



Investigating World Bank Knowledge Assessment Methodology (KAM) using Data Envelopment Analysis (DEA): A study in ASEAN region

Munshi Naser Ibne Afzal,

Phd Student, Faculty of Business, Economics and Policy Studies, Universiti Brunei Darussalam.

Dr. Roger Lawrey, School of Accounting, Economics and Finance,
University of Southern Queensland, Toowoomba Qld 4350, Australia
E-mail: rogerlawrey@gmail.com

Abstract: This paper investigates the World Bank Knowledge Assessment Methodology (KAM) by using Data Envelopment Analysis (DEA), a non-parametric mathematical concept. KAM is designed to present a basic evaluation of countries' readiness for the knowledge economy, and identifies areas where member countries may need to focus more attention. This paper considers selected Association of South East Asian Nations (ASEAN) countries to apply DEA technique in order to exhibit how KAM can be better explained for the client countries.

Keywords: World Bank, KAM, DEA, ASEAN, efficiency, Knowledge economy

1. Introduction

The World Bank Institute (WBI) (1999) has developed the Knowledge Assessment Methodology (KAM) as a Knowledge-Based Economy (KBE) framework for its member states in order to specify their level of knowledge-based economic development. WBI (2002) stated in their framework that a knowledge economy (KE) is one that utilizes knowledge as the key engine of economic growth. It is an economy where knowledge is acquired, created, disseminated and used effectively to enhance economic development. The KAM (www.worldbank.org/kam) benchmarks the performance of an economy or region relative to its neighbours, competitors, or countries it wishes to emulate on important aspects related to the knowledge economy. This methodology helps to underline that countries need to develop clear strategies to connect knowledge to improve economic growth, welfare and increase competitiveness. According to the WBI KAM, the knowledge economy can be quantified by means of a numerical index known as the Knowledge Economy Index (KEI). While constructing the index, WBI ranks the countries based on the absolute values (raw data) that explain each and every one of the variables. Countries with the same performance are given the same rank. However, there are some questions arise while using this methodology for the member countries, for instance, at first if a country wants to emulate other neighbour countries to develop their knowledge economy performance, how the follower country select which neighbour to emulate if two or more neighbours get the same ranking. Secondly, WBI did not explicitly define their KBE definition in relationship of how a country can acquire, produce, distribute and utilize their knowledge by using WBI variables. To investigate these questions this paper uses a non parametric technique Data Envelopment Analysis (DEA) and select Association of South East Asian Nations (ASEAN) countries namely Indonesia, Malaysia, Singapore, the Philippines, Thailand and South Korea as sample. Our research expects to give new insights in order to improve KAM for future analysis. To fulfil our above objectives, we break down our paper into four sections. In section 1 general introduction, section 2 describes the KAM vs. DEA methodology section 3 gives empirical results in ASEAN context and finally section 4 draws the conclusion and policy suggestions.

2. KAM vs. DEA methodology

The World Bank KAM Basic Scorecard provides an overview of the performance of a country in terms



of the pillars of the knowledge economy under 5 sub-titles. Table 1A (appendix-01) shows these indicators in detail. The basic scorecard is developed for constructing the Knowledge Economy Index (KEI) as well as the Knowledge Index (KI). The KEI index is built on the average of the performance scores of a country or region in all four pillars related to the knowledge economy. According to Chen and Dahlman (2006) each of the variables used in the KAM is normalized on a scale from zero to 10. The normalization procedures of KAM use the raw data (u) to rank the countries in each and every one of the KAM variables. KAM calculates the number of countries having lowest rank (N_w) and use the following formula in order to normalize the scores for every country on every variable according to their ranking and in relation to the total number of countries in the sample (N_c) with available data: **Normalized (u) = $10 \cdot (N_w / N_c)$** ; this formula allocates a normalized score from 0-10 for each of the 121 countries with available data. 10 are the top score for the top performers and 0 the worst for the straggler (An example of actual and normalized values is given in appendix01:2A).

2.1 DEA methodology

There are vast similarity between KAM methodology and DEA. Data Envelopment Analysis (DEA) is a methodology leading an application of linear programming. It measures the efficiency of the Decision Making Units (DMU) by the comparison with the best producer in the sample to derive compared efficiency. Therefore the fundamental objective of KAM and DEA is almost similar. Both the methods are used for performance assessment of a country, firm or organizations. A distinctive feature of the DEA approach is that, for each DMU (e.g. an individual country), it calculates a single relative efficiency ratio by comparing total weighted outputs to total weighted inputs for each unit without requiring the proposition of any specific functional form. Unlike KAM, according to the original CCR (Charnes, Cooper and Rhodes, 1978) model, the DEA efficiency value has an upper bound of one and a lower bound of zero. Two types of DEA models, namely the input-oriented and the output-oriented models and evidence indicates that research results are not susceptible to which of the models is being used (Hsu, Luo and Chao, 2005). Charnes, Cooper and Rhodes (1978) have developed a mathematical transformation called CCR (the initials of their name) model which converts the nonlinear programming of efficiency ratio to linear one under constant-returns-to-scale (CRS). A good introduction of DEA is available in Norman and Stoker (1991) and Cooper, Seiford and Tone (2000) provide comprehensive material on DEA (Ramanathan, 2003). Another important feature of DEA is to calculate the Most Productive Scale Size (MPSS) for the inefficient DMU. Mathematically in DEA calculation, the information about MPSS for an inefficient firm is contained in the weights of its Peers or Benchmark countries (Ramanathan, 2003). This is a unique feature compare to KAM to find out which country to emulate for the inefficient or low ranking countries. Hence, we can say that DEA can be used to improve KAM for future research. The next section will discuss the sample countries; investigate WBI KBE definition and DEA results interpretation.

3. Empirical Results and Discussion

In 1996 Michael Mandel published an article in Business Week called *The Triumph of the New Economy* which stresses the development of a technology-driven, fast-growing, low-inflation economy, which he referred to as the *New Economy or knowledge economy*. ASEAN is the fast growing region in the world having the unique characteristics of new economy. It has high growth rate, low inflation and slowly becoming a technology driven economy. Appendix 01: 3A gives the trend of five ASEAN member countries' economic performance. Our paper therefore considers these countries for empirical analysis. However, before going into DEA calculation, we first formulate our policy-focused KBE framework in order to apply DEA method. We build a policy focused KBE framework based on WBI (1999, 2002) KBE definition considering four knowledge dimensions under which there are four output variables and some selected input variables. The KBE input-output variables are selected from WBI KBE frameworks by observing timely data availability and preferably be available for all the study countries for the reference year 2010 for the purposes of comparison (ABS, 2002; Afzal & Lawrey, 2012a, 2012b, 2012c, 2012d). This segregation of the variables under different knowledge dimensions

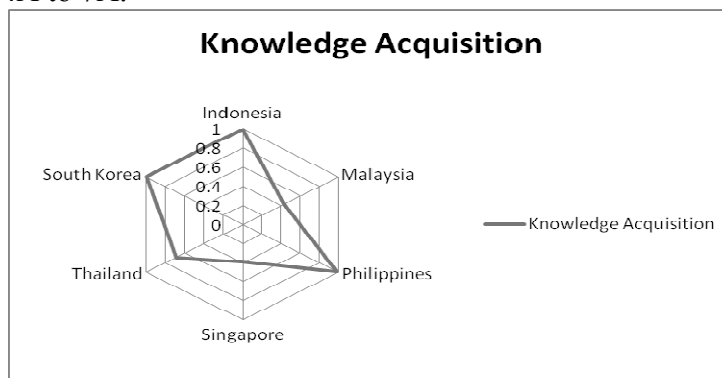


are missing in KAM. This study, however, applies the DEA approach by using the policy- focused KBE framework for ASEAN. Table 1 shows our policy focused KBE framework.

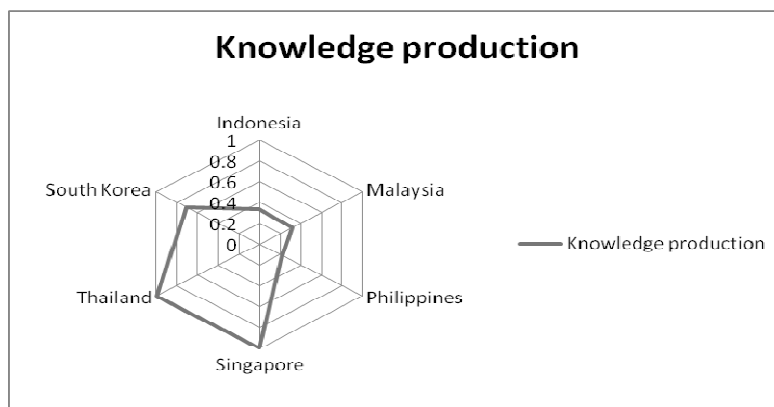
Table 1: Policy Focused KBE framework

Dimensions	Knowledge acquisition	Knowledge production	Knowledge distribution	Knowledge utilization
Input	1.Trade Openness=(Exports + imports)/GDP 2. FDI inward flows as % GDP	1. R & D expenditure as % GDP 2.Intelectual Property Rights (IPR)	1. Education expenditure as % GDP 2. Net enrolment ratio at secondary school	1. Knowledge Transfer rate (university to industry) 2.FDI inflows % of GDP
Output	Real GDP growth	Scientific & Technical publications per 1000 population	Computer users per 1000 population	High-tech export % of Total export

DEA analyses were carried out using DEAP (Data Envelopment Analysis Programme) and Efficiency Measurement System (EMS) software. Note that listed efficiencies should be viewed as relative to the best performing country. Based on the rule of thumb of DEA, the number of DMU should be greater than double of the sum of inputs and outputs. Therefore we add South Korea, a member of ASEAN plus three countries to make robust results for DEA analysis. The results will follow the sequence of our policy focused KBE framework. The following spider diagrams exhibit the knowledge economy performance of selected ASEAN economies and their benchmarks according to the DEA results in appendix 01: 4A to 7A.



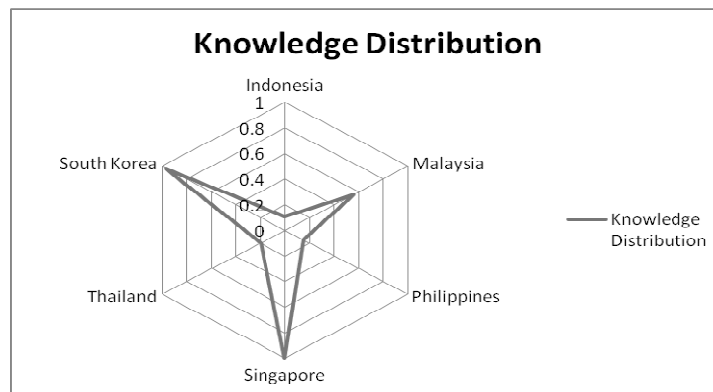
Best performing countries (efficiency score 100% or 1): Indonesia, South Korea
Benchmarks for the inefficient countries to emulate: Indonesia, South Korea



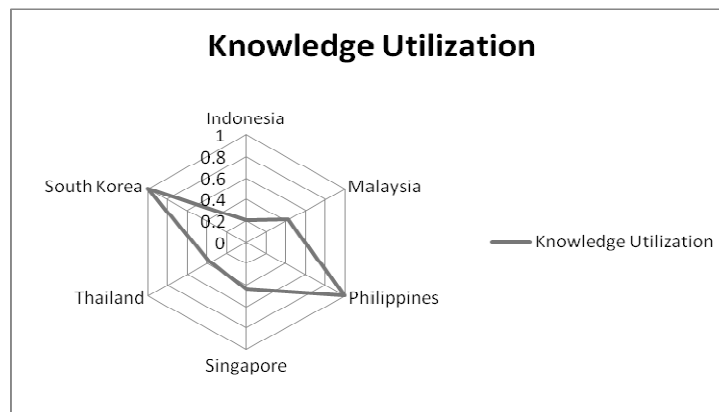
Best performing countries (efficiency score 100% or 1): Singapore, Thailand



Benchmarks for the inefficient countries to emulate: Singapore, Thailand



Best performing countries (efficiency score 100% or 1): Singapore
Benchmarks for the inefficient countries to emulate: Singapore



Best performing countries (efficiency score 100% or 1): Philippines, South Korea
Benchmarks for the inefficient countries to emulate: Philippines

The first and immediate result of the DEA calculations is an efficiency rating of each observation (here, country). A rating of 100% (or 1) in CCR model indicates that the country is located on the efficiency frontier. However, an efficiency rating less than 100% in CCR, model signals non-optimal behaviour. The first spider diagram shows the results of knowledge acquisition dimension where Indonesia and South Korea gets the highest efficiency score in 2010. It refers that these two countries are using their knowledge acquiring inputs- trade openness and FDI most efficiently than other members of ASEAN. However, from our analysis, it appears that other countries in this time period are showing inefficient use of their resources. This inefficiency for other member countries means that it would be possible for the inefficient countries to reduce or without altering the use of its inputs while still obtaining the same amounts or more of the outputs in knowledge acquisition dimension (Afzal &Lawrey, 2012c). Our results also give the information about Peer or MPSS / Benchmarks for countries considered inefficient in the analysis. Peers/Benchmarks are efficient countries with a performance score of 1 and all slacks zero. Since both Indonesia and South Korea are considered as most productive scale size, other inefficient countries in the sample can try to emulate them by attaining better values of element that would result in most productive scale size of 1 (Afzal &Lawrey, 2012c).

Second diagram shows the efficiency score of knowledge production dimension where Singapore and Thailand in 2010 are the best performer and also benchmark countries for others.



According to the third spider diagram, Singapore gets the optimum efficiency in the referred time period. That is, Singapore is the best performer in knowledge distribution dimension. Singapore put an example for other ASEAN as well as many developing countries by altering its geographical size and natural resource constraint by making the country as a manufacturing base, producing increasingly technology and knowledge-intensive goods and increase the use of ICT users in recent times (Yue and Lim, 2003). In 2010, their computer users are 827.48 per thousand populations which give them an upper hand over many Asian economies in ICT use and that eventually disseminate knowledge faster and contribute to build stronger knowledge base economy in the World (WDI-2010). Therefore our calculation exhibits Singapore as the most efficient and benchmark country in this dimension in 2010 among the ASEAN member states.

Finally, from the last diagram, our calculation shows the Philippines and South Korea score the 100% or 1 efficiency in knowledge utilization dimension. The interesting point is here, though both the countries get the same efficiency ranking, the Philippines consider as the benchmark countries for the inefficient members. It implies that from the DEA calculation, Philippines contained better weights or attributes than South Korea for the inefficient countries. Therefore other inefficient countries along with South Korea can take the Philippines as their benchmark countries while formulating future policy of optimization. This is a unique feature of DEA where it specifies which country can take as peer or benchmark country for others. We use FDI inflows as % GDP and knowledge transfer rate from university to industry (WCY-2011 executive survey based on an index from 0 to 10) as input variables and high-tech export as a % total manufacturing export as output variable for this dimension. If we explain in terms of recent experience, we find that, the Philippines' is the largest manufacturer of high-tech products as % total export in 2010. Mainly it exports semi conductor and electronic goods and its percentage of high-tech products as % of total manufacturing export was 65.65 followed by Singapore 50.01, Malaysia 48.11, Indonesia 13.13 and Thailand 27.12 in the same year (WDI-2010). This implies that the Philippines' is making optimum use of its FDI in flows in order to create new knowledge and ideas in the universities that eventually shift this knowledge to high-tech industrial growth. Theoretically, investing in knowledge intensive sector such as ICT, high-tech goods, bio-technology etc can increase the productive ability of the other factors of production as well as convert them into new products and processes which guide a country more efficient in KBE (Afzal and Lawrey, 2012c; Lee, 2001). Hence, we can say that the other inefficient countries can emulate the best performing country in order to achieve optimum efficiency in respective knowledge dimensions.

4. Conclusion and policy recommendations

The results of our analysis have interesting policy implications for improving KAM methodology. Our objective was to improve the existing KAM methodology by using DEA technique. Therefore, we investigate some insights in the KAM that it does not clearly highlight. For instance to improve the KBE definition given by KAM, we introduce a policy-focused framework in which first we segregate the KAM variables under input-output indicators and distribute them among four knowledge dimensions e.g. acquisition, production, distribution and utilization. We consider ASEAN five countries as sample of our study and subsequently we apply DEA technique to find the efficiency score of these countries in each knowledge dimension in 2010. The interesting finding from the DEA calculation is that, it gives us the exact benchmark countries for the inefficient economies to emulate by calculating the weights. In contrast, KAM suggests that, the inefficient countries should follow the best performing countries but in the case of similar ranking, it seems rather difficult to find which one to follow. KAM rank the countries based on raw data of the variables while DEA rank the best performing countries by calculating efficiency score using weights. In case of ASEAN countries, Indonesia in knowledge acquisition dimension, Singapore and Thailand in knowledge production, Singapore in knowledge distribution and the Philippines in knowledge utilization dimension are the best performing countries using DEA CCR assumptions in 2010. Our research also exhibits the benchmark countries in each knowledge dimension for ASEAN five. WBI KAM methodology can take this example and apply for



future research. We believe that our investigation will improve the KAM methodology and its policy suggestion regarding the growth of knowledge-based economy for the client countries.

References

- Afzal, M.N.I and Lawrey, R. (2012a). KBE frameworks and their applicability to a resource-based country: The case of Brunei Darussalam. *Asian Social Science*, 8(7), 208-218.
- Afzal, M.N.I and Lawrey, R. (2012b). Knowledge-based economy (KBE) frameworks and empirical investigation of KBE input-output indicators for ASEAN. *International Journal of Economics and Finance* 4(9).
- Afzal, M.N.I and Lawrey, R. (2012c). A measurement framework for knowledge-based economy (KBE) efficiency in ASEAN: A Data Envelopment (DEA) Window Approach. *International Journal of Business and Management*, 7(18), Forthcoming.
- Afzal, M.N.I and Lawrey, R. (2012d). Evaluating the comparative performance of technical and scale efficiencies in knowledge-based economies (KBEs) in ASEAN: A Data Envelopment Analysis (DEA) Application, *European Journal of Economics, Finance and Administrative Sciences* 51(8), forthcoming.
- Australia Bureau of Statistics (ABS). (2002). Measuring a knowledge-based economy and society – an Australian framework. Discussion paper (cat. No. 1375.0).
- Charnes, A., Cooper, W.W. and Rhodes, E. (1978). Measuring efficiency of decision making units. *European Journal of Operational Research*. 3, 429-44.
- Coelli, T. (1996). A guide to DEAP version 2.1: A data envelopment Analysis (computer) program. CEPA Working Paper 96/08.
- Cooper, W.W., Seiford, L.M. and Tone, K. (2000). *Data Envelopment Analysis: A Comprehensive text with Models, Application, References, and DEA software*, New York, NY: Springer.
- Derek, H., Chen, C. and Dahlman C. J. (2006). The knowledge economy, the KAM methodology and World Bank operations, working paper.
- Hsu, M., Luo, X. & Chao, G. (2005). The fog of OECD and non-OECD country efficiency: a data envelopment analysis approach”, In Johnston, T.C. (Ed.), *Proceedings of the Annual Meeting of the association of collegiate marketing educators*. March 1-5, 2005, Texas, 121-130.
- Lee, K. S. (2001). Economic development through knowledge creation- the case of Korea, *Proceedings of the 34th Hawaii International Conference on System Science*, 2001
- Norman, M. and Stoker, B. (1991). *Data Envelopment Analysis: The Assessment of Performance*, Chichester: John Wiley & Sons.
- Ramanathan, R. (2003). *An Introduction to Data Envelopment Analysis a Tool for Performance Measurement*, New Delhi: Sage Publications.
- Scheel, H. (2000). Efficiency Measurement System, Version 1.3 ([http:// www.wiso.uni-dortmund.de/lisfg/or/scheel/ems/](http://www.wiso.uni-dortmund.de/lisfg/or/scheel/ems/)) (Accessed 10th January, 2012)
- World Bank Institute (WBI). (1999). World development report 1998/99: knowledge for development, World Bank, Washington.
- World Bank Institute. (2002). *Programme on knowledge for development*. Knowledge Assessment Methodology and Scorecards.
- World Competitiveness Yearbook (WCY CD-ROM). (1995-2010). Switzerland: IMD
- World Development Indicators (WDI online). (1995-2010). Washington: World Bank
- Yue, C.S. and Lim, J.J. (2003). Singapore: A regional hub in ICT, Masuyama, S. and Vandenbrink, D. (Ed.), *Towards a Knowledge-based Economy: East Asia's Changing Industrial Geography*, ISEAS & NRI, Singapore & Tokyo, 259.