



Received: 27 April 2017
Accepted: 15 May 2018
First Published: 02 July 2018

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Reviewing editor:
Xubin Zhang, Monash University,
Australia

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

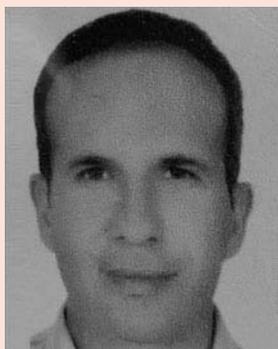
Assessing government spending efficiency and explaining inefficiency scores: DEA-bootstrap analysis in the case of Saudi Arabia

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Abstract: The recent Saudi Arabia's "Vision 2030" including the National Transformation Plan has renewed the debate on the efficiency of government spending. The aim of this paper was twofold. First, to measure the relative efficiency of Saudi Arabia's public spending over the period 1988–2013 using non-parametric approach. Second, to explain the inefficiency scores using a DEA-Bootstrap analysis by incorporating environmental variables. The empirical results show that, on average, the public spending is inefficient, implying that Saudi Arabia can improve their performance on health, education and infrastructure without increasing spending. The empirical explanation of the inefficiency scores using a DEA-Bootstrap analysis shows that the unemployment and broad money negatively impact government expenditure mainly in the case of infrastructure and health. Our findings can be useful for policymakers in order to set out a structural adjustment plan to improve the efficiency level for education, health and infrastructure expenditures.

Subjects: Statistics for Business, Finance & Economics; Middle East Economics; Economics; Political Economy

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PUBLIC INTEREST STATEMENT

The problem of the efficiency of the Saudi Kingdom's public spending is in tune with a major reform work. The latter aims to establish a new vision that would change the Outlook of the Saudi economy of an economy essentially based on the income from oil resources to a more diversified economy.

It is in this context that the study of the possible inefficiencies of the Saudi public expenditure structure proves to be an ultimate usefulness to bring the necessary improvements to the revealed dysfunctions. The results of our research shed light on the inefficiencies affecting both infrastructure spending and the health sector. These results are explained by the combination of two factors, namely unemployment and broad money. Our work would be of relevance to policymakers to the extent that these inefficiencies are likely to be corrected by taking a range of measures affecting the structure of expenditure and which will have, as objective, a better allocation of public resources.

Keywords: government expenditures; public spending efficiency; technical efficiency; DEA-bootstrap

1. Introduction

Government spending (or expenditure) is a tool to strengthen the capacities of people in health, education and income. It represents a key indicator in a country's growth and development. The large variation in this indicator highlights the variety of countries' approaches to delivering public goods and services, and providing social protection. The primary purpose of this paper was to investigate the relative efficiency of Saudi Arabia's public spending and to explain empirically the inefficiency scores. This research track has been deeply exploited by Afonso et al. (see references below) implying the importance of gauging the efficiency of public spending. Gupta and Verhoeven (2001) point out the importance of assessing the efficiency of government spending in that it continuous to attracts attention of policymakers as well as researchers. Filmer and Pritchett (1999) have raised the impact of public spending on health. The focus on Saudi Arabia is explained by the fact that public spending in this country is very important.¹ Saudi Arabia's economy is one of the largest in the Middle East and North Africa, representing 25% of the region's gross domestic product (GDP). It has doubled in size to rank among the top 20 largest economies in the world, climbing from number 27 in 2003.² In addition, the recent Saudi Arabia's "Vision 2030" has renewed the debate on the efficiency of government spending. This vision expresses Saudi Arabia's long-term goals and expectations, and reflects the country's strengths and capabilities.³ Saudi Arabia can no longer grow based on oil revenue and public spending, in the face of a changing global energy market and a demographic transition.

Saudi Arabia is strongly connected to oil and the recent decrease in oil prices led to a significant deficit in the government's budget and has affected Saudi Arabia's credit rating. Then, the recent collapse of oil prices in June 2014, the need to improve competitiveness and the elevation in economic uncertainty have motivated us to investigate the relative efficiency of Saudi Arabia's expenditure. The questions we ask today is not whether Saudi Arabia is too big, but whether it works. More specifically, we address the following questions: Are public services (namely, education, health and infrastructure) satisfactory considering the amount of resources allocated to its activity? Can Saudi Arabia obtain better performance results in public sectors using the same resources? Can we explain the measured inefficiency scores by environmental or non-discretionary component?

This study uses non-parametric approach (Data Envelopment Analysis (*hereafter*, DEA) to estimate efficiency score of public spending. This technique is extensively used in empirical application which means that it is a competing methodology to stochastic frontier approach (SFA) and exhibits many advantages comparing with SFA, such that: (i) unlike SFA, the main feature of DEA is that it does not require specifying a functional form for production technology; (ii) DEA can be applied easily and no distributional assumptions required; (iii) in the case of production function, the DEA approach can be used in the case of multi-inputs multi-outputs. This is the main advantage vis-à-vis the SFA approach that can be only used when we have one output, or aggregate output. Therefore, in this kind of research, aggregate outputs in one output lead inevitably to misleading results.

In the field of the efficiency of public expenditure, a very large number of works have used the non-parametric DEA approach, e.g., Afonso and Aubyn (2004, 2006), Afonso et al. (2005, 2010), Afonso and Fernandes (2008), Afonso and Kazemi (2017), Gupta and Herhoeven (2001), Tanzi (2004) and Volkan et Serdal (2016) among several others.

This study contributes to the existing literature on government spending in two ways. First, we measure the relative efficiency of public spending over the period 1988–2013 in the case of the largest GCC country which is for Saudi Arabia which its finances strained by low oil prices. Second,

we explain the technical inefficiency (TE) using DEA-bootstrap approach allowing the identification of a battery of environmental variables that could affect the policymaker's decision. The remainder of the paper is organized as follows: Section 2 presents literature review. Section 3 highlights the public expenditure structure in Saudi Arabia. Section 4 describes data and empirical methodology. Section 5 reports empirical findings and results discussion. Section 6 analyses the determinants of public expenditure efficiency. The article ends with a conclusion.

2. Literature review

Most of the empirical research on efficiency focuses mainly on bank, insurance, hospital, education, etc. However, there are only few studies that focus on government spending efficiency in the case of emerging markets. Furthermore, most of efficiency studies focused principally on measuring public expenditures in the case of cross-country level and/or panel data, with a limited number of studies conducting a time series analysis (i.e., Rouselle et al. 2015, among others). Gupta and Verhoeven (2001) assess the efficiency of government expenditure in the case of 37 African countries over the period 1984–1995 using the non-parametric approach Free Disposal Hull (FDH). Their main findings stress that, on average, the spending of these countries towards education and health are inefficient. They show that the relationship between efficiency scores and public expenditure is negative, implying that higher educational attainment and health output requires efficiency improvement more than increased budgetary allocations. Jarasuriya and Woodon (2003) assess the public spending efficiency in the case of 76 developing countries over the period 1990–1998. They have separately constructed two efficiency frontiers: the first one considers three inputs (per capita GDP, spending per capita and the adult literacy rate) to produce a single output (the net primary enrolment). The second one considers the same inputs, but to construct a health output indicator (life expectancy). They find no relationship between spending and the two outputs when they take account the per capita GDP. These findings imply that an increase in public spending does not guarantee an improvement in education or health. Greene (2004) use the SFA in the case of WHO panel data to estimate and explain inefficiency scores variation across a sample of counties. The main contribution of this paper to the frontier efficiency literature is the novel model “*True-random effect*” proposed for the first time by the author. The idea behind this model is to distinguish between efficiency and heterogeneity. In a first step, the author estimates a production frontier using expenditure and education as inputs to produce one output (health). In the second step, the author explains the expenditure on health by examining the inefficiency score on a set of explanatory variables by using linear regression. The author stressed that only the income inequality measure, GDP per capita and a dummy variable for tropical location were significant. Greene (2005a) analyse the public spending efficiency in a sample of 232 countries over the period 1975–2002 using a variety of econometric models developed in the stochastic frontier methodology. He argues that the stochastic frontier is more suitable than the non-parametric approach (DEA). Greene (2005b) re-examines a study from the World Health Organization dealing with the public spending efficiency on healthcare and education attainment. He presents a variety of estimation comprising the single input–output case by estimating a production function, and the multi-output–input case but using the parametric distance function. Afonso and Aubyn (2004) use the non-parametric approaches DEA and FDH to analyse the efficiency of expenditure in education and health in the case of a sample comprising some OECD countries. The authors present the different results obtained by input-oriented and output-oriented efficiency estimations. Their main findings exhibit a very low spending and low education attainment results; hence, it can be considered as the “origin” of the efficiency frontier. Carosi et al. (2014) study the global public spending efficiency in Tuscan municipalities by according a particular interest for the impact of the municipal size by adopting the non-parametric methodology. Moreover, they adopt a second-stage analysis in order to explain the inefficiency scores using a Tobit regression. Their main findings either by the DEA methodology or by the Tobit regression seem to be consistent, meaning that it can be considered as a very usefulness tool to the decision makers in order to correct the spending policies adopted by the inefficient municipalities. Furthermore, they find that municipal has a real effect on the efficiency of the public spending (i.e., the bigger is a municipality and the greater is their efficiency level). Yi-Chang Hsu

(2013) use DEA approach to assess health expenditure for 46 European and Central Asia countries. He found that these countries could produce more quantity of outputs by about 2.1% while maintaining the same level of inputs. Rouselle et al. (2015) assess the efficiency of public expenditure on health, education and social protection. Using DEA methodology, they find that countries could reach a higher level of efficiency given their input level (expenditures on education and health). At the health level, the authors find that countries can improve the different outputs by about 4%. Fonchamnyo and Sama (2016) analyse the efficiency of public expenditure on education and health and their determinants in three CEMAC countries (Cameroon, Chad and Central African Republic) using non-parametric DEA method over the period 2000–2012. Furthermore, the authors examine the impact of some non-discretionary variables (institutional and economic factors) that might influence inefficiency by the means of Tobit and Logit regression techniques. The empirical results show that Cameroon is the best in term of efficiency in spending on education and health, and Chad is the worst regarding public spending on education, despite it spends more on education than the other. Central African Republic is the least efficient in public spending on health. Based on the second regression, the authors stated that decision makers should fight against corruption and assess the quality of budgetary and financial management. Afonso and Kazemi (2017) have conducted an analysis dealing with public spending efficiency of 20 OECD countries over the period 2009–2013. Their main contribution to the underlying literature consists in the construction of two indices to gauge Public Sector Performance (PSP) and Public Sector Efficiency (PSE). The main objective of their work is to evaluate performance and efficiency on the basis of inputs and outputs. In a first step, they have constructed two indicators, PSP and PSE. In a second step, they used the non-parametric approach (DEA) by considering six different models. The first two models assess efficiency of government at the aggregate level, but the other four models assess the efficiency of public spending in four main sectors: administration, education, health and infrastructure. The assessment of the PSP scores raises that Switzerland is the best practice over the whole period followed by Luxembourg, Norway and Canada. But the worst are Greece, Italy, Portugal and Spain. Furthermore, authors point out that France, Denmark, Belgium, Finland, Sweden and Austria could improve their efficiency by using less of total expenditure regarding the actual level. The authors raised that countries that spend more are less efficient and vice versa.

3. Structure of public expenditures in Saudi Arabia

3.1. Trends of government expenditure to gross domestic product (GDP)

GDP is an indicator describing the standard of living at the country level. It can be adopted as an environmental variable in the explanation of efficiency. Various researches reveal that this is later positively associated with government spending on education. Theoretically, more is higher GDP per capita, more public spending per capita is better and vice versa (Sopek, 2011). Saudi Arabia GDP in 2016 in fixed prices (100 = 2010) is estimated to be SAR (2,581) million, a rise of 1.40%, with that of the oil sector to grow by 3.37%. The GDP for the government sector is expected to rise by 0.51% and the private sector to grow by 0.11%. The oil refinery activity has grown by 14.78%, the highest growth rate within the economic constituents of the real GDP.⁴ Government expenditure per capita highlights the share of government spending by person, and can be used as an environmental variable in order to show the amount of money spend by government in any sector. It shows their contribution in the assessment of education, health and infrastructure outcomes. Table 1 presents Saudi Arabia's ratio of government expenditure to GDP from 2010 to 2015, with projections up until 2020. Saudi Arabia's ratio of government expenditure decreases from 41.34% on 2015 to 36.18% on 2016.

3.2. Trends in government expenditure on education, health and infrastructure

The averages of government spending on education, health and infrastructure as a share of total government expenditure, over the period 1988–2013 are about 17%, 7% and 20%, respectively. According to the World Bank, Saudi Arabia invested SAR 1.7 trillion in capital projects including infrastructure, education and healthcare over the period 2005–2015. The budget expenditure for the year 2017 is estimated at SAR 890 billion, an 8% increase over the projected 2016 expenditure

Table 1. Saudi Arabia: Ratio of government expenditure to gross domestic product (GDP) from 2010 to 2020

Year	Ratio of government expenditure to GDP (%)
2010	33.97
2011	33.36
2012	33.32
2013	35.64
2014	40.35
2015	41.34
2016	36.18
2017	33.10
2018	34.51
2019	33.37
2020	33.39

Source: Statistica.

of SAR 825 billion. The increase in projected revenues and expenditure is mainly due to the energy pricing reform programme, even if this will be partially counterbalanced by the allowances for those citizens who need government support.

4. Empirical methodology and data description

4.1. Empirical methodology

The efficiency of Decision Making Unit (*hereafter* DMU) is considered as the cornerstone for assessing the performance in any industry, i.e., banks, insurance, energy, public expenditure, etc. Moreover, the frontier approach can be used at the country level or cross-country in order to estimate and evaluate a given sector, even it can be used to analyse the efficiency of the state policy concerning the public spending.

Two main approaches have been proposed in the literature: the non-parametric (linear programming) approach such as DEA or FDH and the parametric approach such as the stochastic frontier relying on the estimation of a parametric frontier function (i.e., production, cost, revenue or profit function).

In this paper, we use the non-parametric frontier approach, DEA, in order to gauge technical (in) efficiency that can be input-oriented or output-oriented, of public spending in Saudi Arabia. The main advantage of this technique is to estimate the inefficiency scores without specifying the frontier function that is usually unknown.

4.1.1. Estimating technical inefficiency using DEA methodology

In this part, we focus on the non-parametric approach, DEA, developed by Banker et al. (1984) and extended by Lynde and Richmond (1999) to the case of productive efficiency time-series analysis. It is worth noting that DEA is a mathematical linear programming approach devoted to measure inefficiency (i.e., technical inefficiency, TE) of different DMUs, but also for the same DMU (e.g., Saudi Arabia) observed over several years. The idea seems to be interesting since each DMU in each period will be treated as it were different DMUs. This procedure allows us to compare the DMU with itself over periods, enabling us to find the change in efficiency over time.⁵

In the present study, government is considered as a DMU or as producer using a given level of input(s) to produce a given amount of output(s) (goods and services).

According to Afonso and Kazemi (2017) and Lynde and Richmond (1999), the mathematical program for each time t used to evaluate the technical efficiency is given as follows:

$$\text{Max}_{\lambda, \phi} \phi \tag{1}$$

Subject to

$$-\phi y_t + Y\lambda \geq 0$$

$$x_t - X\lambda \geq 0$$

$$l'\lambda = 1$$

$$\lambda \geq 0$$

where

ϕ : is a scalar and $\frac{1}{\phi}$ represents the output-oriented technical efficiency score, which lies between 0 and 1. 0 implies an inefficient DMU and 1 signifies a full efficient DMU.

y_t : is a vector of outputs for the year t .

Y : is a vector of outputs for the whole period.

X : K by T input matrix, used to produce M outputs.

x_t : is a $(T \times 1)$ vector of inputs.

l' : is a T by 1 intensity vector.

λ : is a $(T \times 1)$ vector of constants included to assess the weight that identified the position of the inefficient DMU (Afonso & Kazemi, 2017).

Note that the constant return to scale (CRS) model can be obtained simply by ignoring the constraint $\sum_{t=1}^T \lambda_t = 1$. Then, CRS implies that an increase in inputs quantity leads to the same increase in outputs quantity. But, VRS (Variable Return to Scale) implies a non-proportionate relationship between inputs and outputs.

In the case of time series, the main idea behind the application of the above DEA model is that the most efficient year is the year during which we have recorded better results (maximum outputs) with the same level of inputs: this year determines accordingly the best practice frontier, relative to which we compare the efficiency of the other years.

4.1.2. Explaining inefficiency: DEA-bootstrap approach

In the second stage of our study, after having estimated the TE scores, we attempt to explain the variations in efficiency scores of Saudi Arabia public spending, as well as to identify the most important factors that may explain the inefficiency scores. Usually, we can apprehend the effects of some variables on efficiency scores by adopting the regressing equation below:

$$\hat{\delta}_t = z_t\alpha + \varepsilon_t, \quad t = 1, \dots, T \tag{2}$$

where

$\hat{\delta}_t$ is a vector of the obtained TE scores;

z_t is a vector of explanatory variables that might affect the efficiency level for the year t ;

α represents the unknown parameter vector to estimate;

ε_t is a normally distributed error term with zero mean and variance σ_ε^2 .

According to Fonchamnyo and Sama (2016), authors use the OLS technique to estimate the linear equation, Tobit estimation technique (Afonso 2010, Dobdinga et al. (2016)) or fractional logit estimation proposed by Papke and Wooldridge (1996). However, Simar and Wilson (2007) stated that the DEA efficiency scores are biased upward and serially correlated as the estimation of the technical efficiency score for a given year t (or for each DMU) must include all other years (all other DMUs). Furthermore, we can expect a correlation between inputs and outputs and non-discretionary variables that might explain efficiency. This leads to the violation of the assumption of independence between the noise term ε_t and z_t .

These shortcomings lead Simar and Wilson (2007) to propose the two-stage method to explain inefficiency. For this reason, the authors proposed a double-bootstrap procedure in order to obtain consistent inference on efficiency scores, i.e., standard errors, confidence intervals and to adequately estimate the model's parameters.

According to Simar and Wilson (2007), the procedure proposed is as follows:

- (1) Compute $\hat{\delta}_t$ (DEA output-oriented technical efficiency) using the original data.
- (2) Estimate $\hat{\alpha}$ of α and $\hat{\sigma}^2$ of σ^2 by maximum likelihood method, where $\hat{\delta} > 1$.
- (3) For each year $t = 1, \dots, T$ loop over the following four steps (i-iv) B times in order to obtain B bootstrapped technical efficiency, i.e., $\hat{\delta}_{t,b}^*$, $b = 1, \dots, B$.
 - (i) For each $t = 1, \dots, T$, draw ε_t from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left truncation at $1 - z_t \hat{\alpha}$.
 - (ii) For each $t = 1, \dots, T$, compute $\hat{\delta}_t^* = \hat{\alpha} z_t + \varepsilon_t$,
 - (iii) Use bootstrap estimates to construct a pseudo data (x_t, y_t^*) , where $y_t^* = y_t \hat{\delta}_t / \hat{\delta}_t^*$.
 - (iv) Re-estimate new DEA technical efficiency scores δ_t^* using pseudo data.
- (4) For each year, calculate the corrected technical efficiency, $\hat{\delta}_t = \hat{\delta}_t - bias_t$ where $\left(bias_t = \frac{1}{B} \sum_{b=1}^B \delta_{t,b}^* - \hat{\delta}_t \right)$.
- (5) Estimate the truncated regression $\hat{\delta}_t = \alpha z_t + \varepsilon_t$ leading to an estimation of (α, σ) by $(\hat{\alpha}, \hat{\sigma})$ using maximum likelihood technique.
- (6) Loop over the three next steps (i,ii,iii) B_1 times in order to determine the main bootstrap estimates of interest, such as $\left\{ (\hat{\alpha}_b^*, \hat{\sigma}_b^*), b = 1, \dots, B_1 \right\}$.
 - (i) For each $t = 1, \dots, T$, draw ε_t from the $N(0, \hat{\sigma}_\varepsilon^2)$ distribution with left truncation at $1 - \hat{\alpha} z_t$.
 - (ii) For each $t = 1, \dots, T$, compute $\hat{\delta}_t^{**} = \hat{\alpha} z_t + \varepsilon_t$.
 - (iii) Use maximum likelihood technique to estimate $\hat{\delta}_t^{**} = \alpha z_t + \varepsilon_t$, and to obtain an estimate $(\hat{\alpha}^*, \hat{\sigma}^*)$ of (α, σ) .

- (7) Construct a confidence interval for the estimate of interest using the bootstrap results obtained.

4.2. Data description

4.2.1. Inputs and outputs definition

It is well known in the frontier approach literature that the specification and definition of inputs and outputs represent the cornerstone of this kind of research. Our analysis relies mainly on data drawn from Saudi Arabian Monetary Agency (SAMA) and World Bank Data (WBD). Data on public spending in Saudi Arabia consist of information on public spending on education, health and infrastructure, and cover the period 1988–2013.

According to some recent studies (e.g., Afonso et al., 2005; Afonso & Aubyn, 2006; 2008; Afonso, Schuknecht, & Tanzi, 2010; Afonso & Kazemi, 2017; and Angelopoulos et al., 2008, among others), we adopt the quantity of public expenditure on education, health and infrastructure as inputs, whereas the amount of output produced are primary school and secondary school enrolment, infant mortality⁶ and life expectancy, electricity power transmission (Elec.TransPower), energy consumption per capita (EnerConsCapita) and telephone per 100 habits (TelPer100Habit) for infrastructure.

In the first step, we estimate TE separately for each category of government spending (i.e., education, health and infrastructure).⁷ In the second step, we introduce all inputs and outputs in the DEA model to calculate the aggregate TE of government spending on these three sectors. We use the output-oriented DEA model, following Afonso (2010), Afonso and Kazemi (2017) and Dobdinga et al. (2016) given that the major objective of the government is to improve the education level, the life expectancy and to provide a good infrastructure leading to a high level of social satisfaction.

4.2.2. Input and output statistics

As described above, the main three inputs used are public expenditure on education, health and infrastructure. In the production process, the inputs are mobilized to produce a given amount of outputs, such as primary school, secondary school enrolment, infant mortality, life expectancy, Electricity transmission power, Energy consumption per capita and telephone per 100 habit.

Table 2 displays the main statistics of the structure of the different inputs used and outputs produced over the period 1988–2013. It offers a simple, but useful look at the main inputs and the main outputs that we will use here in the construction of the frontier efficiency and then in the analysis of technical efficiency level of government spending on education, health and infrastructure.

5. Results discussion

This section provides the different technical efficiency scores resulting from the estimation of public expenditure efficiency for education, health and infrastructure.

5.1. Efficiency of public spending on education, health and infrastructure

This section provides an estimation of efficiency separately for each sector. Table 3 reports DEA technical efficiency scores estimated of public expenditure on education, health and infrastructure during the period 1988–2013. Results reveal that Saudi Arabia's government expenditure on education was only efficient in 2013. This result means that the government efficiently use the fund allocated to education at the primary and secondary schools level. But, during the rest of the period, the level of technical efficiencies obtained were close to the average of TE level calculated over the whole period averaging 0.507, implying that the inefficiency level over the period of study was about 0.497. Furthermore, we can ascertain that Saudi Arabia' policymakers can improve the level of education in the Kingdom by saving 49.7% of the amount of inputs used (i.e., public

Table 2. Summary statistics on inputs and outputs

		Mean	Standard deviation	Min	Max
Inputs	Public spending on education	0.1680	0.0445	0.0464	0.2467
	Public spending on health	0.0664	0.0228	0.0212	0.0948
	Public spending on infrastructure	0.1984	0.0659	0.1256	0.3788
Outputs	Primary school enrolment	23.0135	11.5445	8.7200	56.3800
	Secondary school enrolment	26.0125	13.7338	8.4150	58.8100
	1/infant mortality	0.0497	0.0146	0.0240	0.0725
	Life expectancy	72.3535	2.1933	68.2443	75.4970
	ElecTransPower (Million)	11,499.7	7,308.9	3,985	28,399.2
	EnerConsCapita	5,285.296	901.893	3,687.471	7,043.846
	TelPer100Habit	12.744	3.492	7.079	16.975

NB: All inputs are explained in total public expenditure percentage.

spending on education). We can point out that the level of efficiency has improved over the whole period, especially over the period 2004–2013.

On the other hand, the least TE scores were observed in 1989. Overall, we deduce that Saudi Arabia’ government spending on education was “weak” and inefficient, but it presents an ascendant trend meaning that there is an improvement of the efficiency level, essentially, during the period 2010–2013.

Regarding TE scores of public spending on health over the period 1988–2013, our result stated that public spending on health services delivered were inefficient over the whole period; the average level of efficiency is about 0.979, suggesting that Saudi Arabia could raise the amount of output by 2.1% with the same level of inputs. This interesting result means that Saudi Arabia can improve performance without increasing health expenditure. Or similarly, Kingdom of Saudi Arabia (KSA) can achieve the same level of output by spending less (with about 2.1%) of resources. Yi-Chung Hsu (2013) found a similar result by analysing the performance of government expenditure on health in Europe and Central Asia. This finding can most likely be explained by the choice of outputs. So, we can understand probably why the efficiency scores are more robust in health than in education and infrastructure. We think that the inclusion of other kind of outputs (e.g., patient treated, the number of first-time visits, the number of beds and the number of admissions) will impact the efficiency scores, and will perhaps lead to a low efficiency scores. Accordingly, we must lead a detailed analysis that comprises the maximum of outputs that can ideally reflect the real production of the sector.

The assessment further suggests that this spending was efficient over the period 2010–2013 and 1991. This means that Saudi Arabia authority was able to improve life expectancy and infant mortality rate over the periods 1989–2009. However, the level of the TEs scores for the period 1988–2009 were closed to the average TE score estimated at 0.979. The least TE level, approximately equal to 0.945, was recorded in 1988. Overall, we observe that health government expenditures was inefficient for most years in the sample.

Table 3. VRSTE of public spending on education, health and infrastructure for the period 1988–2013

Year	Education	Health	Infrastructure
1988	0.238	0.945	0.591
1989	0.194	0.947	0.570
1990	0.303	0.977	0.524
1991	0.524	1	0.599
1992	0.378	0.971	0.664
1993	0.346	0.980	0.719
1994	0.357	0.973	1
1995	0.426	0.978	0.715
1996	0.475	0.982	0.726
1997	0.451	0.985	0.664
1998	0.377	0.978	0.710
1999	0.308	0.956	0.813
2000	0.389	0.960	0.867
2001	0.434	0.965	0.961
2002	0.411	0.967	0.993
2003	0.449	0.972	1
2004	0.503	0.976	1
2005	0.541	0.979	0.948
2006	0.526	0.980	0.971
2007	0.612	0.986	0.923
2008	0.649	0.993	0.921
2009	0.677	0.994	0.959
2010	0.816	1	1
2011	0.865	1	1
2012	0.937	1	1
2013	1	1	1
Mean	0.507	0.979	0.840

NB: VRSTE: Variable Return to Scale Technical Efficiency.

Compared with public spending on education, we conclude that the mean efficiency level reported on health sector was higher than that estimated in the education sector. Consequently, it can be stressed that public spending on education was not used in the right way leading to improve primary and secondary level in Saudi Arabia. Gupta et al. (1997) reported a reverse result in the case of selected African countries; Jafarov and Gunnarsson (2008) in the case of Croatia republic and Onakoya and Somoye (2013) for Nigeria. However, our result must be carefully interpreted since our model does not include some environmental variables, such as management quality, worker's quality and use of high-quality technologies, and this probably can lead to misleading results. We will introduce environmental variables in the section dealing with the explanation of TE scores.

Concerning infrastructure, our result shows that, on average, government spending in this sector was inefficient, and Saudi Arabia can increase the amount of infrastructure outcomes by about 16% without spending more resources. Yet, we can report a fluctuant variability in efficiency scores obtained over the period 1988–2013. Finally, we conclude that the average level technical efficiency of government spending on infrastructure was higher than education spending efficiency level.

We also assess the technical efficiency scores regarding all outputs and one input (i.e., we aggregate all inputs in one input).

5.2. Multi-outputs, one input analysis

Table 4 summarizes output efficiency scores of public spending when considering education, health and infrastructure simultaneously. Then, we consider one input (the sum of government expenditure on education, health and infrastructure) and five outputs (primary and secondary school enrolment, infant mortality, life expectancy, electricity transmission power, energy consumption per capita and telephone per 100 habitats).

The table displays a mean efficiency score that is high comparing with those obtained in the case of separately for each sector. This result could be attributed to the choice of the sample (Santiago & Gaobo, 2005) and/or to the definition of inputs/outputs. Particularly, there was an apparent sensitivity in the case of education. The same result was raised by Santiago and Gaobo (2005). The authors explain this result, in the case of developing countries, by the quality of education.

Table 4. TE of public spending over the period 1988–2013 under many hypothesis of return to scale

Years	CRSTE	VRSTE	SCALE
1988	0.471	0.918	0.514
1989	0.554	0.920	0.602
1990	0.955	0.988	0.967
1991	1.000	1.000	1.000
1992	0.858	0.983	0.873
1993	0.875	0.974	0.898
1994	0.789	0.953	0.827
1995	0.935	0.971	0.962
1996	0.890	0.974	0.914
1997	0.773	0.967	0.799
1998	0.596	0.964	0.618
1999	0.565	0.955	0.591
2000	0.659	0.985	0.669
2001	0.984	0.984	1
2002	0.932	0.999	0.933
2003	1	0.980	1
2004	0.950	1.000	0.950
2005	0.896	0.983	0.911
2006	0.882	0.993	0.889
2007	0.919	0.998	0.921
2008	0.949	0.993	0.956
2009	0.966	1	0.966
2010	1	1	1
2011	1	1	1
2012	1	1	1
2013	1	1	1
Mean	0.861	0.980	0.876

NB: CRSTE: Constant Return to Scale Technical Efficiency; SCALE: Scale Efficiency.

Furthermore, we can rise a very close mean efficiency scores in Health (0.979 versus 0.980) and in infrastructure (0.840 versus 0.876), implying the robustness of our efficiency assessment and then the robustness of the efficiency level obtained by the two models. Regarding the education sector, a different level of technical efficiency was found (0.507 versus 0.861). This result can be explained by the quality of data as regards input used and/or output produced.

5.3. Determinants of public expenditure efficiency: DEA-bootstrap analysis

In this section, we used VRS TE obtained earlier as the dependent variable to be explained. To the authors' knowledge, we have not recorded any prior attempts to explain government spending in the case of Saudi Arabia. Furthermore, this is the first attempt to model government TE using the bootstrap approach. Exogenous factors or environment variables, considered as outside control of policymakers, play an important role in estimating and analysing public spending inefficiency, in that their consideration could lead to improve efficiency. Among them include the scale of the government described by the ratio of public expenditure divided by GDP (*hereafter*, GovScale), openness, inflation, GDP per capita growth, broad money growth (Bmg) and Gross fixed capital formation (Afonso, Romero, & Monsalve, 2013, Dobdinga et al., 2016). In the empirical literature, many techniques can be considered to include these variables and accordingly to explain the different efficiency levels obtained. Hauner and Kyobe (2008), Chan and Karim (2012), Afonso et al. (2013) and Dobdinga et al. (2016) among others used the Tobit model to explain public expenditure efficiency.

In this paper, we use the sampling technique and we adopt the so-called DEA-bootstrap technique in order to apprehend the main environmental variables that might explain inefficiency of Saudi Arabia government spending and to overcome the dependency problem between explanatory variables and the noise term. Formally, the linear model relating efficiency to a set of some explanatory variables (possibly) is as follows:

$$\hat{\delta}_t = \alpha_0 + \sum_{j=1}^6 \alpha_j z_{jt} + \varepsilon_t, t = 1, \dots, 26 \quad (3)$$

where $\hat{\delta}_t$ represent DEA technical efficiency scores of government spending; ε_t is a random variable with mean 0 and standard deviation σ ; z_1, \dots, z_6 are summarized in Table 5 below. We note that the non-discretionary variables had been chosen in line with the current literature and based on the existing data.

Applying the algorithm proposed by Simar and Wilson (2007) described above, we obtained the possible effect of the contextual variables technical inefficiency of government spending in all models. Table 6 reports estimated parameters from bootstrapping procedure.

Table 6 shows that inflation has a significant negative effect on public expenditure efficiency on infrastructure. This finding is similar to results of Dobdinga et al. (2016) showing a decrease in efficiency when inflation slows down. Dobdinga et al. (2016) attribute this result to the economic instability assigned to the increase in price.

Furthermore, we find a significant positive relationship between urbanization (**Urban**) and government spending efficiency in the three sectors (education, health and infrastructure). Unemployment (**Unemp**) is found to have, only, a negative impact in the case of government spending on infrastructure. GDP growth (**Gdpgrow**) and broad money (**Bmg**) are negatively associated with public spending on health, contrary to the general expectation. In addition, result reveals a positive and statistically significant effect of broad money on government expenditure on infrastructure. This finding implies that economic growth leads to an improvement in efficiency in health sector. The same result has been found by Dobdinga et al. (2016).

Table 5. Description of explanatory variables used

Variables	Variables	Descriptions	Expected signs
Govscale	z_1	The scale of government as measured by the ratio of government expenditure reported to GDP. This variable seems to be associated with technical efficiency scores and size of government.	+
Unemp	z_2	The unemployment rate, which can be used to show the impact of the business cycle on public expenditure (Young et al., 1999).	-
Gdpgrowth	z_3	GDP growth	+
Inflation	z_4	Inflation	-
Bmg	z_5	Broad money growth	+
Urban	z_6	Urbanization	+

Table 6. Main specific models: DEA-bootstrap approach

Variables	Parameters	Model 1 Education	Model 2 Health	Model 3 Infrastructure	Model 4 Combined
Constant	α_0	-6.600*	0.315*	-2.865*	-0.500**
Govscale	α_1	0.521*	0.052*	-0.109	0.205*
Gdpgrowth	α_2	0.412	-0.071***	-0.314	-0.136***
Inflation	α_3	2.089*	0.252*	-1.038**	0.232
Bmg	α_4	-0.497	-0.064***	1.043*	0.070
Unemp	α_5	2.392	0.970*	-5.812*	0.033
Urban	α_6	8.487*	0.744*	5.001*	1.764*

Note: *, ** and *** represent significance at 1%, 5% and 10%, respectively.

Our findings reported also a significant positive effect of the size of government (**Govscale**) in all models, except infrastructure. This finding implies that an increase in government expenditure will lead to an improvement of education and health outcomes. The previous papers in this field reported conflicting results, i.e., Gupta and Verhoeven (2001), Jarasuriya and Woodon (2003), and Afonso et al. (2003) found a negative impact of expenditure on efficiency, i.e., in their study the authors suggest that less the size of the government, more the efficiency of government spending. On contrary, Xu et al. (2003) reported a positive impact. However, the study of Filmer and Pritchett (1999) did not report a significant impact. We suggest using the revenue to GDP ratio as indicator of government size instead of expenditure to GDP ratio.

6. Conclusions

Providing more public services with less public spending is an ongoing challenge for Saudi Arabia which is becoming increasingly important in light of the decline of oil price and the adoption of “Vision 2030”. In this paper, we assess Saudi Arabia public spending efficiency on education, health and infrastructure over the period 1988–2013. The empirical results using DEA approach show that government spending was mainly inefficient in the three sectors. However, empirical results show a relatively high technical score for health and infrastructure compared to education. However, the

use of the nonparametric method DEA can mislead results in the presence of outliers, misspecification of inputs and/or outputs.

Consequently, we have performed a supplementary analysis in order to re-estimate and to explain the efficiency of public spending. The empirical results revealed that the mean inefficiency scores for education, health and infrastructure are about 0.507, 0.979 and 0.840, respectively. This finding implies that policymakers should allocate more expenditure on health and infrastructure than education. Similarly, the average inefficiency score for infrastructure shows that government expenditure on infrastructure in Saudi Arabia was relatively inefficient but better than education. The results further indicate that, for government spending on education, inefficiency was very low, mainly over the period 1988–2009, despite effort exerted by the government in terms of investment in capital and labour. Furthermore, the enhancement of budget devoted to education does not imply an improvement of education efficiency. Then, we think that government need to focus more on the quality of teacher, time and other things to enhance the efficiency of education while maintaining “perhaps” the same level of expenditure. A straightforward explanation of what happened in education sector needs a more detailed data and information in order to highlight the exact situation.

By applying DEA-bootstrap analysis in the second stage, empirical results show that there are some environmental variables that affect public spending efficiency in the sectors. So, the size of government positively affects public spending efficiency. The results further revealed that unemployment and broad money negatively impact government expenditure mainly in the case of infrastructure and health. Our findings could help policymakers to answer to the question: Can Saudi Arabia obtain better performance results in public sectors using the same resources? And imagine a strategy is in line with the Kingdom's Vision 2030 and related programs, including the National Transformation Plan, which are designed to enhance government spending efficiency, stimulate economic growth and promote growth of the private sector. Furthermore, at the empirical side, we suggest using another non-parametric approach (e.g., FDH) and/or the parametric one (namely, the SFA approach) for checking the robustness of our results.

Acknowledgements

We greatly appreciate the financial support by Sheikh Mohammed Al-Fouzan Macroeconomic Forecasting Chair (SMF Chair) at Imam University (IMSIU).

Funding

This work was supported by the Shiekh Al-Fouzan Macroeconomic Forecasting Chair (SMFChair) at Imam Mohammad Ibn Saud Islamic University, Riyadh, Saudi Arabia [2015].

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Citation information

Cite this article as: Assessing government spending efficiency and explaining inefficiency scores: DEA-bootstrap analysis in the case of Saudi Arabia, Mohamed Nejib Ouertani, Nader Naifar & Hedi Ben Haddad, *Cogent Economics & Finance* (2018), 6: 1493666.

Notes

1. Government spending in Saudi Arabia averaged 133,540.57 SAR million from 2008 until 2016, reaching an all-time high of 211,243 SAR million in the first quarter of 2014 and a record low of 76,217 SAR million in the first quarter of 2008. However, Government spending decreased to 129,776 SAR million in the third quarter of 2016 from 150,633 SAR million in the second quarter of 2016.
<http://www.tradingeconomics.com/saudi-arabia/government-spending>.
2. 2017 Budget of Kingdom Saudi Arabia: https://mof.gov.sa/en/budget2017/Documents/The_National_Budget.pdf.
3. For more details on Saudi Arabia's “Vision 2030” and National Transformation Program 2020, you can refer to the following link: <http://vision2030.gov.sa/en>.
4. 2017 Budget of Kingdom Saudi Arabia: https://mof.gov.sa/en/budget2017/Documents/The_National_Budget.pdf.
5. For more details on this technique, the reader can be referred to Lynde and Richmond. (1999).
6. According to Yi-Chung Hsu (2013), we use the reciprocal of infant mortality since this is later considered as bad output.
7. Before the estimation of the coefficient scores.

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