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

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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 centres (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 (Boame, 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

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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,

maximize Ω_0 (1)

subject to

$$-X_{0i} + \sum_{k=1}^{s} X_{ki}\lambda_k = 0\,, \qquad i = 1,2,..,n \quad (2)$$

$$-\Omega_0 Y_{0j} + \sum_{k=1}^{S} Y_{kj}\lambda_k \geq 0\,, \qquad j = 1,2,..,m \quad (3)$$

$$\lambda_k \geq 0\,, \quad k = 1,2,..,S$$

Ω_0 unconstrained,

where X_{ki} and Y_{kj} are observed values of inputs and outputs, i=1,2,..,n and j=1,2,..,m, for each of k=1,2,..,S 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 slacks t_j^+, for all j such that

$$\sum_{k=1}^{S} Y_{kj}\lambda_k - t_j^+ = Y_{0j}\Omega_0\,, \qquad j = 1,2,..,m. \quad (5)$$

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

$$Y_{0j}^{\wedge} = \sum_{k=1}^{S} Y_{kj}\lambda_k = Y_{0j}\Omega_0 + t_j^+\,, \quad j = 1,2,..,m \quad (6)$$

which can be achieved by proportional increase of (Ω_0-1) in all outputs plus additional amount (termed as slacks movements) of t_j^+ in output Y_{0j} whenever $t_j + \neq 0$. Thus (Ω_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

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assumptions of variables return to scale, VRS an additional convexity constraint is imposed on λ_k such that

$$\sum_{k=1}^{S} \lambda_k = 1. \tag{7}$$

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 $SE_0 = \frac{E_0^{crs}}{E_0^{vrs}} \leq 1.$

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),

$$M_k\left(X_k^{(t+1)}, Y_k^{(t+1)}, X_k^{(t)}, Y_k^{(t)}\right) =$$

$$-\left\{\left(\frac{D_k^{(t)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}{D_k^{(t)}\left(X_k^{(t)}, Y_k^{(t)}\right)}\right)\left(\frac{D_k^{(t-1)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}{D_k^{(t+1)}\left(X_k^{(t)}, Y_k^{(t)}\right)}\right)\right\}^{1/2} \tag{8}$$

where $D_k^{(t)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)$ 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 frontier shift (or technological change) in time *t*+1,

$D_k^{(t)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right) =$ efficiency of conversion of inputs in period (*t*+1) to outputs in period (*t*+1) relative to technology period *t*

$\neq D_k^{(t)}\left(X_k^{(t)}, Y_k^{(t)}\right).$

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

$$TEC_k = \frac{D_k^{(t+1)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}{D_k^{(t)}\left(X_k^{(t)}, Y_k^{(t)}\right)} \tag{10}$$

and

$$FS_k = \left\{\left(\frac{D_k^{(t)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}{D_k^{(t+1)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}\right)\left(\frac{D_k^{(t)}\left(X_k^{(t)}, Y_k^{(t)}\right)}{D_k^{(t+1)}\left(X_k^{(t+1)}, Y_k^{(t+1)}\right)}\right)\right\}^{1/2} \tag{11}$$

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

$M_k(.)=(PTEC)_k.(SEC)_k.(FS)_k, k=1,2,...,K.$ (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, Slovania 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

X1: total employment,

X2: investment in tangible goods (or capital formation), in million EURO,

Y1: sales revenue, in million EURO, and

Y2: return on investment.

Next, all indicators (including inputs) are normalized on a scale of [1, 100] such that

$$X_{nor} = \frac{99(X_{act} - X_{min})}{X_{max} - X_{min}} + 1 \tag{13}$$

where X_{nor} is the value of the normalized indicator,
X_{act} is the actual value of the indicator,
X_{max} is the maximum value of the indicator,
X_{min} is the minimum value of the indicator.

Table 1. Basic descriptive statistics 2004-2008

Indicators	Mean	Maximum	Minimum	Std. deviation
2008				
X1:Employment	8782782	75888616	88499	16949871
X2: (Mil EURO)	104809	2885891	272	441644
Y1: (Mil EURO)	406946	3654545	4172	657618
Y2: (Ratio)	9.703	33.559	1.232	6.447
2007				
X1:Employment	8711181	82693604	90128	16991800
X2: (Mil EURO)	88070	2316171	280	354252
Y1: (Mil EURO)	368070	2662167	4982	539194
Y2: (Ratio)	10.004	33.562	1.271	6.301
2006				
X1:Employment	8651345	87035328	87523	17179857
X2: (Mil EURO)	76230	1917709	257	293430
Y1: (Mil EURO)	340326	2185868	3958	481915
Y2: (Ratio)	9.827	33.562	1.140	6.462
2005				
X1:Employment	8521180	76530275	85739	16845307
X2: (Mil EURO)	71376	1833937	240	280555
Y1: (Mil EURO)	295349	1918824	3698	429082
Y2: (Ratio)	8.971	18.907	1.046	4.886
2004				
X1:Employment	8673701	79256100	85608	17805762
X2: (Mil EURO)	66852	1750165	222	267941
Y1: (Mil EURO)	281035	1867936	3698	414200
Y2: (Ratio)	9.509	18.325	1.067	5.111

This transformation ensures that $X_{nor} \in [1,100]$, and is synonymous with *United Nation Human Development Index.* We then solve the DEA output-oriented model under the assumptions of CRS and VRS using LINDO Version 6.0 software for each year. Results for the mean efficiency scores and returns to scale are summarized in table 2.

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 developing economies are higher than the economies in transition which are higher than the developing economies (Table 1).

Returns to scale

Apart from the inefficiency that could arise in the conversion process, another reason for the inefficiency of the inefficient units can be attributed to the scale of operations. DMUs that do not operate at the most efficient (or productive) scale size cannot be fully efficient. The 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* ≠ *PTE* , then

Table 2. Mean efficiency scores 2004-2008

Country	*TE*	*PTE*	*SE*	rts
Austria	0.40621	0.42926	0.94683	irs
Belgium	0.57315	0.59060	0.97517	irs
Bulgaria	0.21108	0.28827	0.72434	irs
Cyprus	0.71326	0.78780	0.89947	irs
Czech Republic	0.61131	0.62220	0.98165	drs
Denmark	0.40012	0.42808	0.93608	irs
Estonia	0.50036	0.58758	0.85791	irs
Finland	0.66334	0.70176	0.95361	irs
France	0.57559	0.85716	0.66502	drs
Germany	0.78277	0.98261	0.79556	drs
Greece	0.46141	0.46543	0.99048	drs
Hungary	0.33026	0.35371	0.93809	irs
Ireland	0.71915	0.77633	0.93098	irs
Italy	0.85613	1.00000	0.85613	drs
Latvia	0.23182	0.34434	0.68653	irs
Lithuania	0.25339	0.37432	0.69293	irs
Luxembourg	1.00000	1.00000	1.00000	mpss
Malta	0.85648	1.00000	0.85648	irs
Netherlands	0.67576	0.68232	0.99126	irs
Norway	0.48514	0.62105	0.83263	irs
Poland	0.58800	0.59672	0.98555	irs
Portugal	0.34502	0.35759	0.96856	irs
Romania	0.17271	0.20426	0.85364	irs
Slovakia	0.34700	0.41558	0.85113	irs
Slovania	0.36472	0.43863	0.84566	irs
Spain	0.56650	0.69468	0.81497	drs
Sweden	0.84612	0.85741	0.98244	irs
U. Kingdom	0.75293	0.90039	0.83246	drs
Albania	1.00000	1.00000	1.00000	mpss
Australia	0.27286	0.39823	0.66348	drs
Canada	0.74993	0.96530	0.77143	drs
New Zealand	0.21701	0.27709	0.79218	irs
China	0.12225	1.00000	0.12225	drs
Hong Kong	0.28033	0.38096	0.78179	drs
Indonesia	0.17679	0.19746	0.89141	drs
Japan	0.65292	0.69661	0.92388	drs
Korea	0.15736	0.23125	0.68113	drs
Malaysia	0.17418	0.23879	0.72494	irs
Pakistan	0.13341	0.30217	0.77073	irs
Singapore	0.19560	0.22526	0.87236	irs
Thailand	0.15496	0.16723	0.91880	irs
Turkey	0.45451	0.46045	0.98617	irs
Average	0.47932	0.56902	0.84634	
Std. Deviation	0.25408	0.27269	0.15442	
Maximum	1.00000	1.00000	1.00000	
Minimum	0.12225	0.16723	0.12225	
Dev. economies	0.60012	0.68410	0.88116	
Econ. in transition	0.47541	0.53949	0.85949	
Developing econ.	0.21650	0.35595	0.74995	

Note: *drs* and *irs* refer to decreasing and increasing returns to scale respectively, while *mpss* refers to most productive scale size.

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$$\begin{cases} \sum_{j=1}^{K} \lambda_j < 1 & \rightarrow \textit{irs}, \\ \sum_{j=1}^{K} \lambda_j > 1 & \rightarrow \textit{drs}. \end{cases}$$

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 *mpss*. 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_k 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

Table 3. Mean Malmquist productivity index change 2004-2008

Country	$M_k(.)$	FS_k	TEC_k	$PTEC_k$	SEC_k
Austria	0.965	1.120	0.862	0.975	0.884
Belgium	0.918	1.107	0.829	0.828	1.002
Bulgaria	0.926	0.988	0.938	0.915	1.025
Cyprus	0.981	0.957	1.026	0.973	1.055
Czech Rep	1.009	1.039	0.970	0.973	0.993
Denmark	0.882	1.005	0.877	0.893	0.982
Estonia	0.982	0.967	1.015	1.031	0.985
Finland	0.944	1.014	0.930	0.930	1.001
France	1.014	1.001	1.013	0.979	1.034
Germany	0.976	1.037	0.945	1.097	0.861
Greece	1.009	0.958	1.053	0.917	1.149
Hungary	1.004	0.992	1.012	0.995	1.017
Ireland	1.043	1.007	1.036	1.026	1.009
Italy	0.981	1.035	0.948	1.000	0.948
Latvia	1.005	1.050	0.957	0.916	1.045
Lithuania	0.979	1.006	0.973	0.965	1.008
Luxembourg	0.898	0.898	1.000	1.000	1.000
Malta	0.971	0.918	1.057	1.000	1.057
Netherlands	0.986	0.986	1.000	1.001	0.999
Norway	1.016	1.069	0.951	1.064	0.893
Poland	1.010	0.988	1.023	1.027	0.996
Portugal	0.961	0.988	0.973	0.968	1.005
Romania	0.941	0.923	1.018	0.980	1.039
Slovakia	0.907	0.972	0.933	1.006	0.928
Slovania	0.994	1.005	0.989	1.057	0.935
Spain	0.964	1.028	0.937	1.006	0.932
Sweden	1.122	1.012	1.109	1.138	0.975
U. Kingdom	0.978	1.040	0.940	0.989	0.951
Albania	1.002	1.002	1.000	1.000	1.000
Australia	0.921	1.058	0.870	1.014	0.858
Canada	0.951	1.069	0.890	0.985	0.904
New Zealand	0.996	1.061	0.939	0.957	0.981
China	1.064	1.002	1.062	1.000	1.062
Hong Kong	0.943	1.006	0.938	0.972	0.962
Indonesia	0.962	1.021	0.942	0.987	0.954
Japan	0.974	1.030	0.946	0.936	1.010
Korea	0.981	1.037	0.946	1.010	0.936
Malaysia	0.938	1.032	0.909	1.086	0.837
Pakistan	0.989	1.008	0.981	1.011	0.970
Singapore	0.905	1.050	0.861	1.011	0.852
Thailand	0.924	1.024	0.903	1.055	0.856
Turkey	1.084	1.041	1.041	1.025	1.016
Average	0.976	1.013	0.965	0.993	0.976
Std. Deviation	0.049	0.045	0.062	0.056	0.068
Maximum	1.122	1.120	1.109	1.138	1.149
Minimum	0.882	0.898	0.829	0.828	0.837
Dev. economies	0.974	1.026	0.952	0.985	0.974
Econ. in transition	0.978	0.985	0.993	0.988	1.006
Developing econ.	0.977	1.025	0.954	1.017	0.938

Note: All Malmquist index averages are geometric means.

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 *drs*, 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 *drs* 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

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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.

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