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Analyzing Economic Performance of ASEAN Plus 3 Countries Using Growth Accounting and DEA Models

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Abstract: Economic performance among ASEAN Plus 3 countries was analyzed in this study using the CCR, BCC, and Malmquist index DEA models and Growth Accounting on data collected from 2004 to 2011. Two input variables (labor force and gross capital formation) and one output variable (the GDP) were selected, and an output-oriented formulation was applied to all DEA models. The CCR result indicates that Brunei Darussalam has the best economic performance, while the BCC model illustrates that Brunei Darussalam and Japan have efficient economic activities. The Malmquist index provides a measure and decomposition of performance changes over time, thereby providing information concerning how certain countries catch up to others. Finally, a growth accounting analysis showed that China was recorded as the second highest for the TFP. This analysis will identify the sources of inefficiency for each country and suggest appropriate policies for adjusting inefficient input and output variables to obtain better performance.
Keyword — Economic performance, ASEAN Plus 3, Growth Accounting, Data Envelopment Analysis

1. INTRODUCTION

Every nation needs indicators for measuring progress toward achieving their economic and social goals. A high level of real gross domestic product (GDP) per capita, a low rate of inflation, a low rate of unemployment, and a favorable trade balance are usually considered to be the four major objectives of a nation's macroeconomic policy. For example, only the last objective is not enshrined in the United States Full Employment Act of 1946. The first three objectives appear to guide policy makers in most, if not all, other advanced nations, as well.

GDP has been broadly used to appraise the economic performance of a country. GDP is extensively used by economists, policymakers, and the media as the primary scorecard of a nation's economic health and welfare, and it is considered a good tool for steering economic policy. Macroeconomic policymakers have various specific targets, such as a high growth rate as indicated by the change in GDP, a low rate of inflation as depicted by the change in consumer price index (CPI), a favorable trade balance and a high rate of employment. A nation thus has to assess and evaluate their economic performance periodically to identify any deficiency so that proper steps can be taken to resolve it.

The government can use fiscal and monetary policies to achieve some of economic objectives discussed above. Fiscal policy involves the use of government spending, taxation and borrowing to influence both the pattern of economic activity and also the level and growth of aggregate demand, output and employment. The use of interest rates to control the level and rate of growth of aggregate demand in the economy is the major tool of monetary policy (Mohamad & Said, 2011).

In this paper, we utilized the growth accounting approach to appraise the contribution of different factors to economic growth within each individual country. While data envelopment analysis (DEA), in particular, was used, the CCR, BCC, and Malmquist Productivity Index (MPI) approaches were applied to analyze the total factor productivity (TFP) and its growth in Association of Southeast Asian Nations (ASEAN) Plus 3 countries. By decomposing or isolating the economic growth into changes in technical efficiency and changes in technical innovation (i.e., shifts in the economic frontier), the study aims to provide a new interpretation and explanation of the rapid growth of East Asian

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countries and to draw new policy implications.

The paper is organized as follows: Section 2 presents a review of existing literature. In section 3, we discuss the techniques adopted in this study and the theoretical and mathematical formulations associated with these techniques. The variables and data used in our analysis are presented in section 4. Section 5 contains the empirical findings of this study. The final section presents the paper's conclusions and discusses important policy implications.

2. LITERATURE REVIEW

There are two ways to calculate TFP of a country or an economic entity, the non-frontier and the frontier approaches. A typical non-frontier method is the growth accounting method, which usually decomposes the growth rate of the economy's total output into the component that is due to increases in the number of factors (labor or capital) used and the component that cannot be accounted for by changes in resource accumulation or utilization (which is sometimes called the Solow residual). In contrast, frontier approaches (such as development envelopment analysis or stochastic frontier analysis) estimate the "best practice" or "benchmarking performance" among decision making units (DMUs).

Both techniques have been applied to various problems related to economic efficiency assessments for all types of economic entities. The growth accounting method has been exercised in many economic growth studies to identify the factors that drive the GDP growth of various counties. For example, Young (1992) compared the TFP growth in Hong Kong and Singapore based on differences in the initial quality of their labor forces and subsequent rates of factor accumulation and industrial transformation, and he concluded that a considerable portion of the economic growth of Hong Kong and Singapore in 1980's can be accounted for by capital accumulation. Another work from Young (2005) tried to explain the postwar rapid economic growth in Hong Kong, Singapore, South Korea and Taiwan using the growth accounting method, and that study yielded a similar conclusion. Relevant studies were also reported by Aghion and Howitt (2007), Hulten (2009), and Avila and Evenson (2010).

In contrast, DEA, a mathematical programming model providing a way to aggregate multidimensional inputs and outputs measures, is a vital tool for analyzing and evaluating efficiency of a group of DMUs. Specifically, this method provides an overall objective numerical score, ranking, and efficiency potential improvement targets for each one of the inefficient units; thus, it is widely used in benchmarking in strategy management or economic performance analysis. This approach is principally based on the work by Farrel (1957), which was further elaborated on by Banker and Cooper (1984); Charnes and Rhodes (1978).

While many other tools (e.g., the index approach, regression approach, or multi-attribute decision making methods) may also be used to perform empirical efficiency and productivity analysis in cases where the DMUs use multiple inputs to produce multiple outputs, there are usually problems or issues in defining weights and/or in specifying production functional forms when these alternative methods are employed. DEA does not require input or output prices in determining empirical efficiency frontiers based on best practice technology and related measures of inefficiency; it has become particularly popular not only in the benchmarking study of private business units but also in the study of the efficiency of public sectors (Loikkanen & Susiluoto, 2002).

In the field of regional economic performance analysis, Charnes and Li (1989) employed the DEA model to study the urban economic performance of 28 key cities in China for the years 1983 and 1984. These researchers used labor, working fund, and investment as the input variables, while gross industrial output, both profit and taxes, and retail sales were selected as the three output variables. Karkazis and Thanassoulis (1998) assessed the comparative effectiveness of public investment in infrastructure and investment incentives to attract private investment in regions of Northern Greece. The input variables were public investment and investment incentives. The output variables were the levels of private investment attracted into services, industry and agriculture. Zhu (2001) used the CCR model to measure the quality of life across cities and selected 15 US domestic cities and five international cities for this benchmarking study. Without a priori knowledge of factors' relationships, a multi-dimensional quality of life measure was demonstrated.

At the country level, Desposit (2005) assessed the Human Development Index (HDI) among the countries of the regional aggregate of Asia and the Pacific. This study used GDP per capita as the input and life expectancy and education attainment as the outputs. For evaluating the comparative performance of countries of the Middle East and North Africa, Ramanathan (2006) used the Malmquist Productivity Index to analyze efficiency changes over time. He decided to use the age dependency ratio, illiteracy rate and mortality rate as the inputs, whereas the ratios of total labor to population, life expectancy, primary education and GNP per capita were the outputs. Raab and Feroz (2007) developed a generalized efficiency index for a much larger set of 57 national governments by employing four components of gross national product (private consumption, government consumption, gross domestic investment, and export of goods and services) as the output and five resource-availability components (labor, arable land, commercial energy used, net merchandise imports, and net service import) as the input. Similarly, Mohamad and Said (2011) estimated how well the nations of the Organization of the Islamic Cooperation utilized their resources using the DEA approach. In their study, a high growth rate (as indicated by the change in gross domestic product), a low rate of inflation, a low rate of unemployment and a favorable trade balance are considered four main targets or objectives of a nation's macroeconomic policy makers. Based on the selected macroeconomic input and output indicators, they applied three versions of an output-oriented DEA model under the assumption of variable returns to scale to assess the relative macroeconomic performance of 54 member countries for the period of 2003 to 2007.

3. TECHNIQUE

Growth accounting decomposes the growth rate of output into the growth attributable to the accumulation of factors of production and the Solow residual, which reflect technological progress or something else (i.e., something that plays an important role in economic growth but cannot be explained by the accumulation or utilization of the factors). The growth accounting method was invented by Solow (1957). Using the assumption of constant returns to scale and competitive factor markets, it is possible to measure the growth rate of output that is implied by physical and human capital growth. Deviations of actual output from this implied growth rate are caused by changes in technology, institutional changes, and/or failure of the assumptions of constant returns to scale and competitive factor markets. This deviation is called the growth in Total Factor Productivity. Aghion and Howitt (2007) stated that the TFP growth represents technological progress, while capital deepening represents the capital accumulation. TFP growth can be formulated as follows

$$TEP = \dot{y}/y - a\dot{k}/k \tag{1}$$

where $\dot{y}/y$ is the growth rate output, and $a\dot{k}/k$ is capital deepening.

Regarding multiple inputs and outputs, TFP growth can be measured by aggregating the outputs and inputs, and the weights or factors shared are assigned in the form of their respective price (Pal & Bishnoi, 2009). TFP growth, then, can be formulated by:

$$TEP_t = \frac{Q_t/I_t}{Q_{t-1}/I_{t-1}} = \frac{Q_t/Q_{t-1}}{I_t/I_{t-1}} \tag{2}$$

where Q and I are output and input values

Unlike the growth accounting approach, which focuses more on evaluating the economic performance of one country (instead of bilateral comparisons between different countries), DEA is a mathematical programming based on the frontier approach. It can be used to study comparative performance of units by transforming a set of inputs or resources to produce a set of outputs. In DEA, organizations responsible for converting inputs into outputs and whose performances are to be evaluated are called decision making units (DMUs). This model is a frontier approach to efficiency evaluation as implied by production or cost theory. The original DEA model is the CCR model proposed by Charnes, Cooper, and Rhodes in 1978 (Charnes & Rhodes, 1978), and it is also recognized as the ratio or constant returns to scale (CRS) model. One of the key extensions of the CCR DEA model is the BCC model of Banker, Charnes and Cooper (Banker & Cooper, 1984). The BCC model is characterized by the property of variable returns to scale (VRS). CSR and VSR are two possible assumptions that can be made in efficiency score computation. The assumption of CRS is said to prevail when an increase in all inputs (i.e., increase in terms of undesirable attributes) by 1% leads to an increase in all outputs (i.e., increase in terms of desirable attributes) by 1%. The assumption of VRS is said to prevail when the CRS assumption is not satisfied (B. & Thore, 1997). When analyzing the economic performance of nations, DEA can combine efficiency scores of countries in terms of several desirable and undesirable attributes into a single scalar measure. Countries will register as efficient nations when they have the highest values of desirable attributes and the lowest values of undesirable attributes. A country with an efficiency score less than one operates sub-optimally for a given set of attributes.

The DEA production function approach should be developed when the DEA method is utilized to evaluate the performance of nations. The underlying function could be termed an economic and social performance function. In this sense, performances in terms of undesirable attributes are considered inputs, and performances in terms of desirable attributes are considered outputs. Such generic usage is valid when DMUs in DEA models are countries for evaluation.

Although, in a DEA sense, DMUs are entities that convert inputs into outputs, in some applications in growth or development economics, the term DMU denotes only a country or a region under consideration. Thus, DEA can be applied to compare the performance of different countries using the scalar efficiency score derived. The score improves when the desirable attributes of the country increase, and it decreases when the undesirable attributes increase (Ramanathan, 2006).

In general, DEA studies consider performance analysis for a particular time. However, the method can also be used to analyze performances over a longer period to evaluate the efficiency change over time using procedures such as the Malmquist Productivity Index (MPI). The advantage of MPI lies in its capability of evaluating the changes that occurred in technological practices at countries, as well as changes in the efficiency with which the technologies were used in two different time periods. The DEA models that used in this paper are CCR, BCC, and MPI.

DEA model can evaluate n performance units, DMUs, where each DMU takes m different inputs to produce s different outputs. The essence of DEA models in analyzing the efficiency of a DMU q lies in maximizing its efficiency rate, subject to the condition that the efficiency rate of any other units in the population must not be greater than one. The models must include all characteristics considered i.e. the weights of all inputs and outputs must be greater than zero (Vincova, 2005). The following is fractional programming problem to obtain values for the input weights and output weights.

$$\max_{u,v} E_k = \frac{\sum_{j=1}^{n} u_j^k Y_j^K}{\sum_{i=1}^{m} v_i^k Y_i^K} \tag{3}$$

$$s.t.$$
$$\frac{\sum_{j=1}^{n} u_j^k Y_j^K}{\sum_{i=1}^{m} v_i^k Y_i^K} \leq 1, \quad r = 1, 2, \cdots, R$$
$$u_j^k \geq 0, \quad j = 1, 2, \cdots, n$$
$$v_i^k \geq 0, \quad i = 1, 2, \cdots, m$$

This model can be converted into a linear programming model and transformed into a matrix notation:

$$\max_{u^k, v^k} h_k = u^k Y^k \tag{4}$$

$$s.t.$$
$$v^k X^k = 1$$
$$u^k Y^r - v^k X^r \leq 0, \quad j = A, B, \cdots, H$$
$$u_1^k \geq 0,$$
$$v_1^k \geq 0,$$

The mathematical programming presented in equation (4) is called "CCR ratio form of DEA" which was originally derived in Charnes and Rhodes (1978). The dual model to this can be formulated as follows.

$$\min f = \theta - \varepsilon(e^T s^+ + e^T s^-) \tag{5}$$

$$s.t.$$
$$Y\lambda - s^+ = Y_q$$
$$Y\lambda + s^+ = \theta X_q$$
$$\lambda, s^+, s^- \geq 0$$

where $\lambda = (\lambda_1, \lambda_2, \cdots, \lambda_n)$, $\lambda \geq 0$ is a vector assigned to individual productive units, s^+ and s^- are vectors of slack or surplus variables, $e^T = (1, 1, \cdots, 1)$ and ε is a very small constant greater than zero (which is usually called a non-Archimedean small number).

In evaluating the efficiency of unit DMU q, equation (5) searches for a virtual unit characterised by inputs $X\lambda$ and outputs $Y\lambda$, which are a linear combination of inputs and outputs of other units of the population and which are better that the inputs and outputs of unit DMU_q which is being evaluated. For inputs of the virtual unit $X\lambda \leq X_q$ and for outputs $Y\lambda \geq Y_q$. Unit DMU_q is rated efficient if no virtual unit with requested traits exists or if the virtual unit is identical with the unit evaluated, i.e.$X\lambda = X_q$ and $Y\lambda = Y_q$. Unit DMU_q is efficient if the optimum value of the equation (5) objective function equals one. Otherwise, the unit is inefficient (Vincova, 2005).
Equation (4) and (5) are input-oriented model. These models aim to observe how to improve the input characteristics of the unit concerned for it to become efficient. On the other hand, there are output-oriented models such as this following model. Most studies on performance were focused to find possible improvements in the level of outputs.

$$\max g = \varphi + \varepsilon(e^T s^+ + e^T s^-) \tag{6}$$

$$\begin{aligned} &s.t. \\ &Y\lambda - s^+ = \varphi Y_q \\ &Y\lambda + s^+ = \theta X_q \\ &\lambda, s^+, s^- \geq 0 \end{aligned}$$

This model can be interpreted that unit DMU q is efficient if the optimal value of the objective function in model (6) equals one, $g^* = 1$. If the value of the function is greater than one, the unit is inefficient (Vincova, 2005). The models discussed thus far are the models under the assumption of constant returns to scale. For productivity evaluation under the assumption of variable returns to scale, an additional convexity constraint is imposed on $eT\lambda = 1$. They will be referred to as BCC (Banker, Charnes, Cooper) models hereafter.
The Malmquist Productivity Index measures the productivity change (increase/decrease rate) of a specific decision making unit between two timeframes. Generally, efficiency measurement is performed for a specific time period. However, the change of efficiency over time is a vital issue to be considered. The MPI index is an index that is used for measuring the changes in total factor productivity of DMUs over time.
The MPI is computed as the product of the catch-up effect and frontier-shift effect. The catch-up term is related to the degree of efforts that the DMU attained for improving its efficiency, while the frontier-shift term reflects the change in the efficient frontiers surrounding the DMU between the two time periods, 1 and 2. MPI denotes DMU_o at time period 1 and 2 by (x_o^1, y_o^1) and (x_o^2, y_o^2), respectively. Then, the catch-up effect is measured by the following formula.

$$Catchp = \frac{Efficiency\ of\ (x_0, y_o)^2\ wrt\ period2\ frontier}{Efficiency\ of\ (x_0, y_o)^1\ wrt\ period1\ frontier} \tag{7}$$

Catch-up > 1 indicates progress in relative efficiency from period 1 to period 2, while Catch-up = 1 and Catch-up < 1 indicate that there is no change and a regress in efficiency, respectively. In addition to the catch-up term, it must take account of the frontier-shift effect to evaluate the productivity change fully because the catch-up effect is determined by the efficiencies being measured by the distances from the respective frontiers. Using ϕ_1 and ϕ_2, the frontier-shift can be defined by their geometric mean, i.e.,

$$Frontier - shift = \phi = \sqrt{\phi_1 \phi_2} \tag{8}$$

$$\begin{aligned} &where \\ &\phi_1 = \frac{Efficiency\ of\ (x_0, y_o)^1\ wrt\ period1\ frontier}{Efficiency\ of\ (x_0, y_o)^1\ wrt\ period2\ frontier} \\ &\phi_2 = \frac{Efficiency\ of\ (x_0, y_o)^2\ wrt\ period1\ frontier}{Efficiency\ of\ (x_0, y_o)^2\ wrt\ period2\ frontier} \end{aligned}$$

Frontier-shift > 1 means progress occurred in the frontier technology around DMU_o from period 1 to 2, while Frontier-shift = 1 and Frontier-shift < 1 show the status quo and a regress in the frontier technology, in that order. By multiplying the catch-up and frontier-shift, the MPI will be obtained, as shown by the following expression.

$$MPI = \left[\frac{\delta^1((x_0, y_0)^2)}{\delta^1((x_0, y_0)^1)} x \frac{\delta^2((x_0, y_0)^2)}{\delta^2((x_0, y_0)^1)}\right]^{1/2} \tag{9}$$

MPI > 1 denotes development in the total factor productivity of the DMUs from period 1 to 2, while MI = 1 and MI < 1 respectively indicate the status quo and a deterioration in the total factor productivity.

4. ANALYZING ECONOMIC PERFORMANCE OF ASEAN PLUS 3 COUNTRIES

Since 1997, countries of ASEAN Plus Three have broadened and deepened their cooperation. Relevant activities include cooperation in the areas of politics and security, transnational crime, trade and investment, finance, tourism, food, agriculture, fishery and forestry, minerals, small and medium enterprises, information and communication technology, energy, environmental and sustainable development, networking of track II, poverty alleviation, promotion development of vulnerable groups, culture and people-to-people contact, education, science and technology, public health, and disaster management.

Twelve countries among the ASEAN Plus 3 community were selected as DMUs for this study. These countries are Brunei Darussalam, Cambodia, China, Indonesia, Japan, the Republic of Korea, Lao PDR, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. All of the data needed in this study were taken from The World Bank. Due to incomplete data for Myanmar, Myanmar was not included in the current study.

It is important to note that Farrel (1957) selected 17 Organisation for Economic Co-operation and Development (OECD) countries over the period of 1979 to 1988 in a study of economic performance of industrialized countries. The aim of that study was to provide evidence concerning patterns of total factor productivity growth. A non-parametric programming method was used to compute Malmquist productivity indexes, using GDP as a measure of aggregate output and capital stock and employment as the aggregate input proxies. In an empirical study of the growth theory model, Young (1992) also studied technical change and factor accumulation by focusing on two aggregate inputs, capital and labor, and aggregate compensation of employees as a percentage of GDP as output. Young (1992) used a paired case study of Hong Kong and Singapore to develop various insights into the growth process and evaluate the empirical validity of existing models of endogenous growth.

This study measures the economic performance among countries in ASEAN Plus 3 by analyzing GDP, labor force, and gross capital formation of each nation. This study utilizes GDP because GDP is not only one of three indicators for measuring economic performance that were enshrined in the United States Full Employment Act of 1946, but it is also considered a measure of the total economic activity of a country. GDP can provide a guide to changes in domestic production and hence is a good tool for steering economic policy.

This study employs the two input variables, that are gross capital formation (GCF) and total labor force (TBF). On the word of World Bank, GCF includes outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Data are in current U.S. dollars. TBF comprises people aged 15 and older who meet the International Labor Organization definition of the economically active population: all people who supply labor for the production of goods and services during a specified period. On the other hand, the output variable is GDP. According to World Bank, GDP at purchaser's prices is the summation of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not listed in the value of the products. Data are in current U.S. dollars.

Table 1, below, presents the 12 member countries of ASEAN Plus 3 (as DMUs) and their economic activities (as input and output) in the annual period of 2011. Data are derived from World Bank Data during 2004-2011

5. DISCUSSION OF EMPIRICAL RESULT

5.1 Growth Accounting Analysis

In growth accounting-based evaluation, total factor productivity is measured, which accounts for effects in total output not caused by accumulation of inputs of labor and capital. TFP appears to be more intangible, as it can range from technology to the knowledge of workers (human capital). The growth of TFP typically is the result of technological innovations or improvements.

Table 2 shows the geometric mean of GDP growth, input and TFP. During the study period, China experienced the highest growth of output, a growth of 20.97%. Although TFP, such as technology and innovation (or other managerial practices leading to significant changes in efficiency or productivity), contributed approximately 8.82% to China's

Table 1: ASEAN Plus 3 member countries and their input and output measures (year of 2011)

DMU	Input		Output
	LBF	GCF	GDP
BRN	193,895	2,186,399,183	16,359,795,686
KHM	8,260,386	2,193,583,982	12,829,541,141
CHN	782,422,530	3,533,942,067,590	7,321,935,025,070
IDN	116,379,606	279,238,545,796	846,341,443,778
JPN	65,569,737	1,176,783,611,076	5,896,794,887,859
KOR	14,946,008	328,890,905,004	1,114,471,962,886
LAO	3,230,458	2,183,701,295	8,254,088,067
MYS	12,399,724	67,318,508,990	289,258,937,259
PHL	40,340,544	45,849,750,796	224,095,219,329
SGP	2,906,975	54,370,918,158	245,024,318,394
THA	39,109,599	92,040,424,115	345,672,232,116
VNM	51,933,141	40,323,845,976	135,539,487,317

BRN: Brunei Darussalam; KHM: Cambodia; CHN: China; IDN: Indonesia; JPN: Japan; KOR: Korea Republic; LAO: Lao PDR; MYS: Malaysia: PHL: Philippines; SGP: Singapore; THA: Thailand; VNM: Vietnam.

Table 2: TFP Growth, 2004-2011

DMU	GDP	Input	TFP
BRN	11.02	4.07	6.67
KHM	13.35	5.36	7.57
CHN	20.97	11.17	8.82
IDN	18.57	13.74	4.24
JPN	3.43	0.77	2.64
KOR	6.40	4.17	2.14
LAO	19.54	10.33	8.34
MYS	12.77	7.70	4.70
PHL	13.67	4.18	9.11
SGP	12.22	7.80	4.10
THA	11.50	5.44	5.75
VNM	15.50	8.47	6.48

GDP growth, the GDP growth of China can be attributed more to the accumulation of labor and capital, which explained more than 11% of the GDP growth. In contrast, Japan, a rich country with ample capital, grows considerably more slowly with a mean growth of output of 3.43%, a phenomenon predicted by the neoclassical model in economics. The average input change (0.77%) is marginal, but Japan still manages to achieve 2.64% TFP improvement each year. Finally, it can be observed that Indonesia's GDP growth was mainly driven by accumulated capital; the inputs increases 13.74% per year.

The variation of the mean TFP change of the 12 countries was not high. This implied that technology, innovation, and research and development were transferred well among nations in this association. Conversely, the disparity of mean input change was relatively prominent. It may be caused by the difference of the amount of labor force and fixed assets of the economy. For instance, Indonesia and China have larger populations; thus, the accumulated labor capital will strongly contribute to GDP growth.

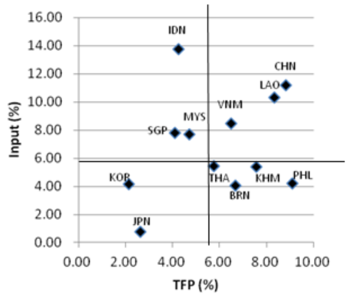

Figure 1: TFP-Input Contribution to GDP

Figure 1, above, divides the 12 countries into four clusters. China, Lao PDR, and Vietnam, which had GDP growths in 2011 of 9.3%, 8.04% and 6.24%, respectively, are the countries with high input and TFP contribution to GDP. Based on the GCF data during 2004-2011, the capital growth averages of these three countries are 23.04%, 22.77% and 14.53%, while the growth averages of labor are 0.56%, 2.9%, and 1.96%. Hence, capital of these countries is more influential to their GDP than labor. They also had many influxes of new technology and innovation. While Indonesia, Malaysia, and Singapore are grouped in one cluster with high input contributions to GDP, their TFP contributions are below the TFP's average. This means that their capital and labor have larger effects than technology and management change do. It is a signal to the policy makers of Indonesia, Malaysia, and Singapore to design more creative management, develop new technology and still keep the fiscal and monetary policy exemplary.

GDP growth of Brunei Darussalam, Cambodia, the Philippines, and Thailand was marked by high technology and institutional innovation rather than capital and labor aspect improvements. In this case, their growth averages for labor are 1.82%, 3.2%, 2.01%, and 0.86%, in that order. Finally, Japan and the Republic of Korea's GDP growth had only small contributions from technological and institutional innovation, labor, and capital formation. These two countries experienced 1.97% and 7.72% capital growth averages during the study period, correspondingly. Likewise for the growth averages of their labor force, where -0.23% and 0.92%, respectively, were recorded. Japan and the Republic of Korea should make new policies regarding the labor force, for instance, public employment services, training schemes, and employment subsidies, so that labor shortages will not occur in those countries.

5.2 DEA Analysis

This paper examines ASEAN Plus 3 countries' economic performance based on the results of the CCR, BCC, and Malmquist Productivity Index DEA models. Output-oriented formulation was employed in this study for both the CCR and BCC models. For the Malmquist index, the model is formulated using the assumption of the radial and output-oriented Malmquist Index under the variable returns to scale. Table III provides technical efficiency scores for the selected 12 countries measured empirically using the CCR model during the economic activities of 2004-2011.

Table 3: Technical efficiency scores using the CCR model

DMU	2004	2005	2006	2007	2008	2009	2010	2011	Mean	Projection at 2011 (%)
BRN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0
KHM	0.83	0.62	0.51	0.61	0.73	0.78	0.91	0.78	0.71	27.94
CHN	0.31	0.27	0.24	0.31	0.31	0.37	0.41	0.28	0.31	261.15
IDN	0.56	0.45	0.41	0.52	0.49	0.55	0.49	0.41	0.48	146.88
JPN	1.00	1.00	1.00	0.93	1.00	1.00	1.00	1.00	0.99	0
KOR	0.74	0.86	1.00	1.00	0.82	0.75	0.83	0.83	0.85	20.61
LAO	0.56	0.49	0.39	0.38	0.43	0.55	0.65	0.51	0.49	97.96
MYS	0.59	0.51	0.46	0.55	0.64	0.97	0.68	0.57	0.61	74.14
PHL	0.62	0.53	0.58	0.75	0.71	1.00	0.77	0.65	0.69	53.09
SGP	0.88	0.89	0.90	0.97	0.87	0.93	0.93	0.94	0.91	6.70
THA	0.50	0.36	0.37	0.49	0.47	0.80	0.61	0.50	0.50	99.23
VNM	0.41	0.34	0.30	0.33	0.37	0.45	0.44	0.45	0.38	122.61

It can be observed from Table 3 that Brunei Darussalam is the only country that achieved technical efficiency during the entire period of 2004-2011. Interestingly, the most inefficient state during those eight years was China. Except for Brunei Darussalam, all countries experienced some fluctuations in their economic performance. Cambodia, the Republic of Korea, Lao PDR, Malaysia, the Philippines and Thailand are the countries with high fluctuations. Among those fluctuating countries, only the Republic of Korea registered an ascending trend in the last three years.

The lowest point of the average economic performance of the ASEAN Plus 3 was in 2006; the geometric mean of the efficiency scores for all countries in that year was only roughly 0.533. In 2009, in contrast, the economic performance had the highest recorded average efficiency score, with a geometric mean of 0.726. The economic performance then decreased during the next 2 years. Brunei Darussalam, Cambodia, Japan, the Republic of Korea, the Philippines and Singapore are the six countries with economic performances above the average in 2011. If we focus on economic performance in 2011, Brunei Darussalam and Japan are the efficient countries. China, however, is the most inefficient nation. Hence, China has to utilize their labor and capital to create more GDP, up to 261.15%, to make the economic performance efficient, as described in the right column of Table III. This is the largest percentage toward the projection of China's GDP among the countries, followed by Indonesia and Vietnam with 146.88% and 122.61%, respectively. These countries not only have to organize liquidity, expenditure, taxes, and debt, but they also must manage their labor force properly. Alternately, the gap between the actual GDP and the projected GDP on the efficient frontier for Singapore is only 6.7%. It is important to note that the DEA results represent the level of actual economic performance in each country.

Turning to the BCC efficiency results, more countries achieved efficient performance during 2004-2011. Table IV notes that Japan joins Brunei Darussalam as an efficient country during the entire period. Fascinatingly, even though China registered as the most inefficient during the first two years, it made a gradual improvement and finally achieved technical efficiency in the years 2010 and 2011. After putting scale efficiency into consideration, in addition to Brunei Darussalam and Japan, which achieved stable efficient economic performance, Lao PDR, Malaysia, the Philippines, and Singapore also experienced quite stable economic performances during the time span, while the remaining countries ran into high fluctuation. Among those countries with fluctuating economic performance, only Vietnam registered a rising trend in the last three years.

Table 4: Technical efficiency scores using the BCC model

DMU	2004	2005	2006	2007	2008	2009	2010	2011	Mean	Projection at 2011 (%)
BRN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0
KHM	0.94	0.63	0.56	0.63	0.81	0.81	0.93	0.78	0.75	27.8
CHN	0.52	0.53	0.62	0.80	0.93	0.99	1.00	1.00	0.77	0
IDN	0.92	0.86	0.84	0.86	0.79	0.62	0.61	0.60	0.75	65.82
JPN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0
KOR	0.75	0.87	1.00	1.00	0.88	0.75	0.83	0.83	0.86	20.53
LAO	1.00	1.00	1.00	0.99	0.99	1.00	1.00	0.99	1.00	0.79
MYS	0.95	0.92	0.92	0.92	1.00	1.00	0.84	0.84	0.92	18.38
PHL	1.00	0.92	1.00	1.00	1.00	1.00	0.95	0.95	0.98	4.85
SGP	1.00	1.00	1.00	1.00	0.93	0.95	0.94	0.94	0.97	6.27
THA	0.82	0.68	0.73	0.77	0.73	0.85	0.76	0.74	0.76	34.87
VNM	0.66	0.59	0.53	0.46	0.54	0.47	0.55	0.65	0.55	52.94

After considering the scale effect, the lowest point of the average economic performance of the ASEAN Plus 3 was in 2005; the geometric mean of the efficiency scores for all countries in that year was approximately 0.815. While, in 2008, the economic performance was recorded as the highest average efficiency score with a geometric mean of 0.871, the technical efficiency decreased during the ensuing three years. Brunei Darussalam, Cambodia, China, Japan, Lao PDR, the Philippines and Singapore are the seven countries with economic performances above the average in 2011. Concentrating on economic performance in 2011, Brunei Darussalam, China and Japan are the efficient countries. However, Indonesia is the most inefficient one. Indonesia has to optimize their labor and capital to make 65.82% more GDP to become technically efficient. This is the largest improvement in GDP needed among the countries in this study, followed by Vietnam and Thailand with 52.94% and 34.87%, correspondingly. Conversely, the Philippines only has a 4.85% disparity between the actual GDP and the GDP in the efficient situation.

The results of the economic performances for the 12 ASEAN Plus 3 member countries using MPI are presented in Table V. The geometric mean of MPI, the catch-up effect and the frontier-shift effect among countries during the 7 periods are 1.003, 0.998 and 1.005, respectively. This MPI indicates that there has been progress in achieving higher values of desirable attributes and lower values of undesirable attributes during these years. The catch-up or recovery relates to the degree to which a country improves or worsens its efficiency. The geometric mean of the catch-up is 0.998. This implies that efforts of the countries for improving their efficiency actually led to a slight regression or setback in efficiency. The frontier-shift or innovation reflects the change in the efficient frontiers between the two time periods. The geometric mean of the frontier-shift (i.e., the change in technology) is 1.005. This implies that, overall, there is slight progress in the frontier technology around the countries during the seven periods. We thus can conclude that, on average, growth was due to innovation, rather than improvements in efficiency.

Turning to the country-by-country results, we found that nine of the twelve countries improved their total factor productivity for the duration of the sample period. Only Cambodia, Indonesia, and Lao PDR experienced a setback in the total factor productivity, with geometric means of 0.916, 0.963, and 0.800, respectively, as mentioned in Table VI. All countries experienced some fluctuations in productivity; Lao PDR underwent the largest fluctuation in economic performance, and Japan experienced the least. This indicates that economic activity of Japan is the steadiest among the counties being evaluated.

Table 5: Efficiency change over the period 2004 - 2011

DMU	2004- 2005	2005-2006	2006- 2007	2007- 2008	2008- 2009	2009- 2010	2010- 2011
BRN	1.09	1.08	1.02	1.07	1.00	1.06	1.14
KHM	0.77	0.96	0.81	0.98	0.84	1.23	0.89
CHN	1.03	1.13	1.29	1.29	1.10	1.18	1.20
IDN	0.96	1.00	1.03	0.91	0.90	0.96	0.98
JPN	0.99	0.97	1.00	1.05	1.10	1.04	1.04
KOR	1.15	1.11	1.08	0.89	0.94	1.15	1.09
LAO	0.95	0.69	0.58	0.64	0.97	1.15	0.78
MYS	1.04	1.00	0.98	1.10	1.17	0.78	1.00
PHL	1.01	1.19	1.06	0.93	1.14	0.83	1.01
SGP	1.09	0.97	1.00	0.94	1.05	1.09	1.06
THA	0.86	1.12	1.08	0.92	1.33	0.83	0.97
VNM	0.97	0.99	0.92	1.11	0.99	1.04	1.20

Table 6: Geometric mean of CCR, BCC, and MPI

DMU	CCR	BCC	SCE	Average annual change		
				ECH	TCH	MPI
BRN	1.000	1.000	1.000	1.000	1.067	1.067
KHM	0.711	0.751	0.946	0.974	0.940	0.916
CHN	0.309	0.773	0.400	1.098	1.067	1.172
IDN	0.482	0.754	0.640	0.941	1.024	0.963
JPN	0.991	1.000	0.991	1.000	1.027	1.027
KOR	0.849	0.858	0.989	1.015	1.039	1.054
LAO	0.486	0.999	0.487	0.999	0.801	0.800
MYS	0.607	0.923	0.658	0.983	1.021	1.004
PHL	0.690	0.978	0.705	0.993	1.025	1.018
SGP	0.912	0.969	0.941	0.991	1.034	1.026
THA	0.499	0.760	0.656	0.985	1.021	1.005
VNM	0.383	0.550	0.697	0.999	1.029	1.028

SCE: Scale efficiency ECH: Efficiency change
TCH: Technology change MPI: Malmquist index

In contrast to the total factor productivity score, only China and the Republic of Korea are good at catching up or moving toward the efficient frontier. The rates of efficiency change (i.e., the average catch-up scores) were 1.098 and 1.015 for China and the Republic of Korea. Brunei Darussalam and Japan showed no change in technical efficiency, and the rest of the countries experienced regress in their efficiency. These data demonstrate that during the sample period, China and the Republic of Korea succeeded in improving their productivity.

In addition to the catch-up effect, the frontier-shift (innovation) effect must be taken into account to fully evaluate the productivity change. Although Lao PDR recorded progress in terms of efficiency change, it registered a regress in terms of technical change. Cambodia was another country that experienced a degeneration. The ten other countries in this study experienced progress in their frontier technology.

By combining both efficiency change and technical change, Figure 2 shows that Brunei Darussalam, Japan, the Republic of Korea, Malaysia, the Philippines, Singapore, Thailand and Vietnam can be classified in the same cluster. There are four significant outliers: Cambodia, Lao PDR, Indonesia, and China. We note that China has the highest total factor productivity change in the sample at approximately 17 percent per year on average, more than half of which is due to improvements in efficiency. In other words, although China made sufficient innovation to boost its production technology, it was even better at moving toward the frontier or catching up.

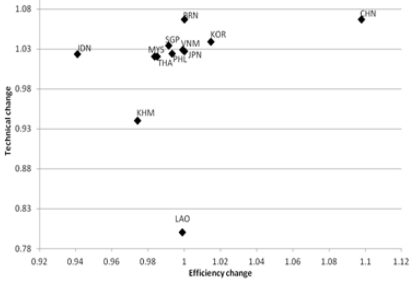

Figure 2: Efficiency change and technical change

The other three outliers are countries that experienced some regression or deterioration in economic performance over the time period of 2004 to 2011. However, by decomposing productivity growth into changes in technical efficiency over time and shifts in technology over time, different strategies (for boosting economic performance) may be proposed for countries with different features. For example, Indonesia has the worst efficiency change at 0.941 on average but an acceptable technical change at 1.024 on average. This finding means that policy makers of Indonesia should focus more on introducing management tools and concepts to industries to raise productivity or improve production efficiency rather than introducing new technology or innovation to the industry or copying the technology or innovations of others. Lao PDR, on the other hand, has the worst technical change at 0.801 but an acceptable efficiency change at 0.999. This means that policy makers of Lao PDR might need to focus more on investing in new technology or innovation for their industries. Cambodia did not have the worst score in either efficiency change or technical change, but both scores show regresses in performance. Some strategic policies and operational policies need to be proposed to boost frontier shift and efficiency improvement.

6. CONCLUSION

Although this article is comparable to Fare and Norris (1994), we have crafted an advanced explanation by applying the projection of an inefficient country onto the referenced efficiency frontier. This study (in which, through implementing an output orientation, one improves efficiency) requires proportional augmentation of output. Compared to Desposit (2005), Mohamad and Said (2011), Raab and Feroz (2007), and Ramanathan (2006), this research presents the projection and also makes available the total factor productivity using both growth accounting and MPI. In constrast to Young (1992) and Young (2005), this paper assesses both the performance of ASEAN Plus 3 using the DEA model and the total factor productivity using growth accounting and MPI comprehensively. This analysis not only can identify the sources of inefficiency for each country and suggest appropriate general guidelines or policies for adjusting inefficient input and output variables to obtain better performance, but it may also provide important theoretical and practical implications for development economics.

In this paper, the economic performances of 12 countries of ASEAN Plus 3 were analyzed using the growth accounting and Data Envelopment Analysis models on data collected from 2004 to 2011. A growth accounting analysis showed that China recorded the highest growth of output and the second highest for the TFP. China's TFP via this method result is quite similar to the TFP result of MPI. In MPI's result, China showed its domination. Growth accounting also informs us those countries with labor and capital that act as larger contributions to GDP are Indonesia, Malaysia, and Singapore. Strategic policy that can be proposed for such countries is enlarging the push for new technology and institutional innovation. Alternately, countries with high contributions to GDP from technology and institutional innovation are Brunei Darussalam, Cambodia, the Philippines, and Thailand. For those countries, policy on human capital and economic capital could be implemented.

Unlike the traditional growth accounting method that cannot make direct multilateral comparisons, the DEA method allows all decision making units to benchmark with each other to constitute an efficient frontier. According to the CCR model in 2011, China, Indonesia, and Vietnam have a tough road ahead to reach the best economic performance. They have to utilize all their resources to boost their GDP up by 261.15%, 146.88, and 122.61%, respectively. Brunei Darussalam and Japan also have the difficult task of maintaining their achievements as the most efficient nations. Contrasted with the constant returns to scale, China made gradual progress during the time period and ended up being regarded as an efficient country in the BCC results. Hence, they have zero projection in 2011. Indonesia and Vietnam, however, still reside in the group of inefficient nations. Those two countries have to develop a strategic policy on labor, capital, and also technology and institutional innovation to catch up. Furthermore, by decomposing productivity growth into changes in technical efficiency over time and shifts in technology over time, different strategic policies or operational policies may be proposed depending on the relative magnitude of the changes in efficiency and in technology.

The DEA score is sensitive to the specification of input and output and the size of the sample. Numkaker (1985) stated that the number of DMUs in the sample should be at least three times greater than the sum of the number of outputs and inputs included in the specification. Conversely, England (1998) stated that GDP is extensively recognized to be a poor measure of social well-being. Due to the number of ASEAN Plus Three members, we, in this study, just apply an output and two inputs that focus on economic aspects. This study did not touch on society's welfare, human well-being, or the quality of life of people. In the future, a similar analysis could be modified in several mix-aspects to provide valuable insight, not only of economic index but also to touch on society's welfare, human well-being, or the quality of life of people.

In economic modeling, DEA is a useful model for analyzing the efficiency of fiscal policies. However, because having a deterministic DEA produces results that are particularly sensitive to measurement error, it might be beneficial to use a stochastic frontier in future studies. A stochastic component will add random shocks that affect the production process. These shocks may come from economic adversities or plain luck. Additionally, it should be noted that the projection of an inefficient DMU needs careful consideration when organizations with several different characteristics are involved. A straightforward projection may cause the problem of rationality. The adjusted projection model could be another potential tool in future comparable analyses.

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