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A TOBIT REGRESSION APPROACH BASED ON DEA EFFICIENCY SCORES

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Keywords: Data Envelopment Analysis, Decision Making Units, efficiency, Saudi Arabia universities, Tobit regression.

Abstract
Data Envelopment Analysis is a powerful technique for measuring the relative efficiency of organizational units with multiple inputs and outputs. This approach was introduced by Charnes, Cooper and Rhodes in 1978, and is gradually becoming a useful management tool. In addition to the efficiency score, Data Envelopment Analysis (DEA) indicates targets for inefficient units. The purpose of this paper is to investigate the performance of fifteen Kingdom of Saudi Arabia universities for the academic year 2013. The study evaluates the technical efficiency of individual Saudi Arabia universities using the nonparametric frontier methodology, the Data Envelopment Analysis (DEA). To investigate the determinants of efficiency, the study use the Tobit regression. This analysis aims to explain the variation in calculated efficiencies to a set of explanatory variables, i.e. total number of students enrolled in undergraduate, graduates, number of academic staff, number of non-academic staff, and number of campuses. In this paper two stage efficiency analyses are applied and used to compare the efficiency of fifteen Saudi Arabia universities using DEA. Two suggested DEA models were used. The study used CRS, and VRS models to measure the efficiency of fifteen Kingdom of Saudi Arabia universities. A second stage the study used the Tobit regression to determine the most environmental factors that affecting the efficiency of this university. The analysis shows that the most influential factors affecting efficiency are the new graduate, graduate last year, previous year graduates PhD, and number of teaching staff.

Introduction
The aim of the higher education policy in any country is establishing a competitive, qualitative higher education with efficiently operating institutions. The question of efficiency needs special attention not only because of the decline of the state support but also the rapid raise of the student mass. In the education system, especially higher education, it's not easy to measure its efficiency. The situation is more complicated since those institutions have multiple inputs and outputs, and not all these outputs could be economically measured. In this case a possible method of determining efficiency is Data Envelopment Analysis.

Data Envelopment Analysis is a linear programming technique which gives a single measure for efficiency. The method has the ability to simultaneously handle multiple inputs and outputs without requiring any judgrnents on their relative importance, so it does not need a parametrically driven input and output production function. Data Envelopment Analysis has become a popular tool for evaluating the efficiency of decision making units. Data Envelopment Analysis (DEA) is a nonparametric mathematical programming approach to the measurement of efficiency that was introduced in the operations research literature by Charnes, Cooper, and Rhodes (1978) and Banker, Charnes, and Cooper (1984). The nonparametric approach has been widely applied to educational production. The primary advantage of the approach is the ability to handle multiple inputs and multiple outputs, particularly in the case when input prices are unavailable.

In this paper two stage efficiency analyses are applied and used to compare the efficiency of fifteen Saudi Arabia universities using DEA. First stage of this paper is to develop a DEA model based on real data in order to test the proposed model and methodology and define targets for efficient units. A second stage the study used the Tobit regression to determine the most environmental factors that affecting the efficiency of this university. Many DEA applications employ a two-stage procedure involving both DEA and Tobit. The result shows that the most influential factors affecting efficiency are the new graduate, graduate last year, previous year graduates PhD, and number of teaching staff. .

The organization of the study is as follows: In Section 2 the study applying regression analysis of DEA efficiency scores. In Section 3 the study applied data envelopment analysis and second stage Tobit. Data analysis and results discussion are given in Section 4. Finally, concluding remarks are provided in Section 5.

Applying regression analysis of DEA efficiency scores
Using regression analysis to explain to variations in the distribution of the DEA efficiency scores has been widely used in the literature. In essence, the efficient input- output levels in DEA are those which are not dominated by the others in the reference set, while regression analysis (RA) is an average method, which estimates an average level for dependent variables by explanatory variables. Many authors have contrasted the use of RA and DEA as methods for comparative performance assessments. Furthermore, an extension of the fuzzy DEA model to a more general form is also proposed with considering the relationship between DEA and

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RA (regression analysis). Using the proposed fuzzy DEA models, the crisp efficiency in CCR model is extended to be a fuzzy number to reflect the inherent uncertainty in real evaluation problems. (Guo and Tanaka 2001).

Taraka et.al 2010 investigated technical efficiency of rice could be grown twice a year. Technical efficiency was evaluated by using the nonparametric approach, DEA approach on 400 rice farms in crop year 2009/2010. Tobit regression model employed in this study provides the results on factors affecting technical inefficiency. The results show that most farms are likely to be operating at lower level of technical efficiency. The study reveals that there is a positive relationship between farm efficiency and family labor, extension officer's service, certified seed use and pest control on weedy rice and insect.

Saima Ayaz, et.al 2010 identified the sources of production inefficiency of the farming sector in district Faisalabad in the Punjab province of Pakistan. Data Envelopment Analysis DEA technique was utilized at farm level survey data of 300 farmers for the year 2009. The overall mean efficiency score was 0.78 indicating 22 percent inefficiency of the sample farmers. Computed efficiency scores were then regressed on farm specific variables using Tobit regression analysis. The results of Tobit regression provided the indication that farming experience, education, access to farming credit, herd size and number of cultivation practices had positive and significant correlation with efficiency of the farmer.

Simar, et al 2011 examined, compared, and contrasted the very different assumptions underlying these two models, and makes clear that second-stage OLS estimation is consistent only under very peculiar and unusual assumptions on the data-generating process that limit its applicability. In addition, the study shows that in either case, bootstrap methods provide the only feasible means for inference in the second stage. The study also comment on ad hoc specifications of second-stage regression equations that ignore the part of the data-generating process that yields data used to obtain the initial DEA estimates.

Yaw-Shun Yu et.al 2012 investigated the efficiency and the determinant the efficiency of optoelectronic firms in Taiwan. Initially, the efficiency of each firms were evaluated using data envelopment analysis (DEA) approach. To investigate the determinants of efficiency, the Tobit regression model was used with the intention to explain variation in calculated efficiencies to a set of explanatory variables, such as firm's size, number of employees, profitability and ownership. The data collected cover the period of year 2010, from the database of the Taiwan' Stock Exchange. The finding reveals that profitable firms are more likely to operate at higher levels of efficiency. The study also reveals that firm's size has a positive impact on efficiency, but its effect is statistically insignificant. Also another finding suggests that the size of employees has a statistically insignificant adverse impact on the performance, indicating that the increase size of employees may have increased the cost and affects efficiency negatively.

G. Thomas Sav2012 investigated how differences in university finances potentially affect operating efficiencies. The analysis uses panel data on 331 universities for academic years 2005-2009. Because finances are only partially under the control of university management, they are treated as quasi environmental in the implementation of data envelopment estimation of efficiencies. Single stage DEA estimates are, therefore, generated with university financial environments included less than one model and excluded under another model. Results are compared to a Tobit two-stage analysis in which first-stage efficiencies are used along with financial environments. Findings indicate that greater tuition dependency promotes inefficiency while increased government funding yields efficiency gains. Investment income also appears to have a slight negative effect, albeit statistically weak.

Gwahula Raphael 2013 presented study empirically investigates the X-efficiency of Tanzanian commercial banks for the period of seven years 2005-2007. The X-efficiency is comprised of Technical efficiency and allocative component, therefore X- inefficiency may be due to technical inefficiency and allocative inefficiency. A non-parametric method of Data Envelopment Analysis (DEA) is used to arrive to the estimated efficiency scores, followed by Tobit regression to investigate what dertermine X-efficiency of Tanzanian commercial banks. During the period of study, most commercial banks were found to have an overall low efficiency level of 53.2 percent, which is quite lower against world mean. Further analysis reveals the allocative efficiency scores are quite lower than technical efficiency scores, which implies that the X-efficiency of Tanzania commercial banks is more associated with choosing an incorrect input combination rather than inappropriate utilization of inputs.

Azmah Othman et al 2013 evaluated the nature and extent of productivity change of the co-operative, Islamic and conventional banks in Malaysia over the period of 2006-2010. This study utilized a non-parametric Data Envelopment Analysis (DEA) methodology and Malmquist productivity index (MPI) to estimate the individual bank efficiency and productivity changes within this period. The results from this analysis showed that 64.3 percent of banks studied had total factor productivity (TFP) progress. The second stage empirical results based on Tobit regression also suggested that bank's assets, status and loan intensity are statistically significant in determining TFP. Environmental factors however, were found to be insignificant determinant.

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Hadi Fazli Ahmadabad et al 2013 utilized non-parametric technique of data envelopment analysis to examine the efficiencies of apple fridges using production and cost data for individual units. Data used in this study were obtained from 18 apple fridges in Tehran province, Iran. The results revealed that, total cost of production was averagely as 59.6 $ per 1000 kg of processed product. Also the results of efficiency analysis with data envelopment analysis (DEA) showed that, 5 units were recognized as efficient units on the basis of variable returns to scale assumptions.

Samar Al-Bagoury2013 adopted the two stage efficiency analysis and uses it to compare the efficiency of African higher education systems in fifteen countries using DEA and then the study use the Tobit regression to determine the most environmental factors that affecting the efficiency of this institute. The analysis shows that the most influential factors affecting efficiency are the growth rate, private share, and public expenditure on education. The main results of the model are the negative impact of private higher education and economic growth on higher education efficiency, while there is positive relationship between government expenditure on education and higher education efficiency.

In Rubayah Yakob et al 2014 the objective of this study was to identify the exogenous variables of risk and investment management efficiency by using a two-stage data envelopment analysis (DEA) method. The first stage involves obtaining the efficiency scores of risk and investment management via DEA that requires only the traditional inputs and outputs. In the second stage, the Tobit regression analysis is conducted in which the efficiency score obtained from the first stage is treated as a dependent variable, while the exogenous factors are considered to be independent variables. The exogenous factors consist of operating systems, organizational form, consumer preference and size. The results showed that the mutual company as well as the takaful system demonstrates better risk management performance than their stock and conventional system counterparts.

The purpose of Domenica Matranga et al 2014 was to compare the technical efficiency of Italian hospitals at a regional level and to examine if differences could be explained by organizational and contextual factors. Technical efficiency was defined as the ability of the operating units evaluated to use optimal resource levels for their level of output. The effect of external factors was explored through a second stage Data Envelopment Analysis (DEA). Efficiency scores were calculated for each hospital using the DEA method (Stage I). Through Tobit regression analysis, the estimated efficiency scores were regressed against a set of organisational and contextual characteristics beyond managerial control, which reflected differences in the population demographics and regional health expenditure (Stage II). Stage I and Stage II efficiency scores were compared in order to indirectly assess managerial contribution in relation to hospital efficiency.

Yustin I. Bangi 2014 paper employs a two-stage Data Envelopment Analysis to examine the efficiency of private Universities in Tanzania in 2008-2012. First, both total technical efficiency and scale efficiency are measured through Data Envelopment Analysis. In the second stage, Tobit regression Model is used to ascertain efficiency determinants. The study use primary and secondary data with three inputs and three outputs derived from multiples sources including 8 surveyed private universities. Results from stage one suggest that there is variability of technical efficiency among private Universities in Tanzania. The study identifies that enrolment, academic staff, non-academic staff and consultancy services are statistically significant.

Data envolpment analysis and second stage Tobit

In this paper two stage efficiency analyses are applied. The first stage the study was estimated DEA models under the assumptions of Constant Returns to Scale (CRS), and Variable Returns to Scale (VRS). Online Software (DEAOS) was used to calculate the technical efficiency scores of the different university. The second stage determined the causes of technical inefficiency using the Tobit Regression Analysis. Tobit regression model is a statistical non-linear model proposed by James Tobin to describe the relationship between a non-negative dependent variable Yi and an independent variable Xi. The word Tobit is taken from the name Tobin and "it" is added to it (Yustin I. Bangi 2014). Tobit model was first suggested in econometrics literature by Tobin 1958. These models are also known as truncated or censored regression models where expected errors are not equal zero. Therefore, estimation with an Ordinary Least Squares (OLS) regression would lead to a biased parameter estimate since OLS assumes a normal and homoscedastic distribution of the disturbance and the dependent variable. To facilitate the Tobit framework, the dependent variable used technical inefficiency rather than technical efficiency. Technical inefficiency was calculated by subtracting the technical efficiency scores. The regression model took the form:

$y^* = x\beta + \varepsilon_t$
where:
y^* is a T x 1 vector of observations on the dependent variable
x is a T x k matrix of observations on the explanatory variables
β is a k x 1 vector of parameters
ε is a T x 1 vector of error terms for T observations

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If y* is unobserved and we observe y instead, then the Tobit model can be defined with the use of a latent variable as: (Cruz *E.*, 2004)

$$y_t = \begin{cases} y_t^* & if \quad y_t^* > 0 \\ 0 & y_t^* \leq 0 \end{cases}$$

Measuring the efficiency of university is differing from measuring the efficiency of any regular production unit from two ways, first: university uses multiple inputs to produce multi outputs making it difficult to use the regular techniques to determine the optimal mix if these inputs and outputs. Secondly, some outputs of university can't be measured because of the nature of this output as social externalities of university or its impact on economic development. DEA can be interpreted with either input-oriented or output-oriented approaches. The output oriented approach focuses on how high maximal output can be achieved with the same amount of resources.

Data analysis and results

Data collected on inputs and outputs for fifteen universities in Kingdom of Saudi Arabia for the academic year 2013 form the basis of the analysis. Data which used are collected from King of Saudi Arabia statistical yearbook for 2013. In this paper two stage efficiency analyses are applied. The first stage the study was estimated DEA models under the assumptions of Constant Returns to Scale (CRS), and Variable Returns to Scale (VRS). DEA was chosen as the analysis technique for a number of reasons, not least that there is no restriction on the types of variables which can be included in the analysis. In DEA studies variables can be measured in different units and there is no need to convert them in to a common scale. Technical efficiency is the ability of the firm to produce the maximum amount of outputs using specific amounts of inputs, and/or conversely, the use of minimum amount of inputs to produce specific amounts of outputs. To measure technical efficiency of the different public university, there is a need to specify the inputs and the outputs. The study presented two DEA models. The first model used the money appropriations or the budget university; total number of new students (bachelor) as inputs and total gradates last year and graduates as output. The second model used total number of academic staff, and total number of non-academic staff, for each university as inputs; and, gradates last year(bachelor) and previous year gradates PhD as output. These two suggested DEA models were estimated under the assumptions of Constant Returns to Scale (CRS), and Variable Returns to Scale (VRS). The technical inefficiency scores from the two DEA models were used as the dependent variable with number of academic staff; non-academic staff ; PhD; number of campuses; number of years since its establishment(age); total number of students enrolled in and graduated number of graduate and undergraduate student as the explanatory variables.

The number of academic staff and non-academic staff were used as possible indicators of the quality of academic staff. The total number of academic staff was used as an indicator of the size of administration. Because it is often alleged that “old” institutions are more efficient than “new” ones, the number of years since establishment of the institution is also included. In addition, the number of campuses was also included as a possible indicator of efficiency. It is assumed that as an institution grows in size the expansion of campuses may allow the institutions to specialize in their activities.

Online Software (DEAOS) was used to estimate technical efficiency scores of the different university. It was available on: www.deaos.com.

Two DEA models were used and CRS, VRS models are running. The efficiency scores of fifteen Saudi Arabia universities were calculated for the two models as seen in table (1).

Table (1) DEA efficiency scores for the two model

University (DMU Name)	Model 1(input oriented efficiency)		Model 2(input oriented efficiency)	
	CRS	VRS	CRS	VRS
King Saud University (Riyadh)	1	1	1	1
King Fahad University for Petroleum & Minerals	0.913	1	0.323	0.702
King Abdul Aziz University,	0.789	1	0.64	1
King Faisal University	0.552	0.577	0.594	0.726
Imam Mohammad Bin Saud Islamic	1	1	1	1
Umm Al-Qura University	0.924	0.932	0.481	0.504
Islamic University	1	1	1	1
King Khaled University	0.827	0.845	0.543	0.568
Taibah University	0.826	0.856	1	1

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Qaseem University	1	1	0.517	0.543
Taif University	0.628	0.654	0.427	0.502
Hail University	1	1	1	1
Tabuk University	0.466	0.811	0.436	0.751
AL-Baha University	1	1	0.639	1
Najran University	0.874	1	0.167	1

From the table, the study observes that nine universities are fully efficient according to VRS while the no. of efficient DMUs was six units according to CRS for the first model. In the second model eight universities are fully efficient according to VRS while the no. of efficient DMUs was five units according to CRS. The study present, for the 15 universities, efficiency scores in the hypothesis of constant returns to scale CRS shows that only a 40%of universities in the sample have a very high level of efficiency, while 60% of them have low level of efficiency and variable returns to scale VRS shows that only a 60%of universities in the sample have a very high level of efficiency, while 40% of them have low level of efficiency for the first model. In the second model efficiency scores in the hypothesis of constant returns to scale CRS shows that only a 33%of universities in the sample have a very high level of efficiency, while 67% of them have low level of efficiency variable returns to scale VRS shows that only a 53%of universities in the sample have a very high level of efficiency, while 47% of them have low level of efficiency.

Table (2) summary statistic for DEA efficiency scores for the two model

	CRS	VRS	CRS	VRS
Mean	0.85327	0.91167	0.65113	0.81973
Standard deviation	0.17632	0.13802	0.28149	0.21178
Min	0.466	0.577	0.167	0.502
max	1	1	1	1

But although the relative high percentage of efficient units there is wide variation in efficiency score and a big gap between lower and higher efficiency score, Najran university have the lower score about 16% and shows the peer unit for each inefficient country. Table (2) showed statistical summary for DEA efficiency scores.

In order to analyze the effect of environmental or external factors and its impact on efficiency, Tobit model is adopted using gretl 1.9.8. The second stage determined the causes of technical inefficiency using the Tobit Regression Analysis. The dependent variable in this model is the University efficiency which calculated by CRS and VRS models, where input and output are treated as independent variables. The sign of coefficients is expected to be either positive (+) or negative (-). A positive sign implies a positive relationship between dependent variable and independent variable, whereas, a negative sign indicates a negative relation between independent and dependent variables. The following table shows the result of the model including the parameters estimates, and standard errors for each estimate.

Table (3) normalized coefficients from Tobit regression analysis

Independent variable	Coefficients for model $1^{(1)}$		Coefficients for model $2^{(2)}$	
	CRS	VRS	CRS	VRS
Number bachelor	-3.20942e-05^{ns} (3.12251e-05)	6.14866e-06^{ns} (3.18499e-05)	-4.20735e-05*** (0.000112506)	-8.89233e-05** (3.73506e-05)
Number graduate	0.00091513^{ns} (0.000714923)	-0.00027432^{ns} (0.000620636)	-0.00192642^{ns} (0.000660823)	-0.00202655*** (0.000377816)
Teach. Staff	-0.00110167* (0.00062767)	8.522e-05^{ns} (0.000460656)	0.000500737^{ns} (0.000555572)	0.00292188*** (0.00064989)
Adm. Staff	-5.62557e-05^{ns} (7.33562e-05)	4.3353e-05^{ns} (5.89649e-05)	-1.25853e-05^{ns} (9.12294e-05)	0.000164472*** (2.62669e-05)
Total gradates last year	0.000328753^{ns} (0.000206118)	0.000184707^{ns} (0.000198464)	0.000170012^{ns} (0.000325192)	-0.00018814*** (5.95387e-05)
Number campuses	0.0120021^{ns} (0.0209771)	0.00217746^{ns} (0.0180727)	0.0482473^{ns} (0.0454556)	-0.0759917*** (0.0240857)
Age	0.0192961^{ns} (0.0195586)	-0.0176229^{ns} (0.0221177)	-0.0392259^{ns} (0.0204364)	-0.0342144*** (0.00989611)
Graduate last	-0.00100223^{ns} (0.002284)	-0.00277312* (0.00166859)	-0.00138095* (0.000947999)	-8.89233e-050*** (0.000670492)

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PhD	-0.00666493^{ns} (0.0226816)	0.0368714* (0.0213053)	0.0737981*** (0.0246748)	0.0929559*** (0.0135122)
R^2	0.513	0.753	0.787	0.722

(1)Used the money appropriations or the budget university; total number of new students (bachelor) as inputs and total gradates last year and graduates as output.
(2)Total number of academic staff and total number of non-academic staff, for each university as inputs; and, gradates last year (bachelor) and gradates PhD as output.
*Significant at the 5%level of significance. *** Significant at the 1%.5%and 10%level of significance.
sn not significant at the 5%level of significance. The numbers between brackets are the associated standard errors.

Tobit analysis using the technical inefficiency from number of the money appropriations or the budget university; total number of new students (bachelor) as inputs and total gradates last year and graduates as output the model 1, yielded Graduate last and PhD of the academic institution as the only significant determinant of technical inefficiency when variable returns to scale VRS is applied. When variable returns to scale CRS is applied number of academic staff only significant. Model 2 used total number of academic staff and total number of non-academic staff, for each university as inputs; and, gradates last year (bachelor) and gradates PhD as output.

Number bachelor, Graduate last year and PhD entered as a significant contributory variable to explain technical inefficiency when variable returns to scale CRS is applied. But when variable returns to scale VRS is applied all explanatory variable are significant.

Conclusion

The objective of this paper was to apply a two-step methodology to investigate the recent performance record and assess the determinants of performance of fifteen Saudi Arabia universities 2013. Data Envelopment Analysis (DEA) techniques are used to estimate technical and scale efficiency of individual Saudi Arabia universities as a first step. The explanation of the efficiency scores using Tobit regressions offers useful economic insights. The study interprets the significance of fifteen Saudi Arabia universities as an indication of higher efficiency of large universities. In this paper two stage efficiency analyses are used and use it to compare the efficiency of fifteen Saudi Arabia universities. The study uses the Tobit regression to determine the most environmental factors that affecting the efficiency of this institute. The result shows that the most influential factors affecting efficiency are the new graduate, graduate last year, previous year graduates PhD, and number of teaching staff.

References

1. *Ahmadabad H., F., Mohtasebi S., S., Avval S., H., M. and Marjani R., M. 2013 Application of Data Envelopment Analysis Approach to Improve Economical Productivity of Apple Fridges International Research Journal of Applied and Basic Sciences Vol, 4 (6): 1603-1607.*
2. *Al-Bagoury S. 2013 DEA to Evaluate Efficiency of African Higher Education. Wyno Academic Journal of Educational Research and Essays Vol. 1(4), pp. 39-46.*
3. *Ayaz, S., Hussain, Z. and Sial M., H., 2010 Role of Credit on Production Efficiency of Farming Sector in Pakistan (A Data Envelopment Analysis) World Academy of Science, Engineering and Technology Vol: 4, 06-27.*
4. *Bangi Y.2014 Efficiency Assessment of Tanzanian Private Universities: Data Envelopment Analysis (DEA). International Journal of Education and Research Vol. 2 No. 5.*
5. *Banker, R., D, Charnes, A., C, Cooper, W., W. 1984. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. Management Science 39 pp. 1078–1092.*
6. *Charnes, A., Cooper, W., W., and Rhodes, E. 1978 Measuring efficiency of decision making units, European Journal of Operational Research, Vol. 2 pp 429-444.*
7. *Cruz E., 2004 Measuring Technical Efficiency In Research Of State Colleges And Universities In Region XI Using Data Envelopment Analysis 9th National Convention on Statistics (NCS).*
8. *Guo P.and Tanaka2001 Fuzzy DEA: a perceptual evaluation method. Fuzzy Sets and Systems 119. 149-160.*
9. *Matranga D., Bono F., Casuccio A., Firenze A., Marsala L., Giaimo R., Sapienza F., and Vitale F.2014 Evaluating the effect of organization and context on technical efficiency: a second-stage DEA analysis of Italian hospitals. Epidemiology Biostatistics and Public Health, Volume 11, Number 1.*
10. *Othman. A., Kari, F. and Hamdan R. 2013 A Comparative Analysis of the Co-operative, Islamic and Conventional Banks in Malaysia. American Journal of Economics, 3(5C): 184-190.*
11. *Raphael G. 2013 X-efficiency in Tanzanian Commercial Banks: An empirical investigation. Research Journal of Finance and Accounting Vol.4, No.3.*
12. *Sav G., T Effects of Financial Source Dependency on Public University Operating Efficiencies: Data Envelopment Single-Stage and Tobit Two-Stage Evaluations Review of Economics & Finance Article ID: 1923-7529-2013-01-63-11.*

Global Journal of Engineering Science and Research Management

13. *Simar L´., Wilson W., P. 2011 Two-Stage DEA: Caveat Emptor. Journal of Productivity Analysis.*
14. *Taraka, K., Latif, A., I. and Shamsudin, N., M. 2010 A Nonparametric Approach to Evaluate Technical Efficiency of Rice Farms in Central Thailand chulalongkorn journal of Economics 22, 1-14.*
15. *Yakob R., Yusop Z., Radam A. And Ismail N. 2014 Two-Stage DEA Method in Identifying the Exogenous Factors of Insurers Risk and Investment Management Efficiency. Sains Malaysiana 43(9): 1439–1450.*
16. *Yu S., Y., Barros A., Yeh L., M., Lu J., M. and Tsai H., C 2012 A Study of Estimating the Technical Efficiency of Optoelectronic Firms: An Application of Data Envelopment Analysis and Tobit Analysis. International Journal of Academic Research in Business and Social Sciences, Vol. 2, No. 7.*