this outcome can be the low level of staff salaries at the medical institutions in Uzbekistan. In other words, annual wages of academic staff at the medicine oriented institutions are not significantly differ from annual salaries of personnel at the non-medicine oriented institutions.

To estimate the mean efficiency scores was a very important in order to find out the financial performance of public HEIs operating in Uzbekistan. The findings reveal that the mean cost efficiency scores were not remarkably high, even though there are signs of efficiency improvements among the HEIs over the last 14 years. The findings of the average inefficiency estimations suggest that the legislative bodies of Uzbekistan should encourage a new set of policy-making decisions which could “force” the less cost efficient HEIs to utilise their resources more efficiently and to learn how to operate more cost efficiently from their prosperous counterparts. In other words, administrative bodies of the public HEIs should take these average efficiency findings as a lesson and should strive to operate above than the mean efficiency scores. Whereas, public institutions those have greater cost efficiency values need to keep their financial performance high through utilising the right combinations of institution, student and staff specific factors.

It was noted earlier that government and tuition incomes have been the main financial resources for the many Uzbek HEIs during the last two decades. According to my findings, institutions with the greater share of tuition revenue but with the smaller share of public funding were more cost efficient compared to institutions with the smaller fraction of tuition revenue but with the greater fraction of government allocations. Particularly, all HEIs’ public share of revenue reduced during the sample period but institutions with greater public share reductions (GA<40%) increased cost efficiency more than institutions with smaller public share declines (GA≥50). These results are not consistent with findings of Sav (2012) and Robst (2001) who conducted cost efficiency analyses in the case of American public HEIs. To the best of my knowledge, there is no other empirical study which examines the impact of the reduced public funding on the cost efficiency of universities. Based on these findings, I can infer that Uzbek HEIs with greater tuition income shares utilised their fiscal recourses more prudently and wisely relative to those public institutions with greater government funding shares.

This study can be extended in a number of directions. Therefore, we propose some suggestions for future research: (1) if data permits, empirical analyses on the economic efficiency of Uzbek HEIs should be conducted by utilising DEA approach. Afterwards, DEA findings could be compared to the results estimated using SFA approach. (2) The similar datasets, like the present study, should be employed to conduct the similar empirical analyses for public HEIs operating in the other Central Asian countries or other lower-middle income countries, such as Armenia, Georgia, Moldova and Ukraine. Findings could then be compared with the findings obtained for Uzbekistan. Since quality of institutional-level data is more likely to vary by country, empirical results of two different groups of public HEIs in two different countries should be compared and interpreted with caution.

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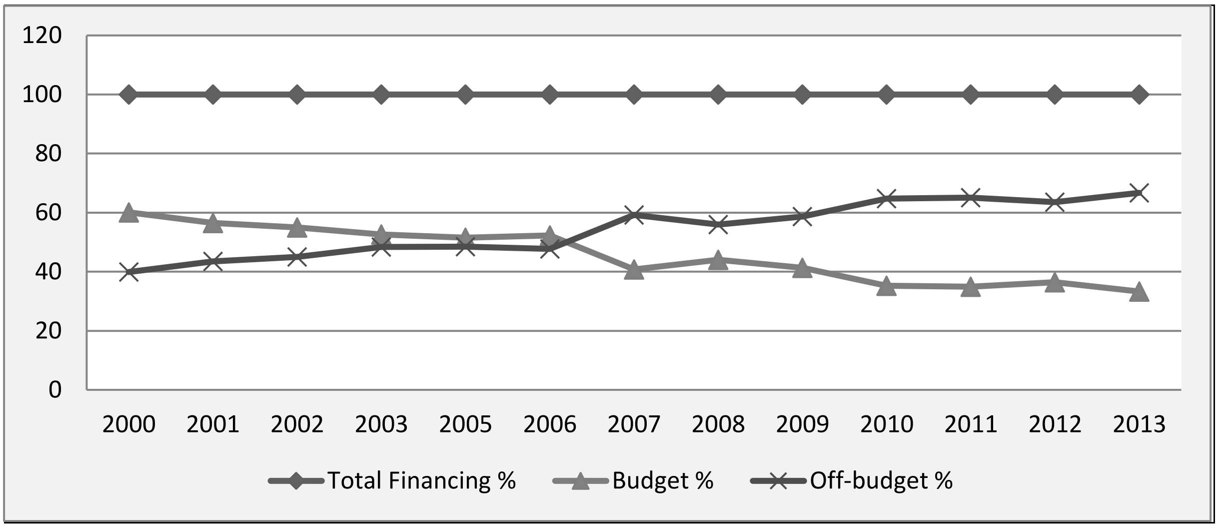
Figure 1: The state-budget and off-budget funding of HEIs in 2000-2013



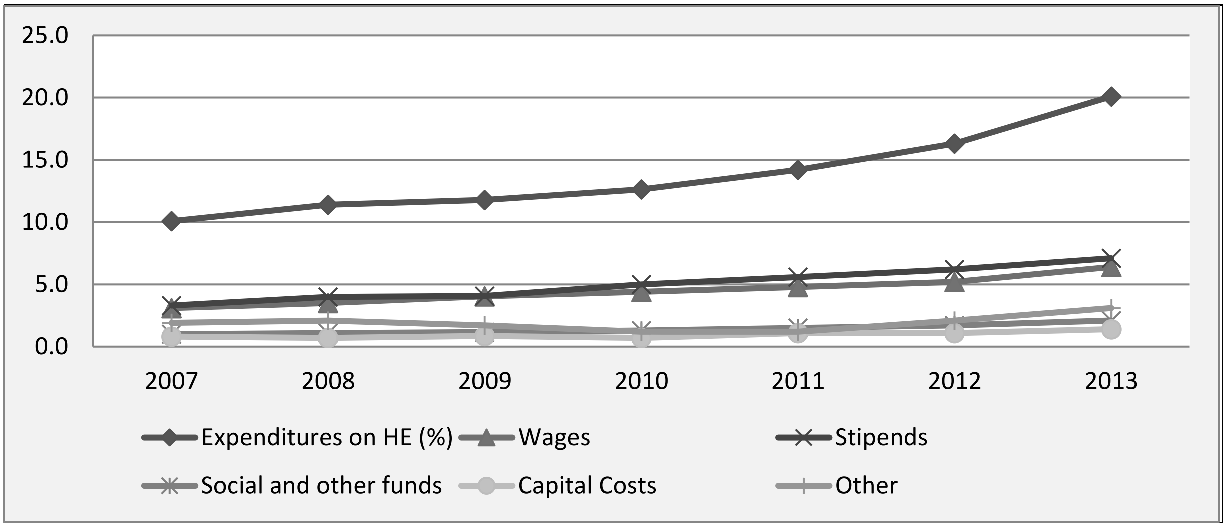
Source: MFUZB (2013)

Table 1: Trends of expenditure per student

Indicators	**Monetary unit**	**2000/2001**	**2003/2004**	**2007/2008**	**2011/2012**	**2012/2013**
Total expenditure per student	*UZS('000)*	*125.8*	*126.3*	*109.1*	*109.1*	*112.3*
	US dollars	*531.7*	*533.8*	*461.1*	*461.1*	*474.6*
State-budget expenditure per student on scholarship	UZS('000)	153.5	171.4	172.1	184.8	197.8
	US dollars	661.5	724.4	727.4	781.1	836
Extra-budget expenditure per student on a fee-based contract	UZS('000)	92.3	96.7	73.7	70.7	72.3
	US dollars	390.1	408.7	311.5	298.8	305.6

Source: MFUZB (2013)

Figure 2: Expenditures on higher education in percentage (between 2007 and 2013)



Source: MFUZB (2013)

Figure 3: An illustration of the cost frontier (OLS vs. cost frontier)

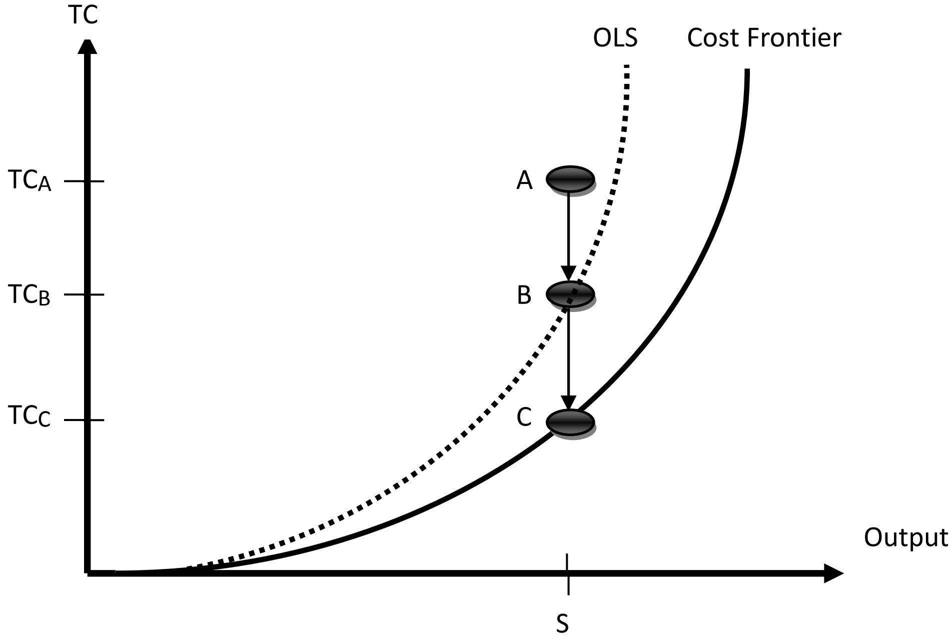
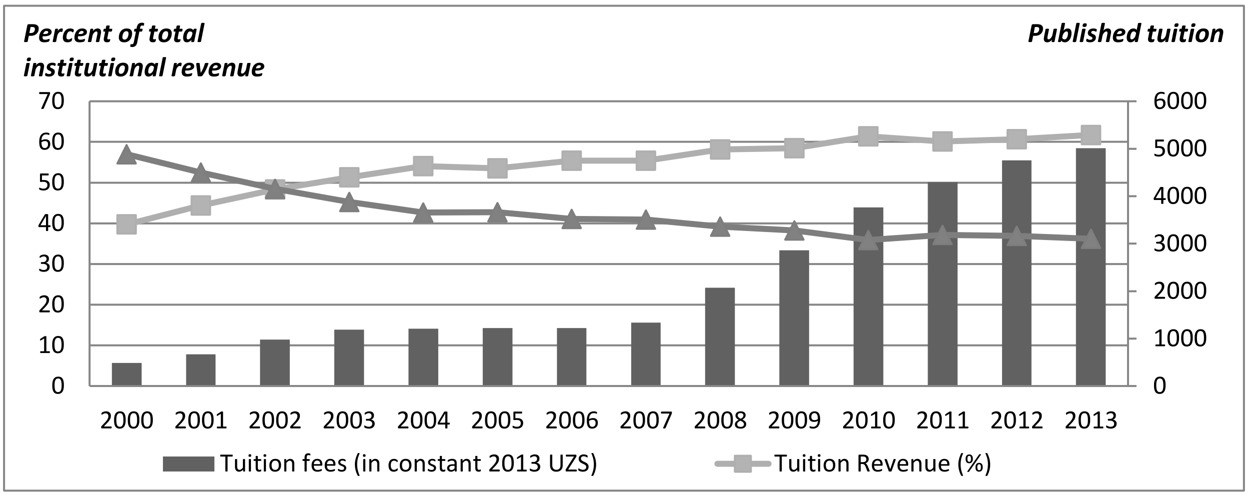


Figure 4: Revenue patterns at the public HEIs in Uzbekistan from 2000 to 2013



Source: MFUZB (2013), author's calculations

Table 2: Descriptive statistics of the key variables

Variable Description	Abbreviation	Mean	St. Dev.	Min	Max
Total Annual Expenditures					
Total Cost (in real 2013 UZB Sums million)	TC	8,220	8,700	51	54,000
Output Indicators					
Undergraduate Students	UG	3,189	2,306	181	12,090
Postgraduate Students	PG	185	232	3	1,630
Incomes from research & other activities (in real 2013 UZB Sums million)	RES	276	431	0.01	3,800
Input Price					
Average staff costs (in real 2013 UZB Sums million)	SALARY	4	3	0.23	18
Exogenous Factors					
Annual stipends per student (in real 2013 UZB Sums million)	STIP	8	0.63	0.02	5
Number of students per teacher	LOAD	8	3	1	20
% of professors	PROF	4	4	0	20
% of full time staff	FTS	53	12	11	99
FTE enrolled students	SIZE	3,374	2,413	204	12,648
Dummy for medical HEI	MED	0.14	0.35	0	1
Revenues					
Share of government allocations (%)	GA	43	16	4	94
Share of tuition revenue (%)	TR	55	16	6	95

Table 3: Cost function and inefficiency effects

	Model 1		Model 2		Model 3	
Cost frontier						
Constant	4.045	(3.77)	-7.935**	(3.34)	1.818	(3.25)
LNUG	0.876*	(0.47)	1.466***	(0.34)	0.917***	(0.33)
LNPG	0.833***	(0.23)	0.613***	(0.19)	0.496**	(0.20)
LNRES	0.243	(0.15)	0.004	(0.11)	0.248*	(0.13)
LNSALARY	-0.060	(0.48)	1.736***	(0.44)	0.588	(0.46)
LNUGSQ	0.002	(0.03)	0.004	(0.02)	0.021	(0.02)
LNPGSQ	0.056***	(0.01)	0.039***	(0.01)	0.025***	(0.01)
LNRESSQ	0.013***	(0.01)	0.001	(0.00)	0.011***	(0.00)
LNSALARYSQ	0.044**	(0.02)	-0.016	(0.02)	0.023	(0.02)
LNUGPG	-0.055**	(0.02)	-0.0423**	(0.02)	-0.058***	(0.02)
LNUGRES	0.003	(0.01)	0.027***	(0.01)	-0.001	(0.01)
LNUGSALARY	0.014	(0.02)	-0.059***	(0.02)	-0.006	(0.02)
LNPGRES	-0.048***	(0.01)	-0.024***	(0.01)	-0.026***	(0.01)
LNPGSALARY	0.008	(0.02)	0.00444	(0.01)	0.019	(0.01)
LNRESSALARY	-0.030***	(0.01)	-0.00685	(0.01)	-0.032***	(0.01)
Determinants of inefficiency						
Constant	1.622***	(0.19)	3.008***	(0.28)	-2.547	(1.98)
PROF	-0.007	(0.01)	-0.011*	(0.01)	-0.006	(0.01)
FTS	-0.014***	(0.00)	-0.024***	(0.00)	-0.021***	(0.00)
SIZE	-0.0004***	(9.77e-05)	-7.37e-05***	(2.67e-05)	1.27e-05	(2.77e-05)
MED	-0.376***	(0.13)	-0.269***	(0.07)	-0.189***	(0.07)
STIP			0.001***	(0.00)	0.001***	(0.00)
LOAD			-0.126***	(0.02)	-0.077***	(0.02)
GA					0.051**	(0.02)
TR					0.035*	(0.02)
σ_u	0.477***	(0.06)	0.311***	(0.03)	0.274***	(0.03)
σ_v	0.201***	(0.02)	0.172***	(0.01)	0.179***	(0.01)
λ (= σ_u/σ_v)	2.371***	(0.06)	1.805***	(0.03)	1.528***	(0.04)
Log likelihood	-214.70		-77.13		-68.00	
Number of HEIs	58		58		58	

Asymptotic standard errors are in parentheses.

* Significant at 10% level, ** Significant at 5% level and *** Significant at 1% level

Table 4: Descriptive statistics for the cost inefficiency

	Model 1		***Model 2***		***Model 3***	
2000	0.53		0.55		0.48	
2001	0.48	-9.4%	0.45	-18.2%	0.44	-8.3%
2002	0.47	-1.7%	0.49	8.9%	0.41	-6.8%
2003	0.45	-4.1%	0.50	2.0%	0.38	-7.3%
2004	0.40	-10.3%	0.46	-8.0%	0.33	-13.2%
2005	0.37	-8.7%	0.38	-17.4%	0.32	-3.0%
2006	0.39	4.9%	0.48	26.3%	0.37	15.6%
2007	0.34	-10.6%	0.37	-22.9%	0.38	2.7%
2008	0.33	-4.4%	0.29	-21.6%	0.37	-2.6%
2009	0.27	-19.5%	0.25	-13.8%	0.31	-16.2%
2010	0.28	6.4%	0.20	-20.0%	0.34	9.7%
2011	0.31	8.5%	0.21	5.0%	0.37	8.8%
2012	0.27	-10.5%	0.21	0.0%	0.35	-5.4%
2013	0.30	9.9%	0.20	-4.8%	0.40	14.3%
Mean	***0.37***		***0.36***		***0.37***	
Median	0.24		0.24		0.29	
Num of HEIs	*58*		*58*		*58*	

Figure 5: Average cost inefficiency scores for the three models

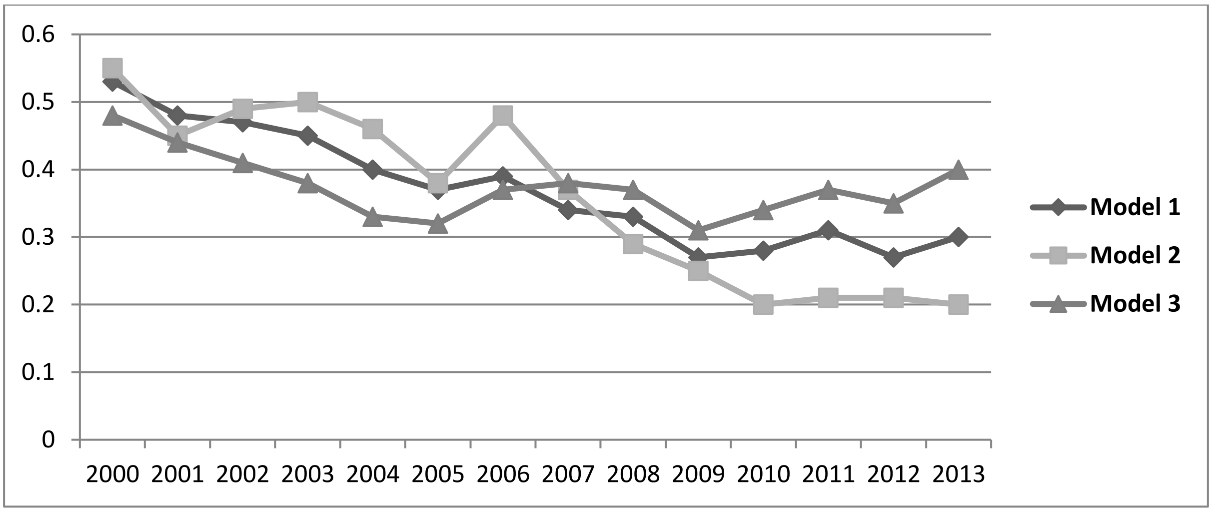


Figure 6: Mean cost inefficiency scores those for 58 public HEIs and for the 14 years

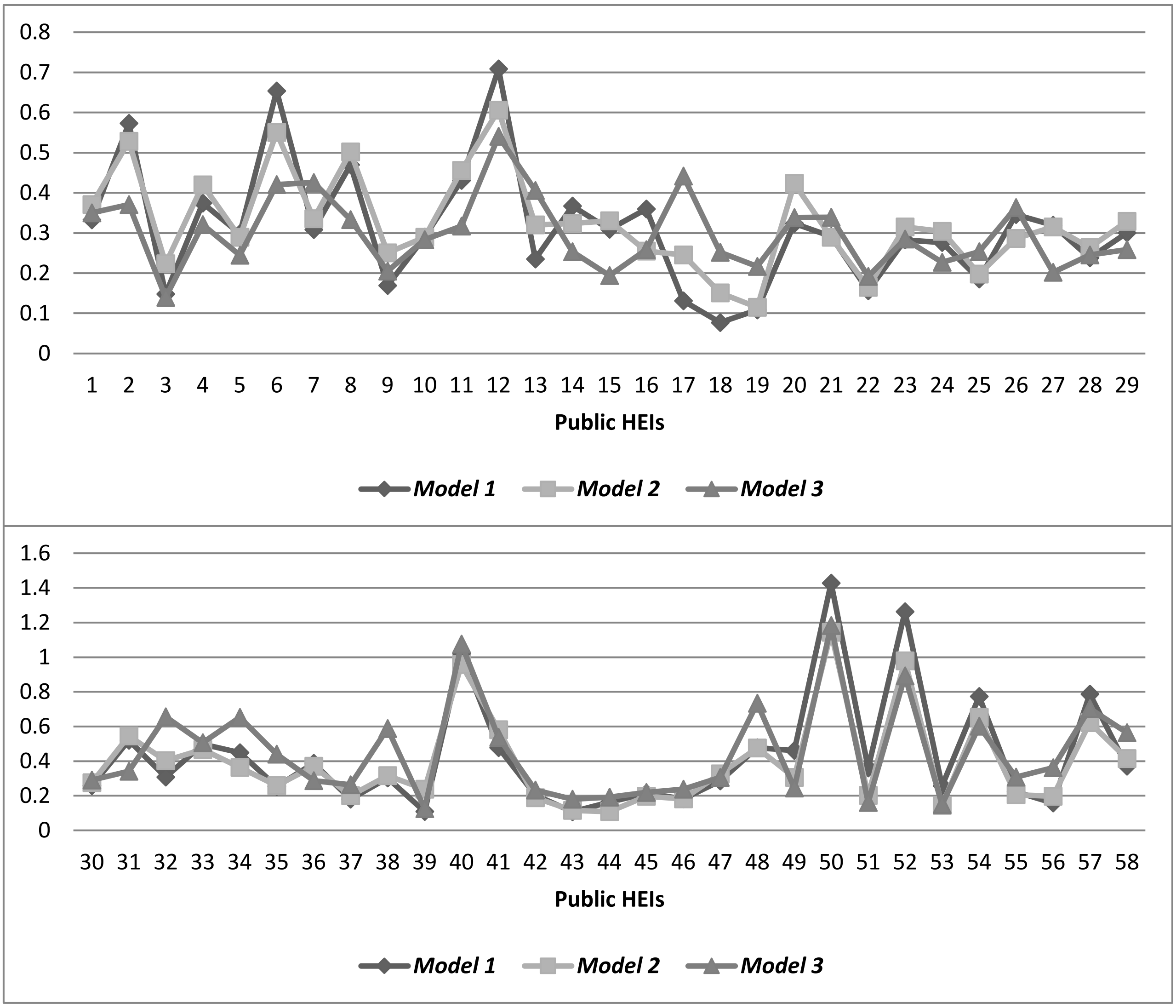


Table 5: Mean inefficiency scores by the HEIs

	Public Higher Education Institutions	Model 1	Model 2	Model 3	Average
1	Andijan State University	0.33	0.37	0.35	***0.35***
2	Andijan Engineering - Economics Institute	0.57	0.53	0.37	***0.49***
3	Buxara State University	0.15	0.22	0.14	***0.17***
4	Buxara Engineering - Technology Institute	0.37	0.42	0.32	***0.37***
5	Gulistan State University	0.30	0.29	0.24	***0.28***
6	Djizzak Polytechnic Institute	0.65	0.55	0.42	***0.54***
7	Karshi State University	0.31	0.34	0.43	***0.36***
8	Karshi Engineering - Economics Institute	0.47	0.50	0.33	***0.44***
9	Karakalpakistan State University	0.17	0.25	0.21	***0.21***
10	Namangan State University	0.29	0.29	0.28	***0.29***
11	Namangan Engineering - Pedagogical Institute	0.43	0.46	0.32	***0.40***
12	Namangan Engineering - Technology Institute	0.71	0.61	0.54	***0.62***
13	Samarkand State University	0.24	0.32	0.41	***0.32***
14	Samarkand State Foreign Language Institute	0.37	0.32	0.25	***0.31***
15	Samarkand State Architecture-Construction Institute	0.31	0.33	0.19	***0.28***
16	Samarkand Economics and Service Institute	0.36	0.25	0.26	***0.29***
17	National University of Uzbekistan	0.13	0.25	0.44	***0.27***
18	Tashkent State University of Technology	0.08	0.15	0.25	***0.16***
19	Tashkent State Pedagogical University	0.11	0.11	0.22	***0.15***
20	Tashkent institute of Textile and Light Industry	0.32	0.42	0.34	***0.36***
21	Tashkent State University of Economics	0.29	0.29	0.34	***0.31***
22	Uzbekistan State World Languages University	0.16	0.16	0.19	***0.17***
23	Tashkent Automobile-Roads Institute	0.28	0.32	0.29	***0.29***
24	Tashkent Architecture-Construction Institute	0.28	0.30	0.23	***0.27***

25	Tashkent Chemistry - Technology institute	0.19	0.20	0.25	***0.21***
26	Tashkent State Institute of Oriental Studies	0.35	0.29	0.36	***0.33***
27	Tashkent Financial Institute	0.32	0.31	0.20	***0.28***
28	Termiz State University	0.24	0.26	0.25	***0.25***
29	Urganch State University	0.30	0.33	0.26	***0.30***
30	Fergana State University	0.26	0.28	0.29	***0.27***
31	Ferghana Polytechnic Institute	0.52	0.55	0.34	***0.47***
32	Tashkent Medical Academy (TMA)	0.31	0.40	0.66	***0.46***
33	Urganch Branch of TMA	0.50	0.47	0.51	***0.49***
34	Andijan State Medical Institute	0.45	0.36	0.65	***0.49***
35	Tashkent Pediatric Medical Institute (TPMI)	0.25	0.26	0.44	***0.32***
36	Tashkent Pharmaceutical Institute	0.39	0.37	0.29	***0.35***
37	Nukus Branch of TPMI	0.18	0.20	0.26	***0.21***
38	Samarkand State Medical Institute	0.30	0.32	0.59	***0.40***
39	Bukhara State Medical Institute	0.11	0.24	0.13	***0.16***
40	Tashkent State Higher School of National Dance and Choreography	1.02	0.96	1.08	***1.02***
41	Tashkent State Art Institute	0.48	0.58	0.54	***0.53***
42	Uzbekistan State Institute of Arts and Culture	0.20	0.19	0.23	***0.21***
43	Nukus State Pedagogical Institute	0.11	0.11	0.18	***0.13***
44	Tashkent State Pedagogical Institute	0.16	0.11	0.19	***0.15***
45	Djizak State Pedagogical Institute	0.21	0.20	0.22	***0.21***
46	Navoi State Pedagogical Institute	0.18	0.18	0.24	***0.20***
47	Kokand State Pedagogical Institute	0.29	0.33	0.31	***0.31***
48	Tashkent University of Information Technology (TUIT)	0.48	0.48	0.73	***0.56***
49	Karshi Branch of TUIT	0.46	0.31	0.24	***0.34***
50	Nukus Branch of TUIT	1.43	1.14	1.18	***1.25***
51	Samarkand Branch of TUIT	0.36	0.20	0.16	***0.24***

52	Urganch Branch of TUIT	1.26	0.98	0.89	***1.04***
53	Fergana Branch of TUIT	0.26	0.14	0.15	***0.18***
54	Andijan Agricultural Institute	0.77	0.65	0.60	***0.68***
55	Samarkand Agricultural Institute	0.22	0.21	0.31	***0.25***
56	Tashkent State Agrarian University (TSAU)	0.16	0.20	0.36	***0.24***
57	Nukus Branch of TSAU	0.79	0.62	0.70	***0.70***
58	Tashkent Institute of Irrigation and Melioration	0.37	0.42	0.56	***0.45***
	Total	***0.37***	***0.36***	***0.37***	

Table 6: Re-estimated GA effect and cost inefficiencies

	GA<40%		***40%≤GA<50%***		***GA≥50%***	
GA	*-0.011***(0.002)*		*0.018**(0.006)*		*-0.001(0.004)*	
Inefficiencies						
2000	0.52		0.80		0.84	
2001	0.53	0.7%	0.67	-16.3%	0.70	-16.7%
2002	0.55	3.9%	0.68	1.4%	0.69	-0.4%
2003	0.59	7.7%	0.60	-12.2%	0.61	-11.4%
2004	0.50	-15.1%	0.52	-12.7%	0.60	-1.8%
2005	0.43	-14.7%	0.45	-13.8%	0.64	6.4%
2006	0.35	-16.9%	0.58	28.9%	0.76	18.0%
2007	0.25	-29.9%	0.48	-17.9%	0.78	3.1%
2008	0.15	-38.1%	0.39	-18.8%	0.80	2.7%
2009	0.14	-10.8%	0.34	-12.9%	0.67	-16.7%
2010	0.23	67.2%	0.34	0.8%	0.60	-10.4%
2011	0.28	23.7%	0.35	2.6%	0.60	-0.2%
2012	0.25	-10.8%	0.28	-19.4%	0.51	-14.2%
2013	0.26	1.4%	0.23	-16.4%	0.67	31.2%
Mean	**0.36**		**0.48**		**0.68**	
Median	0.28		0.36		0.57	
Num of HEIs	26		18		14	

Asymptotic standard errors are in parentheses.
* Significant at 10% level, ** Significant at 5% level and *** Significant at 1% level

Figure 7 Average cost inefficiency scores for the three groups of HEIs