Decomposing total factor productivity growth in small and medium enterprises, SMEs

Nordin Haji Mohamad¹ and Fatimah Said²
¹Institute of Mathematical Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia
²Faculty of Economics and Administration, University of Malaya, 50603 Kuala Lumpur, Malaysia.

Abstract
Small and Medium Enterprises (SMEs) are one of the principal driving forces in economic development and are the backbones of most economies, developing as well as developed. The purpose of this paper is to model and investigate the total factor productivity growth of SMEs with reference to technological and technical efficiency change which are synonym to adoption and adaptation of technology. To do this, we utilize the linear programming based operations research technique known as Data Envelopment Analysis methodology of Malmquist Total Factor Productivity, TFP index. TFP measures the overall efficiency with which products are produced due to non-physical change. Improvement in TFP will enable the economy to generate a larger output from the same available resources, and hence shifting it to a higher frontier. The technological change component of productivity growth provides a measure of innovation or adoption of new technology and captures shifts in the frontier technology. Technical inefficiency, on the other hand, is measured by the difference between the frontier output and the realized output. Thus decomposition of TFP growth into technical efficiency improvement (adaptation or catching up) and technological change is therefore useful in distinguishing innovation or adoption of new technology by ‘best practice’ firms from the diffusion of technology. The study utilizes data on SMEs from 42 selected economies (29 European Union and 13 APEC countries) for the period 2004-2008. Results obtained are analyzed and discussed, and some policy implications are suggested.

Keywords: Data envelopment analysis, Malmquist total factor productivity, Technical efficiency, Technological change, Small and medium enterprises.

Introduction
Performance usually involves the evaluating and analysis of productivity. Performance measurement is used to provide information to decision makers, to measure strategies and ensure that they remain effective and to measure continuous improvement (Shackleton, 2007). The indicators are generally quantitative or numerical in values. There exists a number of methodology or techniques for assessing performance via productivity analysis. This includes score card (Banker et al., 2004; Azar et al., 2011), economic production function framework (Hossain & Al-Amri, 2010), econometric stochastic frontier analysis, SFA (Bhandari & Maiti, 2007), the analytic hierarchy process (Chakraborty et al., 2011) and data envelopment analysis, DEA Malmquist productivity index (Mohamad & Said, 2010b).

Of the methodologies, SFA and DEA Malmquist have gained considerable attention in the literature. The former is a parametric approach that requires the specification of a production function and does take statistical noise into account while DEA is a non-parametric approach that requires no functional specification and does not accommodate statistical noise. There is no consensus as to which is the most appropriate technique each has its own strengths and weaknesses (Coli et al., 2007). In this study, we employ the method of DEA Malmquist to measure productivity changes and decompose the total factor productivity, TPF growth into its associated components.

Apart from its use for assessing industrial performance, DEA has been applied in agriculture (Hasanov & Nomman, 2011), banking (Mostafa, 2007), business (Mohamad & Said, 2010a), education and higher learning (Kao & Hung, 2008), ecological and environmental studies (Ardabili et al., 2007), hospitals and health centers (Laine et al., 2005), manufacturing and industry (Mohamad & Said, 2010b), nations and regional studies (Mohamad & Said, 2011b), port management (Wanke et al., 2011), public sectors (Afonso & Fernandes, 2006), services (Barros & Dieke, 2008) and transports (Boane, 2004). Emrouznejad et al. (2008) and Tavares (2002) provided a comprehensive bibliography of methodological and application aspects of DEA.

DEA was employed by Chen and Lu (2006) to measure innovation and managerial performance of 16 companies in Taiwan’s IC design industry for the period 2001-2003. Three inputs viz. number of employees, general and administrative expenditures and R&D expenditure and four outputs viz. net sales, number of patents, patent citation and market value were selected to characterize the parameters in the multiple-stage analysis. Results show that eight firms are operating at an optimal scale. The average scores of productive efficiency is 0.854, of pure technical efficiency is 0.902 and the scale efficiency is 0.945. However, some companies were found to confront the dilemma of growth or managerial efficiency which indicated that not all innovative efforts may result in financial boosts.

Yang (2006) utilizes DEA methodology to examine the technical efficiency, the production index and input resources of SMEs in Korea during 2000-2002. Comparison was made on the efficiency of enterprises
located in the capital region and non-capital region so as to induce the political significance of regional perspective and to analyze the benefits and disadvantages of the capital reallocation policy in Korea. Large scale enterprises in heavy and chemical industry showed more efficient production than small-scale enterprises. However, the total factor productivity of SMEs is improving as compared to large-sized enterprises. Also, enterprises located in capital area show greater efficiency than those in non-capital regions implying that proper distribution of equity in the political operation of Korea is desired.

In another study, Radam et al. (2008) determines the technical efficiency of 7360 SMEs in Malaysia for the year 2004 using Cobb-Douglas stochastic frontier production model. Results show that only 3.06 percent of the total firms are considered technically efficient. Technical inefficiency varies from 0.30 to 97.10 percent. The focus should therefore be on efficiency improvements and lean production in order to sustain operations and growth. Thus, policy makers should play significant roles in formulating adequate policies and programs to assist SMEs to develop their managerial and technical skills especially in creating innovations and generating economic value from knowledge. The stochastic frontier production model was also utilized by Shazali et al., (2004) to examine the technical efficiency of Malaysian furniture industry. They found that actual firm’s output is 20 percent less than maximal output which can be achieved from the existing level of inputs.

Ten indicators were used to measure the level of innovativeness of fifty Peninsula Malaysia-based manufacturing SMEs in a study conducted by Yahya et al., (2011). Following Laforet and Tann (2006) the top 20 percent companies which scored high on the ten criteria were compared with the bottom 80 percent companies which scored low on the same criteria. The former were referred to as ‘more innovative’ companies while the latter were referred to as ‘less innovative’ companies. It is found that none of the company surveyed was consistently innovative over the ten indicators. Among the findings are one of the drivers of innovation in small manufacturing firms is process innovation including leadership factor and culture, while the main drawbacks are lack of knowledge and skills, networking and training due to lack of financial resources. In less innovative SMEs, training is perceived to be not important as compared to more innovative companies which perceived it to be of high importance.

Another study focusing on SMEs in the Malaysian manufacturing sector investigates the relationship of internationalization and performance (Chelliah et al., 2010). Data was collected from a sample of 77 SMEs in the northern region of Peninsular Malaysia. Internationalization refers to market liberalization and digitization to encourage large corporations and the SMEs to operate beyond their national borders and compete with each other in foreign countries and new regions (Barkema et al., 2002). The financial performance utilized in the study is measured in terms of the average sales growth, the average rate of profit or return on sales (ROS) and the staff turnover rate. These performance indicators are formulated into an index of performance. The study convincingly demonstrates that there exists a positive relationship between internationalization and performance. Internationalization can improve performance and motivate firms to continuously capture foreign markets. It shows that SMEs can increase their return on sales by taking their current products into foreign markets either on their own or through foreign alliances.

In this study, we conduct the performance evaluation and assessment of the dynamic adaptation and adoption or innovation in SMEs across the globe. To do this we utilize the methodology of data envelopment analysis and the Malmquist total factor productivity index.

**Methodology**

The DEA model adopted for the study is the strictly output-oriented (Mohamad & Said, 2010a) with zero input slacks,

\[
\text{maximize } \Omega_0
\]

subject to

\[
-X_{0i} + \sum_{k=1}^{n} X_{ki}\lambda_k = 0, \quad i = 1,2, \ldots, n \quad (2)
\]

\[
-\Omega_0 Y_{0j} + \sum_{k=1}^{m} Y_{kj}\lambda_k \geq 0, \quad j = 1,2, \ldots, m \quad (3)
\]

\[
\lambda_k \geq 0, \quad k = 1,2, \ldots, \Omega
\]

\[
\Omega_0 \text{ unconstrained},
\]

where \(X_{0i}\) and \(Y_{0j}\) are observed values of inputs and outputs, \(i=1,2,\ldots,n\) and \(j=1,2,\ldots,m\), for each of \(k=1,2,\ldots,\Omega\) decision making units (DMUs) and the \(X_{0i}\) and \(Y_{0j}\) represent the input and output for DMU\(_0\) to be evaluated. The efficiency score, \(E_0\) is given by

\[
0 \leq E_0 \leq \frac{1}{\Omega_0} \leq 1. \quad (4)
\]

If (i) \(\Omega_0 = 1\), and (ii) all slacks are zero, then DMU\(_0\) is said to attain full or strong efficiency, that is Pareto Koopman’s efficiency. Otherwise, weak efficiency is attained if only condition (i) is satisfied. For an inefficient, DMU\(_0\) say, improvement or movement towards efficient frontier can be identified by inspecting the system of equations with slack \(t_i^+\), for all \(j\) such that

\[
\sum_{k=1}^{n} Y_{kj}\lambda_k - t_j^+ = Y_{0j}, \quad j = 1,2, \ldots, m \quad (5)
\]

The projected output is dictated by its peers (identified from \(\lambda_k \neq 0\), for all \(k\)) and given by

\[
Y_{0j}' = \sum_{k=1}^{n} Y_{kj}\lambda_k = Y_{0j}/\Omega_0 + t_j^+, \quad j = 1,2, \ldots, m
\]

which can be achieved by proportional increase of \((\Omega_0-1)\) in all outputs plus additional amount (termed as slacks movements) of \(t_i^+\) in output \(Y_{0j}\) whenever \(t_i^+ \neq 0\). Thus \((\Omega_0-1)Y_{0j} + t_j^+\) is a measure of underachievement of output \(Y_{0j}\) experienced by DMU\(_0\).

Model (1)-(3) is the output-oriented model under constant returns to scale, CRS. For evaluation under the
assumptions of variables return to scale, VRS an additional convexity constraint is imposed on \( \lambda_k \) such that
\[
\sum_{k=1}^{5} \lambda_k = 1. \tag{7}
\]
This results in the formation of a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained under the assumptions of CRS. The difference in technical efficiency scores under the two assumptions of returns to scale is mainly attributable to scale efficiency. Thus, scale efficiency, \( SE \) can be viewed as the extent to which a DMU can take advantage of return to scale by altering its size towards optimal size identified as the region in which there are CRS in the relationship between outputs and inputs and is computed as
\[
SE_u = \frac{TEC_{k+1}}{TEC_k} \leq 1.
\]

**Malmquist productivity index, MPI**

In order to further study changes that occurred in technical efficiency and technological practices in two different time periods \( t \) and \( t+1 \), we utilized the output-based MPI of total factor productivity, TFP as given by Mohamad & Said (2010b),
\[
M_k\left(X_{k}^{(t+1)}, Y_{k}^{(t+1)}, X_{k}^{(t)}, Y_{k}^{(t)}\right) =
\left(\frac{E_{k}^{(t+1)}(D_{k}^{(t+1)}(X_{k}^{(t+1)}, Y_{k}^{(t+1)}))}{E_{k}^{(t)}(D_{k}^{(t)}(X_{k}^{(t)}, Y_{k}^{(t)}))}\right)^{1/2}
\]
where \( D_{k}^{(t)}(X_{k}^{(t)}, Y_{k}^{(t)}) \) is the output distance function for DMU\(_k\) with respect to two different time periods under the assumptions of CRS. In other words, if there exist front shift (or technological change) in time \( t+1 \),
\[
D_{k}^{(t)}(X_{k}^{(t+1)}, Y_{k}^{(t+1)}) = \text{efficiency of conversion of inputs in period} \ (t+1) \ \text{to outputs in period} \ (t+1) \ \text{relative to technology period} \ t
\]

MPI, as given by (8) is thus a geometric mean of the productivity changes between two time periods. A value of \( M_k > 1 \) indicates positive TFP growth or gain, \( M_k < 1 \) indicates TFP decline or loss, and \( M_k = 1 \) indicates stagnation or no change in TFP for DMU\(_k\) from time period \( t \) to \( t+1 \).

The MPI can be decomposed into technical efficiency change, \( TEC \) (or catching-up effect) and technological change resulting from shifts in the production frontier, \( FS \) (or innovation) such that
\[
M_k(.) = (TEC_k)(FS_k), \tag{9}
\]

where
\[
TEC_k = \frac{D_{k}^{(t+1)}(X_{k}^{(t+1)}, Y_{k}^{(t+1)})}{D_{k}^{(t)}(X_{k}^{(t)}, Y_{k}^{(t)})}
\]
and
\[
FS_k = \left[\left(\frac{E_{k}^{(t+1)}(D_{k}^{(t+1)}(X_{k}^{(t+1)}, Y_{k}^{(t+1)}))}{E_{k}^{(t)}(D_{k}^{(t)}(X_{k}^{(t)}, Y_{k}^{(t)}))}\right)^{1/2}\right] \tag{10}
\]

Fare et al. (1994) further decomposed \( TEC \) (relative to CRS frontier) into pure technical efficiency change, \( PTEC \) component (relative to VRS frontier) and a residual scale efficiency change, \( SEC \) component which captures changes in the deviation between the VRS and CRS technology. Thus the complete decomposition for DMU\(_k\) becomes
\[
M_k(.) = (PTEC_k)(SEC_k)(FS_k), k = 1, 2, ..., K \tag{12}
\]

**Empirical implementation**

**Data source**

The data utilized for the study are annual time-series data for 42 selected nations covering the period of 2004-2008. These comprise 29 members of European Union and 13 Asia Pacific Economies. Two measures of output, sales revenue which proxies the physical performance and return on investments which proxies the accounting performance are used. Total number of workers and investment in tangible goods (or capital formation or asset) which is taken as proxy for capital constitute the two measures of input.

For comparative purposes we group the 42 nations into three groups, the developed economies comprises of 20 nations viz. Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, Australia, Canada, New Zealand and Japan, economies in transition comprises 13 nations viz. Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia and Albania, and the developing economies comprises 9 nations viz. China, Hong Kong, Indonesia, Korea, Malaysia, Pakistan, Singapore, Thailand and Turkey. The mean basic statistics for the parameters is given in table 1. Mathematically speaking, the indicators are

- \( X_1 \): total employment,
- \( X_2 \): investment in tangible goods (or capital formation), in million EURO,
- \( Y_1 \): sales revenue, in million EURO, and
- \( Y_2 \): return on investment.

Next, all indicators (including inputs) are normalized on a scale of \([1, 100]\) such that
\[
X_{\text{norm}} = \frac{99(X_{\text{act}}-X_{\text{min}})}{X_{\text{max}}-X_{\text{min}}} + 1 \tag{13}
\]

where \( X_{\text{norm}} \) is the value of the normalized indicator,

\( X_{\text{act}} \) is the actual value of the indicator,

\( X_{\text{max}} \) is the maximum value of the indicator,

\( X_{\text{min}} \) is the minimum value of the indicator.
Inefficiency may arise because it is operating under decreasing returns to scale, *drs* or increasing returns to scale, *irs*. Whether a DMU is operating under *irs* or *drs* can be determined by observing its *TE* and *PTE* scores, such that:

- if $TE = PTE$, CRS prevails
- if $TE \neq PTE$, then

### Table 1. Basic descriptive statistics 2004-2008

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X1: Employment</td>
<td>8782782</td>
<td>8711181</td>
<td>8651345</td>
<td>8521180</td>
<td>8673701</td>
</tr>
<tr>
<td>X2: (Mil EURO)</td>
<td>104809</td>
<td>88070</td>
<td>76230</td>
<td>71376</td>
<td>66852</td>
</tr>
<tr>
<td>Y1: (Mil EURO)</td>
<td>406546</td>
<td>368070</td>
<td>340326</td>
<td>295349</td>
<td>281035</td>
</tr>
</tbody>
</table>

#### Technical and scale efficiency

Out of the 42 economies, only two (Luxembourg and Albania) obtain a scale efficiency score of 100 percent, implying that it is technically efficient in all years under evaluation and are operating on the frontier at the most productive scale size, *mpss*. Forty-two or 95.24% are technically inefficient implying that, in general, more than 95 percent of the SMEs were operating inefficiently and they need to increase their output (or reduce their inputs) to become efficient. The average *PTE* score was 56.90% during 2004-2008. This finding suggests that if these SMEs were operating efficiently, they could have produced 43.10% more output. Despite the low technical efficiencies, more than 38% of the DMUs obtained scale efficiency of above 90.0%. On average the scores for efficiency are summarized in Table 2.

### Table 2. Mean efficiency scores 2004-2008

<table>
<thead>
<tr>
<th>Country</th>
<th>TE</th>
<th>PTE</th>
<th>SE</th>
<th>rs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>0.40621</td>
<td>0.42926</td>
<td>0.94683</td>
<td>irs</td>
</tr>
<tr>
<td>Belgium</td>
<td>0.57315</td>
<td>0.59060</td>
<td>0.97517</td>
<td>irs</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>0.21108</td>
<td>0.28827</td>
<td>0.72434</td>
<td>irs</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0.71326</td>
<td>0.78780</td>
<td>0.89947</td>
<td>irs</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>0.61131</td>
<td>0.62220</td>
<td>0.8165</td>
<td>dsr</td>
</tr>
<tr>
<td>Denmark</td>
<td>0.40012</td>
<td>0.42808</td>
<td>0.93608</td>
<td>irs</td>
</tr>
<tr>
<td>Estonia</td>
<td>0.50036</td>
<td>0.58758</td>
<td>0.85719</td>
<td>irs</td>
</tr>
<tr>
<td>Finland</td>
<td>0.66334</td>
<td>0.70176</td>
<td>0.95361</td>
<td>irs</td>
</tr>
<tr>
<td>France</td>
<td>0.57559</td>
<td>0.85716</td>
<td>0.66502</td>
<td>dsr</td>
</tr>
<tr>
<td>Germany</td>
<td>0.72778</td>
<td>0.92823</td>
<td>0.79536</td>
<td>irs</td>
</tr>
<tr>
<td>Greece</td>
<td>0.46141</td>
<td>0.46543</td>
<td>0.99048</td>
<td>irs</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.33026</td>
<td>0.35371</td>
<td>0.93809</td>
<td>irs</td>
</tr>
<tr>
<td>Ireland</td>
<td>0.71915</td>
<td>0.77633</td>
<td>0.93098</td>
<td>irs</td>
</tr>
<tr>
<td>Italy</td>
<td>0.85613</td>
<td>1.00000</td>
<td>0.85613</td>
<td>irs</td>
</tr>
<tr>
<td>Latvia</td>
<td>0.23182</td>
<td>0.34434</td>
<td>0.86653</td>
<td>irs</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.25339</td>
<td>0.37432</td>
<td>0.69293</td>
<td>irs</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>1.00000</td>
<td>1.00000</td>
<td>1.00000</td>
<td>mpps</td>
</tr>
<tr>
<td>Malta</td>
<td>0.85648</td>
<td>1.00000</td>
<td>0.85648</td>
<td>irs</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.67576</td>
<td>0.68232</td>
<td>0.99126</td>
<td>irs</td>
</tr>
<tr>
<td>Norway</td>
<td>0.48514</td>
<td>0.62105</td>
<td>0.83263</td>
<td>irs</td>
</tr>
<tr>
<td>Poland</td>
<td>0.58800</td>
<td>0.59672</td>
<td>0.98555</td>
<td>irs</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.34502</td>
<td>0.35759</td>
<td>0.96856</td>
<td>irs</td>
</tr>
<tr>
<td>Romania</td>
<td>0.17271</td>
<td>0.20426</td>
<td>0.85364</td>
<td>irs</td>
</tr>
<tr>
<td>Slovakia</td>
<td>0.34700</td>
<td>0.41558</td>
<td>0.85113</td>
<td>irs</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0.36472</td>
<td>0.43863</td>
<td>0.84566</td>
<td>irs</td>
</tr>
<tr>
<td>Spain</td>
<td>0.56650</td>
<td>0.69468</td>
<td>0.81497</td>
<td>irs</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.84612</td>
<td>0.85741</td>
<td>0.98244</td>
<td>irs</td>
</tr>
<tr>
<td>U. Kingdom</td>
<td>0.75293</td>
<td>0.90039</td>
<td>0.83246</td>
<td>irs</td>
</tr>
<tr>
<td>Albania</td>
<td>1.00000</td>
<td>1.00000</td>
<td>1.00000</td>
<td>mpps</td>
</tr>
<tr>
<td>Australia</td>
<td>0.27826</td>
<td>0.39823</td>
<td>0.65348</td>
<td>dsr</td>
</tr>
<tr>
<td>Canada</td>
<td>0.74939</td>
<td>0.96530</td>
<td>0.77143</td>
<td>irs</td>
</tr>
<tr>
<td>New Zealand</td>
<td>0.21701</td>
<td>0.27709</td>
<td>0.79218</td>
<td>irs</td>
</tr>
<tr>
<td>China</td>
<td>0.12225</td>
<td>1.00000</td>
<td>0.12225</td>
<td>irs</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>0.28033</td>
<td>0.38096</td>
<td>0.78179</td>
<td>irs</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.17679</td>
<td>0.19746</td>
<td>0.89141</td>
<td>irs</td>
</tr>
<tr>
<td>Japan</td>
<td>0.65292</td>
<td>0.69661</td>
<td>0.92388</td>
<td>irs</td>
</tr>
<tr>
<td>Korea</td>
<td>0.15736</td>
<td>0.23125</td>
<td>0.68113</td>
<td>irs</td>
</tr>
<tr>
<td>Malaysia</td>
<td>0.17418</td>
<td>0.23879</td>
<td>0.72494</td>
<td>irs</td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.13341</td>
<td>0.30217</td>
<td>0.77073</td>
<td>irs</td>
</tr>
<tr>
<td>Singapore</td>
<td>0.19560</td>
<td>0.22526</td>
<td>0.87236</td>
<td>irs</td>
</tr>
<tr>
<td>Thailand</td>
<td>0.15496</td>
<td>0.16723</td>
<td>0.91880</td>
<td>irs</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.45451</td>
<td>0.46045</td>
<td>0.98617</td>
<td>irs</td>
</tr>
</tbody>
</table>

Note: *drs* and *irs* refer to decreasing and increasing returns to scale respectively, while *mpss* refers to most productive scale size.
The last column in Table 2 records the returns to scale based on the most frequent observed during the years under consideration. As mentioned earlier, SMEs from two economies (4.76%), Luxembourg and Albania appeared to be operating at their mpps. SMEs from fifteen economies (35.71%) exhibited drs. These SMEs on average should scale down their scale of operation if they were to operate on the frontier. The remainder SMEs from twenty-five economies (59.52%) exhibited irs. These SMEs on average should expand their scale of operation in order to become scale efficient. The average scale efficiency score in the sample for the period 2004-2008 was 47.93 percent, ranging from a minimum of 12.23 percent to a maximum of 100 percent. It is worth noting that China obtained the lowest technical efficiency score of 12.23%, but it scored 100% under pure technical efficiency. Location wise, it is on the VRS frontier with decreasing return to scale but furthest from the CRS frontier. Malta, on the other hand is on the VRS frontier with increasing return to scale.

Malmquist productivity change

Table 3 presents a summary of the annual geometric means of the Malmquist productivity index and its components. As can be observed, on average, the TFP for SMEs in all nations showed a decrease of 2.38 percent per annum, ranging from the lowest of -11.83 percent (Denmark) to the highest of 12.22 percent (Sweden). This decrease is largely due to technical efficiency change, TEC or adaptation (of -3.47% per year) rather than frontier shift, FS which is synonym with innovation or adoption. The technological change on average improved by a small amount of 1.30% per annum while technical efficiency regressed by 3.47 percent per annum. Hence catching up (i.e diffusion of technology) is a problem facing SMEs in most countries due to both PTEC and SEC (-0.71% and -2.78% respectively). Only six (14.29%) countries viz. France, Ireland, Sweden, Albania, China and Turkey, have their SMEs exhibiting improvement in all components.

Twelve (28.57%) countries have their SMEs showing positive TFP growth while another thirty (71.43%) countries recorded negative growth. The highest TFP growth comes from SMEs in Sweden (12.22% per annum) while the lowest is from SMEs in Denmark (-12.31% per annum).

Technological change (frontier shift)

SMEs in thirty countries experienced technological progress since the FS, index attains a value greater than one. The average score was 1.013, indicating a 1.3% technological progress per annum. The highest technological progress of 12.03% per annum was achieved by SMEs in Austria while the lowest innovative improvement of -10.15% per annum was recorded by SMEs in Luxembourg which was 100% technically efficient during the period 2004 - 2008. On group comparison, the developed economies showed a slightly
better improvement than the developed economies (2.29% as compared to 2.46% per annum). Economies in transition lagged behind with a negative growth of -1.49% per annum. 

Technical efficiency change (catching up effect)

Only twelve (28.57%) showed improvement in technical efficiency with SMEs in Sweden attaining the highest score of 1.1093 (catching up rate of 10.93% per annum). Twenty-eight (66.67%) appeared to be lagging behind with SMEs in Belgium recording the lowest score of 0.8292 (a decline of -17.08% per annum). On average, the group was found to be staggering behind at -3.47% per annum. This indicates that technical efficiency is not improving in line with technological progress. In other words, the gap to the efficient frontier is widening. SMEs from Luxembourg and Albania, which were 100% technical efficient obtained a score of unity, meaning they remained unchanged. All three groups of economies exhibited negative growth (Table 3).

Pure technical efficiency change

As mentioned earlier, TEC is the product of PTEC and SEC. Seventeen (40.48%) indicated increase in pure technical efficiency with SMEs from Sweden taking the lead with improvement of 13.79% per annum. Twenty (47.62%) indicated a decrease with SMEs from Belgium retaining the lowest score of negative growth at -17.22% per annum. The remainder five (11.90%) showed no change during the period under consideration as indicated by their PTEC score of unity. Only the developing economies indicated a small increase of 1.74% per annum.

Scale efficiency change

Sixteen (38.10%) of the DMUs contribute positively to the productivity change since their scores exceed one. SMEs in Greece recorded the highest score of 1.14891 (a change of 14.89% per annum), while SMEs in Malaysia recorded the lowest score of 0.83728 (a change of -16.28% per annum). The average score for the group is 0.97649 (a decrease of 2.35% per annum). Economies in transition indicated a small positive change of 0.64% per annum. The other two groups exhibited on average a decrease of about -2.68% and -6.16% per annum respectively.

Observations

From the above discussions, we can highlight a few observations.

- The Malmquist TFP index for global SMEs from the countries under evaluation indicated only a decrease of -2.38% per annum. All the three groups exhibited negative total productivity growth.
- The TFP growth is largely due to innovation (a small positive shift in the frontier) rather than technical efficiency change (catching up effect). Two of the groups, the developed and developing economies, exhibited a positive frontier shift of about 2.5% per annum respectively.

- A decrease in TEC is attributable to both decrease in PTEC and SEC. All the three groups attained on average negative PTEC.
- SMEs in Sweden on average achieved the highest TFP growth with all components, except SEC indicating positive changes.
- SMEs in Denmark on average recorded the lowest TFP growth with negative scores in three components despite encouraging improvement in FS score. The low TEC was due to the low PTEC and SEC.

Policy implication

The analysis provides some interesting policy implications. The study found that SMEs in two countries viz. Luxembourg and Albania were operating at mpss. This should be sustained as long as possible since they were classified as 100 percent technically efficient. Fifteen (or 35.71%) of the economies were found to exhibit ds, suggesting an over-utilization of input resources, both labour and capital. Thus scaling down their scale of operation is an appropriate action for these sub-industries if they were to be on the efficient frontier. Another 59.52% of the DMUs were operating under irs. This suggests under-utilization of input resources, both in terms of quality and quantity, and provides potential for expansion. Thus expanding their scale of operation by injecting further investments in existing SMEs and/or new investment in new establishments seems the right move forward.

On the technology side, the adoption of new technology, although positive in two of the economies, it is relatively slow but encouraging at 2.5% per annum. The catching-up effect which indicates the gap to the efficient frontier, on the other hand is widening. Therefore, it seems that the choice of technology adopted is not in line with the skills available. Training should be provided by relevant parties such as government and employers for workers to acquire new and higher skills appropriate for the technology before adoption is made. Further, workers should be made more flexible and easily adaptable to new technology. Movements within sub-industries should be made easy, say from an establishment exhibiting ds to an establishment exhibiting irs.

Conclusions

In this study, we have estimated the Malmquist TFP index and its decompositions using the output-oriented DEA distance functions for SMEs in 42 economies for the period 2004-2008. The findings indicate that TFP did not exhibit a positive growth despite an encouraging frontier shift or innovative improvement of 1.30% per annum. This is due to a decline in the catching up effect or TEC of -3.47 percent per annum which is further attributable to decrease in both PTEC and SEC. Only SMEs in two countries were found to be operating efficiently (exhibiting mpss) while forty exhibited variable returns to scale, indicating the needs for operation adjustments. The findings suggest that SMEs from fifteen and twenty-five
countries should scale down and expand their scale of operations respectively if they were to be operating on the efficient frontier.

The study is not without limitations. DEA is non-stochastic and does not capture random noise, thereby may have over-estimated the magnitude of inefficiencies. The data utilized in the study are aggregated data and not firm level data. This is because firm level data is not easily accessible. The study also assumes that all SMES under evaluation are fairly homogenous, utilizing similar set of inputs to produce identical outputs. This can only be achieved if we are evaluating a group of firms operating similar business activities such as banking or financial institutions, hospitals and others. The methodology can be revised, expanded and applied to other public and private organizations.

References