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Estimating Production Efficiency: The Case of Middle-Eastern Countries

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Abstract
This paper estimates the production efficiency for eight Middle-Eastern Countries (MECs) and investigates the possible effect of inflation on efficiency. A panel of aggregate production function is estimated over the period 1984 to 2004 using stochastic frontier analysis (SFA). The estimated efficiency is 70.9% on average for the MECs, which indicate that the MECs have inefficiency in production on average that equal 29.1%. In addition, it is found that the most efficient economy among MECs is the KSA economy, while the least efficient country is Morocco economy. Moreover, the results do not support theories state that inflation cause inefficiency. In contrast the result shows inefficiency decreases as inflation increases.

Keywords: Stochastic frontier analysis, Translog production function.
JEL Classification Codes: C23, L11, O11, O47

1. Introduction
Middle-eastern countries are known by their richness in natural resources, especially oil and natural gas. In this study we are going to investigate effects of these resources on production efficiency of these economies.

Much Literature discusses technical efficiency at the macroeconomic level. This approach deals with countries as a production unit for gross domestic product (GDP) by using labor and capital inputs that exist in each country. For example Tandon (2005), uses this approach to identify the reason behind the success of some countries in achieving higher Millennium Development Goals. he argues that more efficient country can a produce the same output level as other countries but with lower input. This
approach was also used by Koop, Osiewalski and Steel (2000), to measure the production efficiency gap between Poland and other Western countries.

The effect of inflation on efficiency was discussed extensively in the literature. For example, A.S. Shaalan (1962) argues that, during higher inflation periods, prices tend to vary widely. Therefore, this motivates people to search for the best prices, savers search for better assets, and investors search for better investment. As a result, both time and effort are wasted, which lead to misallocation of resources. This paper relies on the above argument, hence it utilizes the production SFA to measure technical efficiency. The SFA methodology is well documented in a number of seminal papers such as Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977), Kumbhkar and Lovell (1977), and T. J. Coelli (1995).

The paper proceeds as follows. Section 2 introduces data and methodology. Section 3 discusses results. And section 4 provides the conclusion.

2. Data and Methodology

2.1. Data

This study uses a set of data consists of eight MECs: Bahrain, Egypt, Jordan, Morocco, Oman, Qatar, Kingdom of Saudi Arabia (KSA) and Tunisia. The period of the study covers from 1986 to 2004. Data set is taken from International Monetary Fund (IMF) database. Variables are defined as follows:

Y_{it}: is the natural logarithm of output of country i at time t, where output is measured by nominal GDP in million of dollars.

L_{it}: is the natural logarithm of labor of country i at time t, where labor is measured by number of workers in millions.

K_{it}: is the natural logarithm of capital formation of country i at time t, and is measured in million of dollars.

Inf: is the inflation rate measured by the percentage change in consumer price index (base year = 2001)

T: is a time variable

2.2. Methodology

Drawing on a seminal work by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977), a translog production function that represents a second order approximation to anonymous production function is adopted to represent the production function of the group of MECs. The function is

\[
\ln Y_{it} = \alpha + \alpha_1 \ln K_{it} + \alpha_2 \ln L_{it} + \frac{1}{2} \alpha_{11} (\ln K_{it})^2 + \frac{1}{2} \alpha_{22} (\ln L_{it})^2 + \alpha_{12} (\ln K_{it})(\ln L_{it}) \\
+ \alpha_{1T} \ln L_{it}T + \frac{1}{2} \alpha_{2T} (\ln T)^2 + \varepsilon
\]

(1)

Where the subscript i represents the specific country and it takes values from 1 to 8, while the subscript t represents time and takes values from 1 to 19. The \( \alpha \) represents the estimated coefficients. \( \varepsilon = (V_i - U_i) \) is the compound error term that is divided into two separate component. V is the random error component that is assumed to be normally distributed and iid \((0, \sigma^2_v)\), and the error component U measures technical inefficiency which is assumed to be a non negative random variable that is iid \((0, \sigma^2_u)\).

The software package Frontier 4.1 (Coelli 1996) is used to estimate model (1). However, it is worth mentioning that, the Frontier 4.1 is used to estimate theoretical models and other modified versions. In addition Coelli(1995) modified the original model, which originally was introduced by
Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). They assume a cross section production function that takes the following specification:

\[ Y_i = x_i \beta + \{ \varepsilon_i \} \]

\[ \varepsilon_i = V_i - U_i \] (2) (3)

Where \( Y \) represents the output, \( x \) is the input vector, \( \beta \) is the estimated parameters, and \( \varepsilon \) is the error term that is divided into two separate components as mentioned above.

Efficiency can be calculated as follows:

\[ TE_i = \exp(-U_i) \] (4)

Where \( TE_i \) is the technical efficiency. The model is also able to estimate the distribution parameters (Gamma) \( \gamma \) and (Sigma-squared) \( \sigma^2 \). The value of \( \gamma \) reflects the relative importance of the efficiency term in the explanation of the residual, and it measures how much the relative contribution of \( U \) and \( V \) to the residual. Note that \( \gamma \) must be between zero and one. With \( \gamma = 0 \) or close to zero, it means that we do not reject the hypothesis that we can estimate the coefficients of the model by OLS production function model.

With no technical inefficiency, where \( \gamma = 1 \) or close to one, the deterministic production frontier model is preferred. Note that \( \sigma^2 \) is the sum of variances of statistical noise \( \sigma^2_v \) and inefficiency \( \sigma^2_U \).

3. Results

The maximum likelihood estimation of the Translog stochastic production frontier function, represented in Equation (1) is given in Table (1).

Table 1: The Estimated Parameters from A SFA

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard error</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-7.3000</td>
<td>0.9720</td>
<td>-7.5000</td>
</tr>
<tr>
<td>Ln(K)</td>
<td>-2.0900</td>
<td>0.6880</td>
<td>-3.0300</td>
</tr>
<tr>
<td>Ln(L)</td>
<td>6.0200</td>
<td>0.6770</td>
<td>8.9000</td>
</tr>
<tr>
<td>Ln(K) Ln(L)</td>
<td>0.0341</td>
<td>0.0497</td>
<td>0.6860</td>
</tr>
<tr>
<td>Ln(K)^2</td>
<td>0.3030</td>
<td>0.0796</td>
<td>3.8000</td>
</tr>
<tr>
<td>Ln(L)^2</td>
<td>-0.7590</td>
<td>0.1260</td>
<td>-6.0100</td>
</tr>
<tr>
<td>T</td>
<td>0.0649</td>
<td>0.1120</td>
<td>0.5800</td>
</tr>
<tr>
<td>T^2</td>
<td>0.0060</td>
<td>0.0054</td>
<td>1.1100</td>
</tr>
<tr>
<td>T *Ln(K)</td>
<td>-0.0290</td>
<td>0.0036</td>
<td>-7.9900</td>
</tr>
<tr>
<td>T *Ln(L)</td>
<td>0.0095</td>
<td>0.0164</td>
<td>0.5770</td>
</tr>
<tr>
<td>Intercept</td>
<td>-7.8700</td>
<td>0.5410</td>
<td>-14.6000</td>
</tr>
<tr>
<td>Inflation</td>
<td>-0.2090</td>
<td>0.0675</td>
<td>-3.0900</td>
</tr>
<tr>
<td>Sigma- squared</td>
<td>3.4100</td>
<td>0.1840</td>
<td>18.5000</td>
</tr>
<tr>
<td>Gamma</td>
<td>0.9890</td>
<td>0.0039</td>
<td>255.0000</td>
</tr>
</tbody>
</table>

Results must be taken in caution since there are several insignificant terms obtained. Statistical results indicate that capital-labor, and the time-labor interaction terms are insignificant. In addition to that, time and the squared time terms are insignificant too. See Table (1) for more details.

We can extract the results from the estimated coefficients of model (1) as shown in equations 5, 6 and 7. Equation 5 shows the elasticity of output with respect to capital, labor and time. It shows that output is an increasing function in capital and labor, and a decreasing function in time, which represents technology.

\[
\frac{\partial \ln(Y)}{\partial \ln(k)} = -2.09 + .0341\ln(L) + .0606\ln(K) - 0.029T
\] (5)
Equation (6) shows the elasticity of output with respect to labor, the estimated coefficients indicate that this elasticity will increase as less labor and more capital are used. In addition the elasticity increases with improvement of technology.

\[
\frac{\partial \ln(Y)}{\partial \ln(L)} = 6.02 + 0.341 \ln(K) - 1.562 \ln(L) + 0.0095T
\]  

Equation (7) represents the output elasticity with respect to technology. It suggests that this elasticity will increase as more labor is used, but will decrease with more capital is used. In addition to that, it will increase as a result of improvement in technology.

\[
\frac{\partial \ln(Y)}{\partial T} = 0.065 + 0.012T - 0.029 \ln(K) + 0.009 \ln(L)
\]  

The relationship between inefficiency and inflation is shown in lower part of Table (1). The results show that there is a significant negative relationship between inefficiency and inflation, suggesting that as inflation increases, the inefficiency will decrease. Although this result is not supported theoretically, it may, however, be explained by the structure of production in most of MECs.

The bottom of Table (1) shows the estimated value of distribution parameters \( \gamma \) and \( \sigma^2 \) with the other parameters. The result shows that \( \gamma = 0.9890 \) and significant, which justify the use of the SFA methodology.

Moreover, the results are obtained to individuals countries. Table (2) presents the estimated efficiency for individual countries over the period of the study. The efficiency had changed over time as indicated by statistical evidence. It shows that the average efficiency for all countries was 70.9 %. And this may indicate that, on average, the output in the MECs is 30 % less than output with full utilization of resources. Therefore, there is a waste in resources.

**Table 2:** The Estimated Efficiency for MECs individual countries over the period (1986-2004)

<table>
<thead>
<tr>
<th>Year</th>
<th>Bahrain</th>
<th>Egypt</th>
<th>Jordan</th>
<th>Morocco</th>
<th>Oman</th>
<th>Qatar</th>
<th>KSA</th>
<th>Tunisia</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>0.777</td>
<td>0.657</td>
<td>0.705</td>
<td>0.411</td>
<td>0.797</td>
<td>0.705</td>
<td>0.881</td>
<td>0.433</td>
<td>0.671</td>
</tr>
<tr>
<td>1987</td>
<td>0.770</td>
<td>0.698</td>
<td>0.723</td>
<td>0.371</td>
<td>0.807</td>
<td>0.753</td>
<td>0.894</td>
<td>0.505</td>
<td>0.690</td>
</tr>
<tr>
<td>1988</td>
<td>0.743</td>
<td>0.584</td>
<td>0.732</td>
<td>0.458</td>
<td>0.825</td>
<td>0.744</td>
<td>0.878</td>
<td>0.564</td>
<td>0.691</td>
</tr>
<tr>
<td>1989</td>
<td>0.755</td>
<td>0.610</td>
<td>0.660</td>
<td>0.504</td>
<td>0.825</td>
<td>0.744</td>
<td>0.880</td>
<td>0.548</td>
<td>0.691</td>
</tr>
<tr>
<td>1990</td>
<td>0.703</td>
<td>0.581</td>
<td>0.631</td>
<td>0.550</td>
<td>0.801</td>
<td>0.682</td>
<td>0.921</td>
<td>0.573</td>
<td>0.680</td>
</tr>
<tr>
<td>1991</td>
<td>0.712</td>
<td>0.684</td>
<td>0.569</td>
<td>0.587</td>
<td>0.803</td>
<td>0.682</td>
<td>0.936</td>
<td>0.618</td>
<td>0.699</td>
</tr>
<tr>
<td>1992</td>
<td>0.739</td>
<td>0.684</td>
<td>0.577</td>
<td>0.532</td>
<td>0.805</td>
<td>0.701</td>
<td>0.945</td>
<td>0.614</td>
<td>0.699</td>
</tr>
<tr>
<td>1993</td>
<td>0.797</td>
<td>0.795</td>
<td>0.545</td>
<td>0.520</td>
<td>0.807</td>
<td>0.747</td>
<td>0.944</td>
<td>0.654</td>
<td>0.726</td>
</tr>
<tr>
<td>1994</td>
<td>0.753</td>
<td>0.799</td>
<td>0.545</td>
<td>0.544</td>
<td>0.789</td>
<td>0.693</td>
<td>0.929</td>
<td>0.696</td>
<td>0.719</td>
</tr>
<tr>
<td>1995</td>
<td>0.714</td>
<td>0.792</td>
<td>0.545</td>
<td>0.489</td>
<td>0.765</td>
<td>0.663</td>
<td>0.928</td>
<td>0.761</td>
<td>0.707</td>
</tr>
<tr>
<td>1996</td>
<td>0.632</td>
<td>0.797</td>
<td>0.541</td>
<td>0.512</td>
<td>0.769</td>
<td>0.644</td>
<td>0.928</td>
<td>0.790</td>
<td>0.702</td>
</tr>
<tr>
<td>1997</td>
<td>0.562</td>
<td>0.614</td>
<td>0.567</td>
<td>0.485</td>
<td>0.793</td>
<td>0.756</td>
<td>0.928</td>
<td>0.807</td>
<td>0.689</td>
</tr>
<tr>
<td>1998</td>
<td>0.593</td>
<td>0.669</td>
<td>0.540</td>
<td>0.553</td>
<td>0.795</td>
<td>0.864</td>
<td>0.922</td>
<td>0.825</td>
<td>0.720</td>
</tr>
<tr>
<td>1999</td>
<td>0.575</td>
<td>0.753</td>
<td>0.574</td>
<td>0.556</td>
<td>0.756</td>
<td>0.911</td>
<td>0.916</td>
<td>0.844</td>
<td>0.735</td>
</tr>
<tr>
<td>2000</td>
<td>0.600</td>
<td>0.834</td>
<td>0.511</td>
<td>0.515</td>
<td>0.751</td>
<td>0.881</td>
<td>0.918</td>
<td>0.850</td>
<td>0.733</td>
</tr>
<tr>
<td>2001</td>
<td>0.560</td>
<td>0.860</td>
<td>0.533</td>
<td>0.495</td>
<td>0.792</td>
<td>0.836</td>
<td>0.897</td>
<td>0.867</td>
<td>0.730</td>
</tr>
<tr>
<td>2002</td>
<td>0.662</td>
<td>0.877</td>
<td>0.540</td>
<td>0.484</td>
<td>0.792</td>
<td>0.705</td>
<td>0.891</td>
<td>0.873</td>
<td>0.728</td>
</tr>
<tr>
<td>2003</td>
<td>0.713</td>
<td>0.904</td>
<td>0.546</td>
<td>0.507</td>
<td>0.809</td>
<td>0.581</td>
<td>0.907</td>
<td>0.890</td>
<td>0.732</td>
</tr>
<tr>
<td>2004</td>
<td>0.716</td>
<td>0.894</td>
<td>0.570</td>
<td>0.518</td>
<td>0.836</td>
<td>0.520</td>
<td>0.905</td>
<td>0.899</td>
<td>0.732</td>
</tr>
</tbody>
</table>

**Average** 0.688 0.741 0.587 0.505 0.796 0.727 0.913 0.716 0.709

Rank 6 3 7 8 2 4 1 5

We may distinguish three periods of efficiency. In the first one, efficiency increased by 6% over time from the low of 67.1 % in 1986 to 73.5 % in 1999. After this year the second period starts, where a moderate decrease in efficiency took place until it reached 72.8% in 2002. In the last period, a slight increase in efficiency occurred when efficiency increased by only 0.4% . This time path can be seen clearly in Graph (1)
The most efficient country in our sample was KSA, its efficiency took the average of 91.3%, Oman was next with average efficiency of 79.6, then Egypt by 74.1. The least efficient country in our sample was Morocco with an average efficiency of 50.5%.

Graph (2) shows the change in efficiency for individual countries over time. We can clearly see that KSA was the most efficient in all years of study. Its efficiency was in its peak in 1992 with 94.5%. This indicates that the output produced in that year was 5.5% less than the most efficient production level, with the perfect utilization of resources. The lowest efficiency scored by KSA was taking place in the first year of the study with 88.1%. Notice that in the end of period, the efficiency was 91.3%.

The efficiency improvement of Tunisia fluctuates over time. It increases about twofold over the period 1986 to 2004. For Jordan the efficiency dropped from 70.1% in 1986 to 51% in 2000. It reached 57% at the end of the period. For Egypt the efficiency almost increased rapidly over the study period with some fluctuations. It reached a peak in 2003. For Qatar the efficiency fluctuated over the period 1986 to 1998. Then it declined sharply during the last five years from 91.1% in 1998 to 52% in 2004.

<table>
<thead>
<tr>
<th>Year</th>
<th>Asia average</th>
<th>African average</th>
<th>Gulf average</th>
<th>Non-Gulf average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>0.77</td>
<td>0.50</td>
<td>0.79</td>
<td>0.55</td>
</tr>
<tr>
<td>1987</td>
<td>0.79</td>
<td>0.52</td>
<td>0.81</td>
<td>0.57</td>
</tr>
<tr>
<td>1988</td>
<td>0.78</td>
<td>0.54</td>
<td>0.80</td>
<td>0.58</td>
</tr>
</tbody>
</table>
Moreover, the differences of efficiency among different geographical areas is examined. Table (3) presents the results for the following country groups: Asian, African, Gulf and Non-Gulf countries. For Asian country group, the efficiency scored an average that equal to 74% and reached its maximum efficiency in 1987 with efficiency equal to 79%. While in 1996 its efficiency was at minimum at 70%.

For African country group, the efficiency was in general less than efficiency of Asian country group before year 2000 and more than that since then. 2000. Efficiency increased from 50% in the beginning of the period, and reached maximum high of 77% at the end of the period.

Almost the same result can be obtained if we divide the sample to Gulf and Non-Gulf country groups. The Gulf counties, which are generally oil-producing countries, experienced an efficiency decrease from 79% to 74% over the period of the study, while the Non-Gulf countries, which do not in general produce oil, experienced an increase in efficiency from 55% to 72% over the same period. Nevertheless, the efficiency of Gulf countries was always higher than the efficiency of Non-Gulf countries. See Table 3 and Graph (3) for complete results.

**Graph 3:** Average efficiency for MECs over time
Finally, almost half of the countries under the study are Oil-producing countries, and the other half are countries that have a significant number of workers, who are working in the first group of Oil-producing countries, and sending remittances to home countries which play a noticeable rule in these economies.

4. Conclusion

This work attempts to estimate production efficiency for a panel of 7 Middle Eastern Countries over the period 1986 to 2004 using a Translog production function.

The statistical result shows that for the sample country group, there is a significant negative relationship between inefficiency (waste in resources) and inflation. And the average estimated efficiency for the group was 70.9%. However, the most efficient country was KSA, its efficiency took the average of 91.3%. Whereas, the least efficient country was Jordan with an average efficiency of 58.7%.

Regarding county group results, the estimated efficiency for Asian countries decreased from 77% to 71% over the period of the study, While for African countries efficiency increased from 50% to 77%. In addition to that, the African countries efficiency was in general less than efficiency of Asian countries before year 2000 and more after that year. For the Gulf counties the estimated efficiency decreased from 79% to 74%, while for the Non-Gulf countries the estimated efficiency increased from 55% to 72%. Moreover, the efficiency of Gulf countries had been always higher than the efficiency of Non-Gulf countries.

References

4] Economic report of the president (1990), "cost of inflation" centre for economic policy research, discussion paper, no. 293.