Does government expenditure play an efficient role on economic growth? Evidence from some OPEC members

Arshia Amiri\textsuperscript{a,b,\ast}, S. Aziz Arman\textsuperscript{c}, Ulf-G Gerdtham\textsuperscript{d,e,f} and Mansur Zibaei\textsuperscript{b}

\textsuperscript{a} GREQAM CNRS – ORS PACA – INSERM U912, 23 rue Stanislas Torrents, F-13006 Marseille, France
\textsuperscript{b} Department of Agricultural Economics, College of Agriculture, Shiraz University, Shiraz, Iran
\textsuperscript{c} College of Economics, Shahid Chamran Ahwaz University, Ahwaz, Iran
\textsuperscript{d} Department of Economics, Lund University, Sweden
\textsuperscript{e} Health Economics & Management, Institute of Economic Research, Lund University, Sweden
\textsuperscript{f} Centre for Primary Health Care Research, Lund University, Sweden

Abstract

In this study we calculate the efficiency rate of government expenditure on increasing economic growth for some OPEC members in a Barro framework during the period of 1995 to 2005. Firstly, data envelopment analysis (DEA) method helps us to develop a neutral evaluation, an unbiased priori by any type of criteria, regarding proportions in which the goal of productive spending is persuaded, for any expenditure. In order to determine how much the effective amounts of government expenditure plays role on increasing economic growth, Adaptive neuro fuzzy inference system (ANFIS) is applied to estimate economic growth using input data taken at frontier. At the end of the DEA-ANFIS chain, examining the power of prediction is positive: grid partition method has lower validation error compared with the best result of subtractive clustering and both methods perform the same in training. This result confirms that the effective government expenditure plays a high role on economic growth of OPEC members.

Keywords: Economic growth; government expenditure; DEA-ANFIS; OPEC

\ast Corresponding author. Tel.: +98 917 308 57 22; fax: +98 711 822 42 22.
E-mail addresses: arshiaamirishiraz@gmail.com (A. Amiri).
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1. Introduction

The economic growth of OPEC members is highly dependent on oil price of international market and there exists a rhetorical relationship between oil price and government expenditure in these countries. There has been much interest in estimating the efficiency of government expenditure on increasing economic growth. The issue of measuring the efficiency of an economic system is important to both economic theorist and economic policy maker. If the theoretical arguments as to the relative efficiency of different economic systems are to be subjected to empirical testing, it is essential to be able to make some actual measurements of efficiency. Equally, if economic planning is to concern itself with particular economic systems, it is important to know how far a given index can be expected to increase (or decrease) its amount by simply increasing its efficiency, without absorbing further resources (see Farrell, 1957). Also, finding the role of effective amount of government expenditure on economic growth has a special importance in politics of macroeconomic, for example, the potential effects of expansionary and contractionary policies of governments on economic growth in short-run and appointing the optimum size of governments to compare with other countries which has similar economic structure.

This paper uses an explicit endogenous growth model due to Barro (1990), in which government expenditure is considered to be an input of the macroeconomic production function. For y, the GDP per unit of labor, we have: \( y = f(k, d) \) with \( k \), the private capital by unit of labour, and \( d \), a “productive government expenditure”. As firstly was shown by Barro (1990), this enrichment of the Solow model allows to generate positive and permanent growth rate for the economy: the law of decreasing returns (valid for the private capital) could be offset by a continuous flow of government expenditure, counterbalancing period after period the “falling tendency of the rate of profit”.

On the empirical side, there are some good attempts to find the relationship between government expenditure and economic growth, like Bleaney, Gemmel & Kneller (2001), and Ventelou & Bry (2006). Ventelou, and Bry applied DEA method to correct the government expenditure data by a factor of “productive efficiency”, supposing that inefficiency is not “pure inefficiency” associated with wasted resources but could be “hidden output” (Ventelou & Bry, 2006). More precisely, we call attention to studies conducted by Aschauer (1988, 1989), Lynde (1992), Devarajan, Swaroop & Zou (1996), Kneller, Bleaney & Gemmell (1999), Hamiltona & Turton (2002), and we follow the results of Ventelou & Bry (2006), to apply DEA method to correct the government expenditure data in order to find the efficiency of government expenditure on increasing economic growth in OPEC members. Another aim of this study is to determine how much the effective amounts of government expenditure plays role on increasing economic growth. In order to this, Adaptive neuro fuzzy inference system (ANFIS) is applied to estimate economic growth with the effective government expenditure as result of DEA.
2. Data resource and modeling

In order to conduct this analysis, we reconsidered government expenditure data categorized by functions for a maximum number of OPEC members, as well as data concerning their GDP growth rates per person. Despite the small size of the sample (only 12 countries), these are the only available countries of World Development Indicators (WDI) from OPEC members. The data of this study is the same as Ventelou and Bry (2006) and Amiri and Ventelou (2011) for OECD countries.

We chose analyzing growth rates of the “per capita GDP” over an 11-year period, 1995–2005, rather than using raw data from each 1 year. There were several reasons for this choice. Firstly, the decade chosen allows us to study the majority of the countries in our chosen sample within the framework of a nearly identical (peak to peak) economic cycle so that the differences in growth do not reflect cycle discrepancies but, rather, the (tested) efficiency of government expenditure. From the perspective of a conditional convergence test, it was necessary to enhance this growth measured by an adjusting factor of the “catching-up effect”, which was, in this case, a value for per capita GDP at the beginning of the study period (1995). Then, after a standard OLS-adjustment to GDP/capita in 1995 (in logarithm), we obtained the data series “Index of Adjusted Growth Rates”, which indicate by comparison to what degree economic growth was strong during the given period.

As for the input, in order to work on a precise breakdown of government expenditure by function, we used the OPEC members nomenclature. The reported figures are based on PPP in dollars and are deflated using the US consumer price index in order to obtain volume data for the base year, 2000. Finally, we divided this adjusted data by the total population in order to obtain government expenditure per person.

We chose 1996 as the observation base year for government expenditure. To put it more simply, for each country we observed a level and a pattern of public expenditure at the beginning of the period (the decade defined for peak to peak growth rates) and sought to evaluate to see to what extent exactly these patterns were able to be contributed the relative growth in these countries during the following years.

2.1. Data Envelopment Analysis method (DEA)

Data envelopment analysis is the non-parametric mathematical programming approach to frontier estimation. Firstly, a paper by Charnes, Cooper & Rhodes (1978) coined the term Data Envelopment Analysis (DEA). There have since been a large number of papers which have extended and applied the DEA methodology.

Charnes, Cooper & Rhodes (1978) proposed a model which had an input orientation and assumed constant returns to scale (CRS). Subsequent papers have considered alternative set of assumptions, such as Banker, Charnes & Cooper (1984) who proposed a variable returns to scale (VRS) model. One form of their VRS model is:

\[
E_r = \max \sum_{k=1}^{t} u_k y_{ik} \quad \text{s.t.} \quad \sum_{k=1}^{t} u_k y_{ik} \leq 1, \quad i = 1, \ldots, n
\]

\[
\left( v_0 + \sum_{j=1}^{s} v_j x_{ij} \right)
\]

\[
\left( v_0 + \sum_{j=1}^{s} v_j x_{ij} \right) \leq 1,
\]

where \(u_k\) is a weight associated with input \(k\), \(y_{ik}\) is the level of output \(i\) associated with input \(k\), \(v_0\) and \(v_j\) are non-negative weights associated with the outputs and \(x_{ij}\) is the level of input \(j\) associated with output \(i\).
\[ u_k; v_j \geq \varepsilon > 0; v_0 \text{ unconstrained in sign, } \tag{1} \]

Where \( X_{ij} \) and \( Y_{ik} \) represent input and output data for the \( i \)th decision making unit (DMU) with \( j \) ranging from 1 to \( s \) and \( k \) from 1 to \( t \), and \( \varepsilon \) is a small non-Archimedean quantity (Charnes & Cooper, 1984; Charnes, Cooper & Rhodes, 1979). Index \( r \) indicates the DMU to be rated, and there are \( n \) DMUs. When \( v_0 \) is set to 0, the assumption of constant returns to scale is imposed, and the model becomes that of Charnes, Cooper & Rhodes (1979). Note that Model (1) is a linear fractional program which can be transformed into a linear program (LP):

\[
E_r = \max \sum_{k=1}^{t} u_k y_{rk}
\]

s.t. \( v_0 + \sum_{j=1}^{s} v_j x_{ij} = 1 \)

\[
\sum_{k=1}^{t} u_k y_{rk} - \left( v_0 + \sum_{j=1}^{s} v_j x_{ij} \right) \leq 0, \quad i = 1, \ldots, n
\]

\[ u_k; v_j \geq \varepsilon > 0; v_0 \text{ unconstrained in sign, } \tag{2} \]

2.2. Neuro-fuzzy model structure

Neuro-fuzzy modelling is a powerful problem-solving methodology with many applications in embedded control and information processing. It provides a simple way to draw definite conclusions from vague, ambiguous or imprecise information. In some sense, neuro-fuzzy modelling resembles human decision making with its ability to start from approximate data and find precise solutions; also the method is similar in nature to that of neural networks. From the ‘cross-pollination’ between fuzzy logic and neural networks a new modelling approach has emerged: the Adaptive Neuro-fuzzy Inference System (ANFIS). ANFIS takes a given input/output data set and constructs a fuzzy inference system whose membership function parameters are tuned, or adjusted, using either a back propagation algorithm alone or a combination of the latter with a least squares type of method. The basic structure of ANFIS consists of three conceptual components: a ‘rule base’ which contains a selection of fuzzy rules, a ‘data base’ which defines the membership function (MFs) used in the fuzzy rules, and ‘reasoning membership’ which performs the inference procedure upon the rules to derive an output as is shown in Fig. 1.

![Figure 1: Fuzzy Inference System (Source: Jang, 1993)](source)

ANFIS has been introduced by Takagi and Sugeno (1983). Readers are referred to Jang (1993) for a thorough description of the system and to Mathworks (2001) for guidelines concerning its practical implementation.

3. Result and discussion
3.1. DEA results (Efficiency of government expenditure on increasing economic growth)

This study uses DEA analysis to measure how far from the frontier different countries are located, i.e. indicating how much economic growth may be increased at the current level of government expenditures. In other words, static efficiency exists at a point in time and focuses on the maximum potential of government expenditures which can be decreased with the current economic growth of each country in comparison with other countries. According to table 1, we find a low efficiency rate for OPEC members. Sudan, Brazil, Indonesia and Syrian Arab Republic are at frontier and have high efficiency rates in OPEC members and other countries have the low efficiency. This result argues that low efficiency of government expenditure on increasing economic growth of OPEC members is for being highly dependent on oil price of international market, which does not have a fixed manner. Table 1 illustrates the results of DEA method, adjustment score of DEA efficiency and index of adjusted growth rates. DEA was implemented using Frontier analyst software package (Frontier analyst version 4 with DEA toolboxes). After using DEA method, ANFIS was applied to determinate how much the effective amounts of government expenditure plays role on increasing economic growth.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Government expenditure</th>
<th>Adjustment score (% efficiency)</th>
<th>Index of adjusted growth rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Arab Emirates</td>
<td>49.37</td>
<td>1.56</td>
<td>102.28</td>
</tr>
<tr>
<td>Sudan</td>
<td>30.22</td>
<td>100</td>
<td>102.01</td>
</tr>
<tr>
<td>Brazil</td>
<td>612.32</td>
<td>100</td>
<td>102.518</td>
</tr>
<tr>
<td>Algeria</td>
<td>30.19</td>
<td>12.81</td>
<td>101.93</td>
</tr>
<tr>
<td>Venezuela, RB</td>
<td>58.6</td>
<td>13.36</td>
<td>102.41</td>
</tr>
<tr>
<td>Indonesia</td>
<td>60.73</td>
<td>100</td>
<td>102.445</td>
</tr>
<tr>
<td>Iran</td>
<td>30.17</td>
<td>13.48</td>
<td>101.87</td>
</tr>
<tr>
<td>Kuwait</td>
<td>29.9</td>
<td>0.63</td>
<td>100.95</td>
</tr>
<tr>
<td>Syrian Arab Republic</td>
<td>122.19</td>
<td>100</td>
<td>102.495</td>
</tr>
<tr>
<td>Bolivia</td>
<td>51.5</td>
<td>36.46</td>
<td>102.31</td>
</tr>
<tr>
<td>Oman</td>
<td>33.05</td>
<td>2.02</td>
<td>102.0533</td>
</tr>
<tr>
<td>Ecuador</td>
<td>30.11</td>
<td>22.6</td>
<td>101.6767</td>
</tr>
</tbody>
</table>

3.2. Accuracy determination

The performance of all ANFIS configurations was assessed based on calculating the mean absolute error (MAE), and the root mean square error (RMSE). The coefficient of determination, $R^2$, of linear regression line between the predicted values from either the ANFIS and the desired output was also used as a measure of performance. The three statistical parameters used to compare the performance of the various ANFIS configurations are:

$$ MAE = \frac{1}{N} \sum_{i=1}^{N} |O_i - t_i|, $$

$$ RMSE = \sqrt{\frac{\sum_{i=1}^{N} (O_i - t_i)^2}{N}}, $$

$$ R^2 = 1 - \frac{\sum_{i=1}^{N} (O_i - t_i)^2}{\sum_{i=1}^{N} (O_i - \bar{O})^2}. $$

(3)
Where $O_i$ and $\hat{t}_i$ are observed and predicted for the $i$th output (observed output that comes from catching-up effect and predicted output that ANFIS forecasts), and $\bar{t}$ is the average of predicted, and $N$ is the total number of events considered. The models that minimized the two error measures described in the previous section (and optimum $R^2$) were selected as the optimum. The whole analysis was repeated several times.

3.3. Development of ANFIS method for prediction the role of government expenditure in economic growth

The main reason of executing this step is to determine the ability of ANFIS for estimating the role of government expenditure on economic growth. In this study, two types of ANFIS models were developed, grid partition ANFIS method and subtractive clustering ANFIS method (for more details of these method see Jang; 1993). The whole data set consisting of 13 data points was divided into two parts randomly: a training set consisting of 80% of the data points and a validation or testing set consisting of 20% of the data points. The training data set was used to train the ANFIS, as where the testing data set was used to verify the accuracy and the effectiveness of the trained ANFIS model for the prediction of the role of government expenditure on economic growth. The best result in grid partition obtains with 11 member functions and 10 rules. After several numbers of clustering are evaluated, the radius of 0.25 was used for each cluster, which led to generate 4 fuzzy rules. To evaluate the performance of the ANFIS prediction, observed role of government expenditure on growth rate is plotted against the predicted ones for grid partition and subtractive clustering. Figure 4 and 5 illustrate the results with the performance indices between predicted and observed data for the training and testing data sets, respectively.

![Figure 4: performance of ANFIS testing of single hidden layer model.](image1)

![Figure 5: performance of ANFIS training of multiple hidden layer models.](image2)
We also use ordinary least squares (OLS) to estimate economic growth with the effective government expenditure in order to compare with ANFIS result. According to the result of table 2, grid partition method has lower validation error compared with the best results of subtractive clustering and both methods have the same performance in training. The results of OLS are lower than ANFIS for prediction. Both results from out of sample and training come to improve the deficit degree of freedom. With basing the Granger–Newbold test (1976), results of ANFIS are more powerful than OLS.

### Table 2. Result of ANFIS models and OLS.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Grid partition</th>
<th>Subtractive clustering</th>
<th>OLS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MAE</td>
<td>RMSE</td>
<td>RSQ</td>
</tr>
<tr>
<td>Validation or testing (20% of data as an out of sample)</td>
<td>0.0410</td>
<td>0.0016</td>
<td>0.9732</td>
</tr>
<tr>
<td></td>
<td>0.0880</td>
<td>0.0002</td>
<td>0.8527</td>
</tr>
<tr>
<td>Training (80% of data)</td>
<td>0.1719</td>
<td>0.0000</td>
<td>0.6373</td>
</tr>
<tr>
<td></td>
<td>0.1880</td>
<td>0.0001</td>
<td>0.6478</td>
</tr>
<tr>
<td></td>
<td>0.3114</td>
<td>0.4314</td>
<td>0.1590</td>
</tr>
<tr>
<td></td>
<td>0.0195</td>
<td>0.4314</td>
<td>0.1590</td>
</tr>
</tbody>
</table>

### Conclusion

This study aims to investigate the efficiency rate of government expenditure on increasing economic growth for some OPEC members in a Barro framework during the period of 1995 to 2005. In order to do this, DEA method helps us to develop a neutral evaluation, unbiased a priori by any type of criteria, of the proportions in which the goal of productive spending is pursued, for any expenditure. This evaluation is coherent with the standard way of analyzing production functions: identification of the best practices, as a prerequisite for the identification of a production frontier. The result of DEA method confirms low efficiency for OPEC members. In the following step, we are able to re-calculate the role of government expenditure using ANFIS on these data taken at frontier. Although of debatable reliability since it utilizes a small sample. Finally, the best result of subtractive clustering and both methods have the same performance in training. The result of ANFIS shows that this chain of DEA-ANFIS is a useful and appropriate method to find the role of effective amount of government expenditure on economic growth.

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### References


