The Energy Efficiency and Public Health in the ASEAN Plus Three Cooperation

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Abstract
This study pays more attention to the energy consumption saving, environmental pollution, and health efficiency improvement. We employ the Slack-based measure of Dynamic network Data Envelopment Analysis (DEA) model (DNSBM) to assess the impact of forestry area on annual and overall energy and health efficiency in 2 intertemporal stages, and also put forward on direction and magnitude to be improved respect to the slack variables. For the empirical study, this study employs the 13 countries in the Association of Southeast Asian Nations Plus Three Cooperation (hereinafter referred to as APT) during 2011-2015. From the empirical evidence, it is not easy to raise gross domestic product while reducing energy consumption and PM2.5 emissions to improve energy efficiency. What makes people neglect is the impact of reduced forestry area on health efficiency. Optimistically, all economies are able to adopt measures from policy and technical perspectives, for instance, appropriately adjust energy-related policies, energetically develop innovative energy technologies, and preserve forestry areas, to create a harmonious atmosphere featuring economic development, environmental conservation, and national health and well-being.

Keywords
Association of Southeast Asian Nations, Paris Agreement, forestry area, energy efficiency, health efficiency, dynamic network SBM

What do we already know about this topic?
The energy consumption will result in the environmental pollution, and the latter maybe harm human health.

How does your research contribute to the field?
This study first introduces the link between the economic growth drive by energy consumption and human health drive by environmental pollution into the dynamic network Data Envelopment Analysis (DEA) model to investigate the efficiencies of energy and health.

What are your research’s implications toward theory, practice, or policy?
We formulate feasible policies on energy and health and put into place effectively, to enhance the overall efficiency.

Introduction
The economic development is attracting great attention globally, and accompanying issues are also brought into focus, such as emissions of greenhouse gas and damages to natural environment. Accordingly, all countries begin to attach great importance to reducing carbon and greenhouse gas emission and lowering global temperature from the signing of the Kyoto Protocol in 1997 to the Paris Agreement signed at the 21st UNFCCC Conference (COP21) in 2015. However, different from the Kyoto Protocol, the Paris Agreement listed Mainland China and India as countries with emission reduction obligations and supported by developed countries economically that should assist developing countries in controlling the emissions of greenhouse gas. According to findings from UNEP (United Nations Environment Programme) on Emissions Gap Report

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2018, it was believed that there was still possibility to control the global temperature rise within 2°C, but the feasibility assessment from many perspectives had showed decreasing chance to control the rise within 1.5°C. As a response, countries are energetically developing low-pollution alternative energy sources, hoping to replace oil, natural gas, and coal that significantly pollute the environment by wind, hydro, tidal power, and the establishment of nuclear power plants. However, in 2017, after a 3-year stabilization period, an increasing trend was observed in global total carbon dioxide emissions, and greenhouse gas concentrations also reached a new record. For example, the mole fraction of global average carbon dioxide was 405.5 ± 0.1 ppm, methane (CH4) at 1859 ± 2 ppb, and nitrous oxide (N2O) was at 329.9 ± 0.1 ppb, which were equivalent to 146%, 257%, and 122%, respectively, under industrial standards in 1750. The growth rate of carbon emissions reached the highest level from 2010 to 2011 due to global energy consumption. This went against goals set by Paris Agreement in 2015. Suppose that emissions of greenhouse gas are out of control by 2030, global warming may break through the threshold at 2°C.

In 2015, after the Kyoto Protocol, a consensus was reached among 195 countries in discussions that the Paris Agreement was passed by which the forest issue was clearly raised and valued. As early as in the COP3 Kyoto Protocol (1997), it proposed to include net carbon value of afforestation and reforestation into national reduction value. Therefore, in Kyoto Protocol, the concepts of afforestation, reforestation, and strengthening of forest management were listed in discussion. Today, it has been an important issue globally on how to reduce carbon emissions caused by deforestation and forest degradation. Moreover, according to Global Forest Resources Assessment by the Food and Agriculture Organization of the United Nations in 2015, the past 25 years (1990-2015) had witnessed that global forestry area was decreased by 3.1%, or about 130 million hectares. There is no doubt that the change is related to economic development of a country. For instance, in countries with high national income, there is a positive correlation between the higher income and forestry area, whereas in those with low income, forestry area was reduced gradually due to the lands development for economic growth. In fact, it shall be an essential issue on how to achieve balanced development between both. Therefore, in this article, the study mainly studied issues concerning economic development, energy usage efficiency, impact of undesired outputs, and the impact of forestry area’s change on national health.

However, out of demand for rapid economic growth, the developing countries face urgent issues concerning forestry area development and energy consumption. Here is an example of gross domestic product (GDP) growth rate of APT economies and the whole world. The average GDP growth rate of APT economies was 4.9252% in 5 years, a figure far exceeding 2.8060%, the average world’s GDP growth during the same period.

According to the arranged statistics on forestry area (Figure A1), during this period, the global forestry area decreased continuously, whereas that of APT economies was in a continuous increase as a whole. Apparently, the APT economies attach great importance to and well maintain the forestry area, but, in fact, it shows from statistical data that among the 13 member states (Figure A2), the forestry area of BRN and SGP remains fixed, and that is increased continuously in only 6 countries, such as CHN, LAO, MYS, PHL, THA, and VNM, whereas a decreasing trend is observed in IDN, JPN, KHM, KOR, and MMR. It signifies that only some countries lay emphasis on the maintenance of forestry area while ensuring economic development, and that KHM and KOR experience significant changes in forestry area reduction. After research, a conclusion could be drawn that the reduction of forestry area imposes a negative impact on health efficiency and overall efficiency of 2 countries.

According to relevant literature abroad, forest vegetation, covering the ground surface, plays the role of stabilizing water resources, temperature, climate and preventing soil erosion, and is also a necessary condition for breeding diverse species and maintaining human health. Becker et al from University of Illinois, the United States, took the United States as an example to explore the relationship between the area and type of green space with additional expenditures of U.S. medical insurance in 3086 towns from 2010 to 2014. According to them, the green space was divided into forest, shrub, grassland, agricultural land, and urban vegetation, which were later analyzed by generalized linear models. The research results indicated that there was no such an obvious relationship between medical expenditures with area of grassland, agricultural land, and urban vegetation. However, in places with forests and shrubs, a negative correlation is observed between their coverage and medical expenditures, or in other words, the higher the forest and shrub coverage, the lower the cost of additional health insurance required. Therefore, there is probably a relationship shared by area of forests and shrubs with the reduction of medical expenditures. While from this perspective, the article is different from the traditional ones that merely focused on economic development and energy efficiency, a fewer discussed health issues, and fewer explored the interrelation among economic development, energy efficiency, and health efficiency. Here, the study conducted the study from 2 stages of DN-SBM, filling the gap in traditional literature research. In addition, the research results can be provided to developing countries as a basis for formulating related policies concerning energy, national health, and the maintenance of forestry area.

Most scholars focused on economic development and energy efficiency and also studied relevant issues on environmental pollution and global warming caused by the release of greenhouse gases due to the use of fossil fuel energy and the impact on efficiency at production stage. Therefore, countries across the world devote themselves to finding alternative energy sources and improving production technologies, hoping to effectively enhance energy efficiency and reduce greenhouse gas. For instance, Lam and Shiu analyzed efficiency of China’s thermal power technologies; Zaim explored changes
in pollution intensity and environmental performance of manufacturing industries in the United States; and Hu and Wang investigated energy efficiency indexes in different regions of China. Ramanathan explored the relationship between world economic growth and energy consumption with carbon emissions. Hu and Kao discussed high energy-saving objectives of Asia-Pacific Economic Cooperation (APEC) economies. Chien and Hu studied the impact of renewable energies on Asia-Pacific economies. Moreover, Zhou and Ang researched energy efficiency in 21 OECD (Organisation for Economic Co-operation and Development) countries, and Christina and George explored the interrelation among economic growth, environmental pollution, and energy consumption with economic growth in 31 European countries. Zhang discussed the analysis of environmental efficiency in China’s manufacturing; Shi et al evaluated industrial efficiency in 28 provinces, autonomous regions, and cities in China; and Zhou et al researched carbon emission efficiency of 18 countries with the largest output of CO2. Yeh et al explored the comparison in energy efficiency between Taiwan and China. Sueyoshi and Goto summarized the relationship between energy and power with CO2 in the top 10 industrial nations globally, and Wang et al studied environmental assessments by industrial department in the United States. In addition, Dogan and Tugcu discussed energy efficiency of electricity production in G20 countries. Liu and Liu analyzed the low-carbon economic efficiency of top 20 countries with the largest carbon emissions.

Similarly, Sueyoshi and Goto evaluated the operation and environmental efficiency of the fossil fuel power generation industry in Japan. Song et al analyzed the relationship between energy efficiency and CO2 emissions with energy efficiency in BRICS. Lu et al discussed performance assessment of new energies, and Hu et al analyzed dynamic energy efficiency of high-income economies. In addition, Uusivuori et al analyzed studies on natural forest areas in 90 countries under the Food and Agriculture Organization by estimating a regression model based on FORIS database. Laden et al discussed the relationship between airborne particles and mortality through Cox proportional estimation and regression model. Zhou et al analyzed environmental performance of OECD countries by a non-oriented Data Envelopment Analysis (DEA) model; Romano and Scandurra applied dynamic regression analysis to study investment in renewable energies. Chiu et al by applying mixed element boundary DEA model, measured ratio of technology efficiency and technology gap in 4 regions; Zhao applied dynamic multinomial regression analysis to study whether productivity would be affected due to the regulation of carbon dioxide emissions. Nowak et al adopted BenMAP model to explore PM2.5 simulated by trees and related health efficiency in 10 cities in the United States. Aziz et al selected dynamic regression analysis to analyze factors affecting energy needs for developing countries. In addition, adopting dynamic regression analysis, Chaido and Melina explored the relationship between consumption and economic growth with carbon emissions in 3 southern European countries. Similarly, Azam et al by introducing Granger Causality, discussed causal relationship between energy consumption and economic growth in 5 countries of the Association of Southeast Asian Nations. Zou et al analyzed technology gap efficiency and spatial convergence of energies in different countries by applying DEA and Malmquist. Moreover, Chiu et al also selected the DEA Malmquist Index to analyze efficiency and poor productivity of G20 countries.

According to above literature, when analyzing energy and energy efficiency via DEA, researchers tend to view capital stock, labor, and energy usage as input variables, and GDP and CO2 as output variables. The dynamic network DEA can well investigate the sources of production efficiencies in each subdivision and consider the carryover over time. However, this method still fails to expand studies to the impact of energy usage efficiency on health efficiency. In this article, we adopted SBM dynamic network DEA model to assess the impact of forestry area on annual and overall energy and health efficiency of APT economies in 2 intertemporal stages. In first stage, the input variables are the labor, labor force, and final power consumption; output is GDP, and the undesirable output PM2.5 is viewed as link that connects medical expenditure as input, and mortality and average life as outputs in second stage. As a response to 2015 Paris Agreement’s focus on forest issues and the fact that forest cannot be restored by forestation in a short period of time, the study adopted forestry area as a carry-cover, which can objectively highlight the impact and importance of changes in forestry area on overall national efficiency.

**Materials and Methods**

Data Envelopment Analysis is a method usually used to measure the effectiveness of its decision-making unit (DMU), such as Chen et al and Chen. It was to evaluate efficiency of nonprofit institutions and public sectors, which does not limit the number of inputs and outputs. As a linear programming technique, it can be solved probably without parameters. In past researches, the efficiency of toolroom machine was measured by single-stage DEA method that could handle multiple inputs and outputs simultaneously, but only a single comprehensive efficiency value was obtained that was used to assess scale efficiency and pure technical efficiency of the machine. However, the production process tended to be ignored, so that it failed to further understand true efficiency at each stage. Therefore, the DN-DEA was applied here to explore energy and health efficiency.

Undoubtedly, the network DEA model improves some functions of traditional DEA in failing to analyze department performance. For instance, in case that a company operates in multiple periods, the dynamic DEA model can be applied to analyze department performance; when cases with both department data and multiple time points are analyzed, the analysis can be conducted by network DEA and dynamic DEA at the same time. Fare et al proposed network DEA. Tone and Tsutsui designed weighted SBM network DEA; and then in 2013, proposed the research on dynamic and network DEA and Malmquist Index. Subsequently,
researches related to network DEA were raised by Li et al., Liu and Lu, Tone and Tsutsui re-put forward-weighted SBM (weighted slack-based measures) dynamic network DEA model and analyzed network DEA model based on the linkage among DMUs. This model can evaluate (1) overall efficiency over the entire chosen period, (2) dynamic change of efficiency over the period, and (3) dynamic change of divisional efficiency. Figure 1 refers to analysis method for variables and schematic diagram.

There are DMUs \((j = 1, \ldots, n)\) consisting of \(K\) divisions \((k = 1, \ldots, K)\) at time periods \(T (t = 1, \ldots, T)\). Let \(rk\) be the numbers of inputs and outputs in division \(k\), respectively. The link leading from division \(k\) to division \(h\) is represented by \((k, h)\) and the set of links by \(L\). The overall efficiency is evaluated by

\[
\sum_{t=1}^{T} \sum_{k=1}^{K} W^k (1 - \frac{m_k + \text{linkin}_k + nbad_k}{\lambda_k})
\]

\[
0'^*_a = \min \left[ \frac{1}{r_k + \text{linkout}_k + ngood_k} \right] \right]
\]

\[
\sum_{t=1}^{T} \sum_{k=1}^{K} W' (1 + \frac{1}{r_k + \text{linkout}_k + ngood_k})
\]

\[
x'_k = X'_k \lambda'_k + s'_o \quad (\forall k, \forall t)
\]

\[
y'_k = Y'_k \lambda'_k - s'_o \quad (\forall k, \forall t)
\]

\[
\delta'_o = 1 \quad (\forall k, \forall t)
\]

\[
\lambda'_k \geq 0, s'_o \geq 0, s'_o \geq 0, (\forall k, \forall t)
\]

\[
Z'_{(kh)\text{in}} = Z''_{(kh)\text{in}} \lambda'_k + S'_{(kh)\text{in}} \quad (\text{linkin}_k)
\]

\[
Z'_{(kh)\text{out}} = Z''_{(kh)\text{out}} \lambda'_k - S'_{(kh)\text{out}} \quad (\forall k; \forall k; t = 1, \ldots, T - 1)
\]

\[
\sum_{t=1}^{T} Z'^{(l+1)}_{(kh)} \lambda'_k = \sum_{t=1}^{T} Z''_{(kh)} \lambda'_k + S'_{(kh)\text{in}} (\forall k; t = 1, \ldots, T - 1)
\]

\[
Z_{(kh)\text{in}} = \sum_{t=1}^{T} z_{(kh)\text{in}} \lambda'_k - s_{(kh)\text{in}} \quad (k_i = 1, \ldots, n\text{good}_k; \forall k; \forall t)
\]

\[
Z_{(kh)\text{out}} = \sum_{t=1}^{T} z_{(kh)\text{out}} \lambda'_k - s_{(kh)\text{out}} \quad (k_i = 1, \ldots, n\text{bad}_k; \forall k; \forall t)
\]

\[
s_{(kh)\text{good}} \geq 0, s_{(kh)\text{bad}} \geq 0, s_{(kh)\text{free}} \text{free} (\forall k; \forall t)
\]

The period and division efficiencies are shown as below:

**Period efficiency:** see Formula (2)

**Division efficiency:** see Formula (3)

The period efficiency of division is defined in Formula (4):

\[\sum_{t=1}^{T} W^k (1 - \frac{m_k + \text{linkin}_k + nbad_k}{\lambda_k}) + \sum_{i=1}^{n} S_{(kh)\text{in}} \lambda'_k - S_{(kh)\text{in}} \quad (k_i = 1, \ldots, n\text{good}_k; \forall k; \forall t)
\]

\[\sum_{t=1}^{T} W' (1 + \frac{1}{r_k + \text{linkout}_k + ngood_k}) + \sum_{i=1}^{n} S_{(kh)\text{out}} \lambda'_k - S_{(kh)\text{out}} \quad (k_i = 1, \ldots, n\text{bad}_k; \forall k; \forall t)
\]

\[\sum_{t=1}^{T} W' (1 + \frac{1}{r_k + \text{linkout}_k + ngood_k}) + \sum_{i=1}^{n} S_{(kh)\text{in}} \lambda'_k - S_{(kh)\text{in}} \quad (k_i = 1, \ldots, n\text{good}_k; \forall t)
\]
**Results**

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

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**Data and Variables**

This study, by adopting APT economies as a case, explored the impact of forestry area in ATP economies on energy and health efficiency, with study period lasting 5 years from 2011 to 2015. The data were mainly from the UN Data Retrieval System and open data of the World Bank. In first stage, it measured energy efficiency and viewed labor, capital formation, and final power consumption as input variables, current per capita price GDP as output variable, and undesirable output PM2.5 as intertemporal intermediate property (also as input in the second stage). The government provides health expenditures to reduce diseases caused by environmental pollution. Media reports can objectively present air pollution information, identify the causes of pollution in a timely manner, and identify protective measures so as to prevent or control the risk of physical injury and reduce the incidence of diseases. Followed by Li et al., in second stage, as for health efficiency measuring, it selected medical expenditures as input variable, mortality and average life as output variables, and forestry area in the DN-SBM model as intertemporal variable in carryover. In summary, we, viewing 13 countries of APT as research objects, described their input and output variables as follows. The research lasts for 5 years from 2011 to 2015, and Table 1 refers to the collection of descriptive statistical analysis tables. As shown in Table 2, as for the input of first stage, the mean labor of the APT countries has a stable and light growth from 2011 to 2015. Relative to the labor, the capital grows more quickly as well as the...
consumption of powers. The economic development GDP presents a decreasing trend in contract to the change of PM 2.5. In the second stage, as the expenditure of the health care increases, the average life presents an improvement; however, the death rate still increases.

**Empirical Results**

We set production process as variable returns to scale and adopted nonoriented DN-SBM model as analysis condition. This section mainly explores the impact of forestry area in ATP economies on energy and health efficiency, hoping to encourage the economies to attach great importance to forest policies through the empirical results. Moreover, it also expected to propose suggestions and directions of improvement for countries with poor energy and health efficiency.

**Table 1. The Statistic of Variables During 2011-2015.**

| Variable       | 2011     | 2012     | 2013     | 2014     | 2015     | Mean   | Ranking |
|----------------|----------|----------|----------|----------|----------|--------|---------|
| Stage 1        |          |          |          |          |          |        |         |
| Input          |          |          |          |          |          |        |         |
| Labor          | 163,499  | 164,586  | 165,683  | 166,797  | 167,903  |        |         |
| Capital formation | 463,030 | 503,677  | 527,906  | 556,059  | 551,364  |        |         |
| Power consumption | 500,978 | 527,252  | 564,490  | 582,895  | 598,422  |        |         |
| Output         |          |          |          |          |          |        |         |
| GDP per capita | 15,751   | 16,167   | 15,686   | 15,537   | 14,138   |        |         |
| PM2.5          | 24,681   | 25,160   | 26,015   | 26,230    | 26,123   |        |         |
| Stage 2        |          |          |          |          |          |        |         |
| Input          |          |          |          |          |          |        |         |
| Medical        | 4,523    | 4,644    | 4,714    | 4,897    | 5,030    |        |         |
| Outputs        |          |          |          |          |          |        |         |
| Death rate     | 6,787    | 6,930    | 7,073    | 7,198    | 7,342    |        |         |
| Average age    | 73,466   | 73,718   | 73,958   | 74,196   | 74,419   |        |         |
| Carryover      |          |          |          |          |          |        |         |
| Forest area    | 342,886  | 343,392  | 343,898  | 344,910  | 344,910  |        |         |

Note. Unit: Labor: person. Capital formation: Million US$. Power consumption: million KW/h. GDP: US$. PM2.5: micrograms per cubic meter. Medical expenditure: the percentage of GDP. Death rate: Crude (per 1000 people). Average age: Year. Forest area: sq. km. GDP = gross domestic product.

**Table 2. The Energy Efficiency in Production Stage During 2011-2015.**

| Decision-making unit | 2011 | 2012 | 2013 | 2014 | 2015 | Mean | Ranking |
|----------------------|------|------|------|------|------|------|---------|
| BRN                  | 1    | 1    | 1    | 1    | 1    | 1    |         |
| KHM                  | 1    | 1    | 1    | 1    | 1    | 1    |         |
| CHN                  | 0.9975 | 0.9976 | 1 | 1 | 0.9988 | 0.9988 | 5 |
| IDN                  | 0.0247 | 0.0244 | 0.0239 | 0.0233 | 0.0243 | 0.0241 | 10 |
| JPN                  | 0.2569 | 0.254 | 0.2163 | 0.2065 | 0.2312 | 0.233 | 7 |
| KOR                  | 0.1776 | 0.1724 | 0.1806 | 0.1831 | 0.2011 | 0.183 | 8 |
| LAO                  | 1    | 1    | 1    | 1    | 1    | 1    |         |
| MYS                  | 0.0402 | 0.0496 | 0.0529 | 0.0557 | 0.0569 | 0.0511 | 9 |
| MMR                  | 0.997 | 0.9973 | 0.9975 | 0.0158 | 0.0174 | 0.605 | 6 |
| PHL                  | 0.006 | 0.007 | 0.0078 | 0.0075 | 0.0119 | 0.008 | 12 |
| SGP                  | 0.9994 | 0.9995 | 1    | 1    | 0.9999 | 0.9998 | 4 |
| THA                  | 0.0157 | 0.0164 | 0.0181 | 0.0182 | 0.024 | 0.0185 | 11 |
| VN M                  | 0.0039 | 0.0045 | 0.0055 | 0.0054 | 0.0098 | 0.0058 | 13 |
| Mean                 | 0.5015 | 0.5017 | 0.5002 | 0.4243 | 0.4289 | 0.4713 | NA |
| Maximum              | 1    | 1    | 1    | 1    | 1    | 1    | NA |
| Minimum              | 0.0039 | 0.0045 | 0.0055 | 0.0054 | 0.0098 | 0.0058 | NA |

Note. NA = not applicable.

**Energy efficiency analysis in production stage.** In first stage (production stage), it assessed the impact of forestry area in ATP economies on energy and health efficiency from 2011 to 2015, wherein it measured energy efficiency of ATP economies, and viewed the labor, capital formation, final power consumption as input variables, current per capita GDP as output variable, and undesirable output PM2.5 as intertemporal intermediate property (also as the input in second stage). Table 2 describes analysis on performance score and ranking at this stage. The following data are collected in DEA, with average score (value) as geometric average.

From the results in the production stage, the average efficiency of APT countries has a light reduction from the 0.5015 in 2011 to 0.4713 in 2015. However, in these countries, we find that there is a significantly large difference between the
efficient and inefficient economies. Furthermore, there also exists an attention that efficient economies always have a high efficiency level and the inefficient economies also keep the low efficiency level. From the empirical evidence between 2011 and 2015, the production efficiency level for each economy almost presents a stable situation. Specially, BRN, KHM, and LAO performed the best in the 5 years, with efficiency values of all 1. CHN performed well in 2013 and 2014, with an efficiency value of 1, but it was above 0.99 in 2011 (0.9975), 2012 (0.9976), and 2015 (0.9988). In addition, its total average efficiency value in 5 years is 0.9988, indicating that it is able to control unstable factors in production inputs. The year 2011 saw the best performance of IDN with 0.0247, but it did the worst job in 2014, with the value only 0.0233. In addition, its total average efficiency value in 5 years is 0.0241, indicating no significant improvement in production inputs. JPA performed the best in 2011 with 0.2569, but the worst job was done in 2014, with the value only 0.2065. In addition, its total average efficiency value in 5 years is 0.233, indicating no significant improvement in production inputs. KOR performed the best in 2015, with an efficiency value of 0.2011, but the worst job was done in 2012, with the value only 0.1724. In addition, its total average efficiency value in 5 years is 0.183, indicating no significant improvement in production inputs. Similarly, MYS performed the best in 2015 with 0.0569, but performed worst in 2011, with the value only 0.0402. In addition, its total average efficiency value in 5 years is 0.0511, indicating no significant improvement in production inputs. By contrast, MMR reached efficiency value more than 0.99 for 3 consecutive years in 2011, 2012, and 2013, but had performed the worst since 2014, with the value reduced to 0.0158, and it was 0.0174 in 2015. In addition, its total average efficiency value in 5 years is 0.605, indicating that there were probably unstable factors in production inputs from 2014 to 2015. PHL performed the best in 2015, with an efficiency value of 0.0119, but the worst job was done in 2011, with the value only 0.006. In addition, its total average efficiency value in 5 years is 0.008, indicating no significant improvement in production inputs. Subsequently, SGP performed better in 2013 and 2014 with an efficiency value of 1, but it was above 0.99 in 2011 (0.9994), 2012 (0.9995), and 2015 (0.9999), respectively. In addition, its total average efficiency value in 5 years is 0.9988, indicating that it is able to control unstable factors in production inputs. Moreover, THA performed the best in 2015 with 0.024, but did the worst in 2011, with the value only 0.0157, and its total average efficiency value in 5 years is 0.0185, indicating no significant improvement in production inputs. Finally, VNM also performed the best in 2015, with an efficiency value of 0.0098, but did the worst in 2011, with the value only 0.0039. The total average efficiency value in 5 years is 0.0058, indicating no significant improvement in production inputs.

**Health efficiency analysis.** In second stage (health efficiency), it assessed the impacts of forestry area in ATP economies on energy and health efficiency from 2011 to 2015, wherein it measured health efficiency of ATP economies and viewed output PM2.5 in first stage as link to connect efficiency across departments in production stage. At this stage, inputs referred to medical expenses, outputs to mortality and average life, and finally, the forestry area was used as the transannual carryover. Table 3 describes analysis on performance score and ranking at this stage.

### Table 3. Health Efficiency for the APT Economies During 2011-2015.

| Decision-making unit | 2011 | 2012 | 2013 | 2014 | 2015 | Mean | Ranking |
|----------------------|------|------|------|------|------|------|---------|
| BRN                  | 1    | 1    | 1    | 1    | 1    | 1    | 1       |
| KHM                  | 0.109| 0.113| 0.1202| 0.1359| 0.1469| 0.125| 13      |
| CHN                  | 0.9999| 0.9999| 0.6842| 0.6868| 0.7241| 0.6887| 7       |
| IDN                  | 0.6717| 0.6765| 0.8459| 0.8201| 0.9118| 0.8976| 4       |
| JPN                  | 0.9619| 0.9482| 0.2234| 0.2369| 0.2531| 0.2265| 12      |
| KOR                  | 0.2092| 0.2098| 0.6953| 1    | 1    | 0.8339| 5       |
| LAO                  | 0.7173| 0.7567| 0.428 | 0.4237| 0.4987| 0.4271| 8       |
| MYS                  | 0.4025| 0.3824| 0.428 | 0.4237| 0.4987| 0.4271| 8       |
| MMR                  | 0.3036| 0.2954| 0.3375| 0.3777| 0.4488| 0.3526| 10      |
| PHL                  | 0.9995| 0.9995| 0.442 | 0.4267| 0.516 | 0.423 | 9       |
| SGP                  | 0.3489| 0.3815| 0.6183| 0.6011| 0.6408| 0.6176| NA      |
| THA                  | 0.2502| 0.2248| 0.3012| 0.3718| 0.2819| 11    |         |
| VNM                  | 0.6134| 0.6144| 0.6183| 0.6011| 0.6408| 0.6176| NA      |
| Mean                 | 0.109| 0.113| 0.1202| 0.1359| 0.1469| 0.125| NA      |
| Maximum              | 1    | 1    | 1    | 1    | 1    | 1    | NA      |
| Minimum              | 0.109| 0.113| 0.1202| 0.1359| 0.1469| 0.125| NA      |

**Note.** NA = not applicable.
average efficiency value in 5 years is 0.125, indicating that health efficiency should be improved. As for CHN, it performed better in 2013 and 2014, with an efficiency value of 1, but the value was 0.9999, respectively, in 2011, 2012, and 2015. In addition, its total average efficiency value in 5 years is 0.9999, indicating the sound health efficiency. IDN maintained between 0.6717 and 0.7241 from 2011 to 2015, and the total average efficiency value in 5 years is 0.6887, indicating mediocre health efficiency. JPN maintained between 0.8201 and 0.9619 from 2011 and 2015, and the total average efficiency value in 5 years is 0.8976, indicating acceptable health efficiency. As for KOR, its efficiency values were maintained between 0.2092 and 0.2531 from 2011 to 2015, and the total average efficiency value in 5 years is 0.2265, indicating that health efficiency should be improved. LAO maintained between 0.6953 and 0.7567 from 2011 to 2013, but the value was 1 from 2014 to 2015. In addition, its total average efficiency value in 5 years is 0.8339, indicating significant improvements in health efficiency. Well, in terms of MYS, its efficiency values hovered between 0.3824 and 0.4987 from 2011 to 2015, and the total average efficiency value in 5 years is 0.6887, indicating mediocre health efficiency. As for VNM, the efficiency value was maintained between 0.3489 and 0.516 in THA from 2011 to 2015, and the total average efficiency value in 5 years is 0.423, indicating mediocre health efficiency. Finally, as for MMR, the efficiency value was maintained between 0.2248 and 0.3718 from 2011 to 2015, and the total average efficiency value in 5 years is 0.2819, indicating that health efficiency should be improved.

**Overall stage efficiency.** Table 4 describes analysis on performance score and ranking overall stages. BRN did an excellent job in energy efficiency and health efficiency in the 5 years, with efficiency values of all 1. KHM maintained its efficiency value between 0.2829 and 0.3073 from 2011 to 2015, and the total average efficiency value in 5 years was 0.2928, indicating mediocre efficiency as a whole. As for CHN, it performed better in 2013 and 2014, with efficiency values of all 1, but it was maintained between 0.9987 and 0.9994 in 2011, 2012, and 2015. In addition, its total average efficiency value in 5 years was 0.9998, indicating fairly good health efficiency. The efficiency value was maintained between 0.3489 and 0.516 in THA from 2011 to 2015, and the total average efficiency value in 5 years is 0.423, indicating mediocre health efficiency. Finally, as for VNM, the efficiency value was maintained between 0.2248 and 0.3718 from 2011 to 2015, and the total average efficiency value in 5 years is 0.2819, indicating that health efficiency should be improved.

### Table 4. The Results of the Overall Efficiency for the APT Economies During 2011-2015.

| Decision-making unit | 2011(1) | 2012(1) | 2013(1) | 2014(1) | 2015(1) | Mean | Ranking |
|----------------------|---------|---------|---------|---------|---------|------|---------|
| BRN                  | 1       | 1       | 1       | 1       | 1       | 1    | 1       |
| KHM                  | 0.2829  | 0.2843  | 0.2895  | 0.2992  | 0.3073  | 0.2928 | 6       |
| CHN                  | 0.9987  | 0.9988  | 1       | 1       | 0.9994  | 0.9994 | 3       |
| IDN                  | 0.0746  | 0.0736  | 0.0721  | 0.0699  | 0.0768  | 0.0733 | 10      |
| JPN                  | 0.5008  | 0.4974  | 0.4556  | 0.4423  | 0.474   | 0.4728 | 5       |
| KOR                  | 0.1506  | 0.1508  | 0.1628  | 0.1712  | 0.1893  | 0.1649 | 7       |
| LAO                  | 0.8218  | 0.8461  | 0.8186  | 1       | 1       | 0.8935 | 4       |
| MYS                  | 0.103   | 0.1064  | 0.1208  | 0.1225  | 0.142   | 0.1181 | 8       |
| MMR                  | 0.9985  | 0.9987  | 0.9987  | 0.0278  | 0.0324  | 0.1097 | 9       |
| PHL                  | 0.0171  | 0.0179  | 0.0228  | 0.0266  | 0.0413  | 0.0237 | 12      |
| SGP                  | 0.9993  | 0.9994  | 1       | 1       | 0.9998  | 0.9996 | 2       |
| THA                  | 0.0463  | 0.0532  | 0.067   | 0.0642  | 0.0916  | 0.0626 | 11      |
| VNM                  | 0.0079  | 0.0076  | 0.0107  | 0.0133  | 0.0243  | 0.0117 | 13      |
| Mean                 | 0.4617  | 0.4642  | 0.463   | 0.4028  | 0.4137  | 0.4017 | NA      |
| Maximum              | 1       | 1       | 1       | 1       | 1       | 1     | NA      |
| Minimum              | 0.0079  | 0.0076  | 0.0107  | 0.0133  | 0.0243  | 0.0117 | NA      |
years is 0.8935, indicating significant improvements in overall efficiency. Well, in terms of MYS, its efficiency value hovered between 0.103 and 0.142 from 2011 to 2015, and the total average efficiency value in 5 years is 0.1181, indicating mediocre efficiency as a whole. In MMR, the value was maintained between 0.9985 and 0.9987 from 2011 to 2013, but from 2014 to 2015, the value fell sharply to between 0.0278 and 0.0324. In addition, its total average efficiency value in 5 years is 0.1097, indicating possible unstable factors in overall efficiency from 2014 to 2015. Moreover, PHL maintained between 0.0171 and 0.0413 from 2011 to 2015, and the total average efficiency value in 5 years is 0.0197, indicating possible unstable factors in overall efficiency from 2014 to 2015. Moreover, PHL maintained between 0.0171 and 0.0413 from 2011 to 2015, and the total average efficiency value in 5 years is 0.0234, indicating that overall efficiency should be improved. In SGP, the values were all 1 from 2013 to 2014, but it was maintained between 0.9993 and 0.9998 in 2011, 2012, and 2015. In addition, its total average efficiency value in 5 years is 0.9996, indicating fairly good overall efficiency. The efficiency value was maintained between 0.0463 and 0.0916 in THA from 2011 to 2015, and the total average efficiency value in 5 years is 0.0626, indicating that overall efficiency should be improved. Finally, as for VNM, the efficiency value was maintained between 0.0076 and 0.0243 from 2011 to 2015, and the total average efficiency value in 5 years was 0.0117, indicating that overall efficiency should be improved.

### Analysis on Adjustment Range of Link

In traditional DEA model, each activity should be clearly classified as an input or output because intermediate property cannot be included in the assessment. However, unlike DEA model, the network DEA model, instead of converting production within organizations into a [black box], interacts with departments via connecting subproduction activities. When the model is used, it is able to completely analyze the impact of cross-departmental links during overall efficiency evaluation and encourage units assessed to make improvements through adjustment range of the link, to achieve efficient reference. Here, the link is PM2.5. There was predicted adjustment range for efficiency boundary from 2011 to 2015, as shown in Table 5.

From the empirical evidence, it can be found that the adjustment rate of the link (PM 2.5) on average changes from 2011 with −20.1877% to 2015 with −25.5846%. The mainly adjustment economies are the PHL, THA, MYS, and VNM. A lot of economies have a perfect adjustment rate, such as BRN, KHM, CHN, IDN, JPN, and LAO. It can be concluded that these economies have controlled their PM 2.5 amount. However, for MMR, there is a perfect adjustment rate with 0% from 2011 to 2013, but at 2014, it presents an 83.31% reduction of PM 2.5.

### Analysis on Adjustment Range of Inputs for the APT Economies in Production Stage

The research period is from 2011 to 2015. The study analyzed results via dynamic network DEA model and selected 3 inputs, namely, labor, capital formation, and final power consumption. Tables 6 to 8 refer to summarized original values of inputs, predicted value of efficiency boundary, and adjustment range from 2011 to 2015. It proposes recommendations for APT economies to make improvements and is of reference value and significance.

According to Table 6, in terms of labor, the average of original value is 163 499 162, predicted value is 109 165

### Table 5. The Adjustment Rate of APT Economies During 2011-2015.

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 |
|---------|------|------|------|------|------|
| BRN     | 0    | 0    | 0    | 0    | 0    |
| KHM     | 0    | 0    | 0    | 0    | 0    |
| CHN     | −0.01| −0.01| 0    | 0    | 0    |
| IDN     | 0    | 0    | 0    | 0    | 0    |
| JPN     | 0    | 0    | 0    | 0    | 0    |
| KOR     | −7.24| −10.76| −10.75| −17.05| −2.65|
| LAO     | 0    | 0    | 0    | 0    | 0    |
| MYS     | −46.21| −46.76| −47.49| −48.74| −49.13|
| MMR     | 0    | 0    | 0    | 83.31| −79.1|
| PHL     | −70.54| −70.17| −70.92| −72.54| −68.82|
| SGP     | −0.05| −0.04| 0    | 0    | −0.01|
| THA     | −66.27| −67.57| −68.76| −71.2| −64.81|
| VNM     | −72.12| −72.23| −71.7| −73.02| −68.08|
| Mean    | −20.1877| −20.58| −20.74| −28.1431| −25.5846|
| Maximum | 0    | 0    | 0    | 0    | 0    |
| Minimum | −72.12| −72.23| −71.7| −83.31| −79.1|

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**Analysis on Adjustment Range of Inputs and Outputs**

**Analysis on Adjustment Range of Link**

In traditional DEA model, each activity should be clearly classified as an input or output because intermediate property cannot

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**Table 5. The Adjustment Rate of APT Economies During 2011-2015.**

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 |
|---------|------|------|------|------|------|
| BRN     | 0    | 0    | 0    | 0    | 0    |
| KHM     | 0    | 0    | 0    | 0    | 0    |
| CHN     | −0.01| −0.01| 0    | 0    | 0    |
| IDN     | 0    | 0    | 0    | 0    | 0    |
| JPN     | 0    | 0    | 0    | 0    | 0    |
| KOR     | −7.24| −10.76| −10.75| −17.05| −2.65|
| LAO     | 0    | 0    | 0    | 0    | 0    |
| MYS     | −46.21| −46.76| −47.49| −48.74| −49.13|
| MMR     | 0    | 0    | 0    | 83.31| −79.1|
| PHL     | −70.54| −70.17| −70.92| −72.54| −68.82|
| SGP     | −0.05| −0.04| 0    | 0    | −0.01|
| THA     | −66.27| −67.57| −68.76| −71.2| −64.81|
| VNM     | −72.12| −72.23| −71.7| −73.02| −68.08|
| Mean    | −20.1877| −20.58| −20.74| −28.1431| −25.5846|
| Maximum | 0    | 0    | 0    | 0    | 0    |
| Minimum | −72.12| −72.23| −71.7| −83.31| −79.1|
and the adjustment range is $-51.67\%$. Among them, the adjustment range of CHN is $-0.02\%$, signifying a tiny room for improvement, and that of IDN and JPN is $-98.43\%$ and $-97.94\%$, respectively, signifying a large room for improvement. Moreover, it is $-82.93\%$, $-83.17\%$, and $-96.31\%$ for KOR, MYS, and PHL, respectively, signifying a large room for improvement too. Subsequently, it is $-0.07\%$ for SGP, signifying a tiny room for improvement, and that of THA and VNM is $-98.51\%$ and $-98.48\%$, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and MMR are all 0%, so no improvement is required.

According to Table 7, in terms of capital formation, the average of original value is US$463 029 861 037.34, predicted value is US$300 118 546 056.40, and the adjustment range is $-47.37\%$. Among them, the adjustment range of CHN is $-0.02\%$, signifying a tiny room for improvement, and that of IDN and JPN is $-81.17\%$ and $-97.24\%$, respectively, signifying a large room for improvement. Moreover, it is $-83.17\%$, $-92.06\%$, and $-88.98\%$ for KOR, MYS, and PHL, respectively, signifying a large room for improvement too. Subsequently, it is $-0.07\%$ for SGP, signifying a tiny room for improvement, and that of THA and VNM is $-86.14\%$ and $-86.97\%$, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and MMR are all 0%, so no improvement is required.

According to Table 6, the adjustment range of CHN is $-0.02\%$, signifying a tiny room for improvement, and that of IDN and JPN is $-98.43\%$ and $-97.94\%$, respectively, signifying a large room for improvement. Moreover, it is $-82.93\%$, $-83.17\%$, and $-96.31\%$ for KOR, MYS, and PHL, respectively, signifying a large room for improvement too. Subsequently, it is $-0.07\%$ for SGP, signifying a tiny room for improvement, and that of THA and VNM is $-98.51\%$ and $-98.48\%$, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and MMR are all 0%, so no improvement is required.

According to Table 8, in terms of final power consumption, the average of original value is 500.97828 billion kilowatt hours, predicted value is 346.43374 billion kilowatt hours, and the adjustment range is $-50.08\%$. Among them, the adjustment range of CHN is $-0.02\%$, implying a tiny room for improvement, and that of IDN and JPN is $-80.46\%$ and $-97.69\%$, respectively, signifying a large room for improvement. Moreover, it is $-91.80\%$, $-96.44\%$, and $-94.08\%$ for KOR, MYS, and PHL, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and MMR are all 0%, so no improvement is required.
improvement too. Subsequently, it is −0.07% for SGP, signifying a tiny room for improvement, and that of THA and VNA is −94.31% and −96.20%, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and MMR are all 0%, so no improvement is required.

**Analysis on Adjustment Range of Outputs for APT Economies in Production Stage**

The research period is from 2011 to 2015, and the study analyzed results via the dynamic network DEA model and viewed current per capita GDP (US$) as output. Table 9 refers to a summary from 2011 to 2015, which is expected to encourage APT economies to make improvements and achieve efficient reference.

According to Table 10, in terms of per capita GDP, the average of original value is US$15 751.2, predicted value is US$33 907.8, and the adjustment range is 559.663%. Among them, the adjustment range of CHN is 0.24%, signifying a tiny room for improvement, that of IDN is 1319.2%, signifying a large room for improvement, and that of JPN is 4.27%, signifying a small room for improvement. Moreover, it is 89.84% and 328.88% for KOR and MYS, respectively, signifying a large room for improvement too, but that of MMR is 0.3%, signifying a tiny room for improvement. Subsequently, the adjustment range of PHL, THA, and VN is 1862.89%, 770.91%, and 2899.09%, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, KHM, LAO, and SGP are all 0%, so no improvement is required.

### Table 8. The Adjustment of Power Consumption in APT Economies During 2011-2015.

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 | Mean |
|---------|------|------|------|------|------|------|
| BRN     | 0    | 0    | 0    | 0    | 0    | 0    |
| KHM     | 0    | 0    | 0    | 0    | 0    | 0    |
| CHN     | −0.02 | −0.02 | 0   | 0    | −0.01 | −0.01 |
| IDN     | −80.46 | −81.48 | −82.82 | −82.65 | −88.36 | −83.154 |
| JPN     | −97.69 | −97.54 | −97.53 | −97   | −97.94 | −97.54 |
| KOR     | −91.8 | −91.74 | −91.65 | −91.51 | −91.23 | −91.586 |
| LAO     | 0    | 0    | 0    | 0    | 0    | 0    |
| MYS     | −96.44 | −90.72 | −90.77 | −90.56 | −92.67 | −92.232 |
| MMR     | 0    | 0    | 0    | −4.03 | −15.45 | −3.896 |
| PHL     | −94.08 | −94.12 | −94.08 | −94.02 | −92.08 | −93.676 |
| SGP     | −0.07 | −0.06 | 0    | 0    | −0.01 | −0.028 |
| THA     | −94.31 | −94.46 | −94.48 | −94.22 | −95.52 | −94.598 |
| VNM     | −96.2 | −96.45 | −96.56 | −96.84 | −94.14 | −96.038 |
| Mean    | −50.08 | −49.74 | −49.84 | −50.06 | −51.34 | −50.212 |

### Table 9. The Improvement of the Health Output for APT During 2011-2015.

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 | Mean |
|---------|------|------|------|------|------|------|
| BRN     | 0    | 0    | 0    | 0    | 0    | 0    |
| KHM     | −4.6 | 8.42 | 0    | 8.59 | 0    | 6.2  |
| CHN     | −0.01 | 0   | −0.01 | 0   | 0    | 0    |
| IDN     | 0    | 0    | 0    | 0    | 0    | 0    |
| JPN     | −0.15 | 0   | −0.15 | 0   | −0.15 | 0   |
| KOR     | −4.54 | 0   | −6.9  | 0   | −5.1  | 0   |
| LAO     | −52.59 | 8.79 | −47.63 | 8.83 | −42.89 | 8.28 |
| MYS     | −80.8 | 0.41 | −75.28 | 0.23 | −70.95 | 0.09 |
| MMR     | 0    | 0    | 0    | 0    | 0    | 0    |
| PHL     | −38.71 | 11.09 | −38.52 | 10.96 | −38.16 | 10.85 |
| SGP     | 0.03 | 0    | −0.02 | 0    | 0    | 0    |
| THA     | −58.8 | 1.42 | −58.54 | 1.15 | −58.61 | 0.95 |
| VNM     | −25.15 | 0.15 | −24.31 | 0    | −23.8  | 0   |
| Mean    | −20.4138 | 2.3292 | −19.6862 | 2.2892 | −18.4354 | 2.0285 |

### Table 10. The Improvement of the Health Output for APT During 2011-2015.

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 | Mean |
|---------|------|------|------|------|------|------|
| BRN     | 0    | 0    | 0    | 0    | 0    | 0    |
| KHM     | −4.6 | 8.42 | 0    | 8.59 | 0    | 6.2  |
| CHN     | −0.01 | 0   | −0.01 | 0   | 0    | 0    |
| IDN     | 0    | 0    | 0    | 0    | 0    | 0    |
| JPN     | −0.15 | 0   | −0.15 | 0   | −0.15 | 0   |
| KOR     | −4.54 | 0   | −6.9  | 0   | −5.1  | 0   |
| LAO     | −52.59 | 8.79 | −47.63 | 8.83 | −42.89 | 8.28 |
| MYS     | −80.8 | 0.41 | −75.28 | 0.23 | −70.95 | 0.09 |
| MMR     | 0    | 0    | 0    | 0    | 0    | 0    |
| PHL     | −38.71 | 11.09 | −38.52 | 10.96 | −38.16 | 10.85 |
| SGP     | 0.03 | 0    | −0.02 | 0    | 0    | 0    |
| THA     | −58.8 | 1.42 | −58.54 | 1.15 | −58.61 | 0.95 |
| VNM     | −25.15 | 0.15 | −24.31 | 0    | −23.8  | 0   |
| Mean    | −20.4138 | 2.3292 | −19.6862 | 2.2892 | −18.4354 | 2.0285 |
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The research period is from 2011 to 2015, and the study analyzed results via the dynamic network DEA model and viewed current medical expenditure (percentage of GDP) as input. Table 11 refers to a summary from 2011 to 2015. In terms of current medical expenditure, the average of original value is 4.523, predicted value is 3.2386, and the adjustment range is −24.644. Among them, the adjustment range of KHM is −55.57%, signifying a large room for improvement, and that of JPN is −0.06%, signifying a tiny room for improvement. Moreover, it is −50.38%, −36.11%, and −52.71% for KOR, MYS, and PHL, respectively, signifying a large room for improvement too, but that of LAO is −17.42%, signifying a small room for improvement. Subsequently, it is −0.04% SGP, signifying a tiny room for improvement, and that of THA and VNA is −44.48% and −63.6%, respectively, signifying a large room for improvement. However, the adjustment ranges of BRN, CHN, IDN, and MMR are all 0%, so no improvement is required.

**Analysis on Adjustment Range of Outputs for APT Economies in Health Efficiency Stage**

The research period is from 2011 to 2015, and the study analyzed results via the dynamic network DEA model and viewed mortality and average life as outputs. Table 9 refers to a summary of adjustment range of outputs from 2011 to 2015. In terms of current mortality, the adjustment range is −14.2685. Among them, it is −0.15% in JPN, signifying a tiny room for improvement; −2.05% in KOR, signifying a small room for improvement; and −68.89% in MYS, signifying a large room for improvement. Moreover, it is −2.12% in MMR, signifying a small room for improvement, and -38.07% in PHL, −59.93% in THA, and −23.48%

| Economy | 2011 | 2012 | 2013 | 2014 | 2015 | Mean |
|---------|------|------|------|------|------|------|
| BRN | 0 | 0 | 0 | 0 | 0 | 0 |
| KHM | −55.57 | −53.35 | −49.98 | −42.43 | −37.17 | −47.7 |
| CHN | 0 | 0 | 0 | 0 | 0 | 0 |
| IDN | 0 | 0 | 0 | 0 | 0 | 0 |
| JPN | −0.06 | −0.05 | −0.05 | −0.06 | −0.05 | −0.054 |
| KOR | −50.38 | −48.9 | −44.75 | −40.75 | −35.41 | −44.038 |
| LAO | −17.42 | −14.12 | −22.31 | 0 | 0 | −10.77 |
| MYS | −36.11 | −38.9 | −34.07 | −36.46 | −30.01 | −35.1 |
| MMR | 0 | 0 | 0 | −47.26 | −42.25 | −17.902 |
| PHL | −52.71 | −54.74 | −50.11 | −45.75 | −39.19 | −48.5 |
| SGP | −0.04 | −0.05 | 0 | 0 | −0.02 | −0.022 |
| THA | −44.48 | −39.85 | −32.25 | −35.61 | −27.06 | −35.85 |
| VNM | −63.6 | −67.72 | −63.61 | −59.09 | −51.27 | −61.058 |
| Mean | −24.644 | −24.437 | −22.8562 | −23.6469 | −20.187 | −23.154 |
in VNA, respectively, all signifying a large room for improvement. However, the adjustment ranges of BRN, CHN, IDN, LAO, and SGP are all 0%, so no improvement is required.

In terms of current mortality, the adjustment range is 2.5069. Among them, it is 8.89% in KHM, 8.83% in LAO, 12.11% in MMR, and 10.79% in PHL, all signifying a small room for improvement. As for THA, it is 0.8%, signifying a tiny room for improvement. However, the adjustment ranges of BRN, CHN, IDN, JPN, KOR, LAO, MYS, SGP, and VNM are all 0%, so no improvement is required.

**Policy Significance**

1. The forest issue was explicitly raised and emphasized in the *Paris Agreement* in 2015. As a response to the forestry area issue hereunder, the study listed forestry area as an intertemporal variable, to explore the impact of changes in forestry area on economic efficiency as a whole. According to empirical analysis, it is true the overall efficiency will be changed due to dramatic fluctuation in the forestry area.

2. Among copious literature, where the traditional DEA was adopted to assess efficiency, most of them only discussed energy efficiency and failed to expand to health efficiency field and even make assessment and recommendations. Therefore, it is necessary to objectively understand the specific conditions of people of all countries through a thorough exploration. For example, KHM, when purely evaluating its energy efficiency, the study found the efficiency value was 1, showing a good performance. But in terms of health efficiency, the value was only 0.125, ranking 13th in the APT economies, and the forestry area experienced dramatic changes in the study, which made overall efficiency fall to the sixth place.

3. According to the *Paris Agreement*, a long-term goal is to control the rise in global temperature to a maximum of 2°C (compared with the industrial era before 1750), and signatory countries should strive to achieve the goal of controlling the raise to 1.5°C. However, after evaluation, it was found difficult to achieve this goal in a short time. Therefore, countries were called on to emphasize researches and development of energy efficiency and alternative energy sources, control the growth of GDP effectively, and evaluate whether eco-environment and living space of mankind were affected by wastes due to overproduction. In particular, developing countries should attach great importance to the role of energy efficiency, health efficiency, and forest conservation.

4. Among APT economies, only JPN, KOR, and SGP are developed countries. Except for SGP, the energy efficiency of the other 2 countries is all lower than the average value 0.4713 in 5 years among the economies, and health efficiency of KOR is lower than the 5-year average 0.6176. Frankly, in case that developed countries fail to effectively control energy usage, ensure national health or maintain forestry area; obviously, it would be more difficult for developing countries to achieve that goal by *Paris Agreement*. Therefore, there are still jobs to be done by countries to maintain energies, universal health and well-being, and forestry area.

**Conclusions and Proposals**

**Conclusions**

In this article, the study mainly adopted DN-SBM model to explore the impact of forestry area in APT economies on energy and health efficiency, and measure energy, health, and overall efficiency of the countries. The research period is from 2011 to 2015. The empirical results are summarized as follows:

1. Among APT economies, from 2011 to 2015, there were 3 countries performing the best in average overall efficiency—BRN (1), SGP (0.9996), CHN (0.9994). Another 3 countries with the worst job were THA (0.0626), PHL (0.0237), and VNM (0.0117). According to empirical analysis, it was found that in 3 countries with the best overall efficiency, the adjustment range in forestry area in 5 years was 0. While as for the worst 3 countries, it was a must to enlarge forestry area and make corresponding adjustments. In summary, it has been an essential factor to assess the overall efficiency of a country by changes in forestry area.

2. When measuring overall efficiency of a country, one should take into account the energy efficiency and economic development, and besides, attach great importance to the health and well-being of people and the protection of natural environment. Here is the example of energy efficiency of APT economies from 2011 to 2015: 3 member states performed the best in average energy efficiency, namely, BRN, KHM, and LAO, with energy efficiency values of all 1. However, as for KHM, the average value was 0.125 in its health efficiency stage, ranking 13th, which made its overall efficiency fall to the sixth place in 5 years. Anyway, the results are different from those of previous scholars who merely explored efficiency measurement from production or health perspectives and show more objective efficiency measured at dynamic 2 stages.
3. The carryover or average maximum adjustment value of the forestry area in 5 years is KHM (950.01%) and KOR (387.71%), which means 2 countries should enlarge afforestation dramatically and reduce reclamation. Similarly, 2 countries rank 13th and 12th, respectively, in terms of health efficiency among the 13 member countries. Therefore, this study highlights the focus of Paris Agreement on forest issues in 2015 and also calls on countries to pay more attention to health and well-being of the people and conservation of forestry areas while developing economy. Moreover, they should formulate feasible policies on energy and health and put into place effectively, to enhance the overall efficiency.

Limitations and Recommendations

1. The public quantifiable data to study APT economies were from the World Bank and the UNdata, which were public and objective to analyze energy and health efficiency. With respect to input and output items, and related variables, some data were obtained after hard work and might be incomplete, which limited the selection of variables and observation period. Therefore, it is suggested that in the future, scholars can select other databases and related statistical data as variables, so as to make input and output items more specific and extensive, perfecting researches as a whole.

2. The DN-SBM here refers to a linear programming research method, which is different from the traditional regression research method, so scholars may adopt other research methods for evaluation. Furthermore, the research period of the article is from 2011 to 2015, but future researchers may extend it, to obtain more complete and sound empirical analysis.

3. The study mainly explores the impact of forestry area in APT economies on energy and health efficiency. It is suggested that in the future, the research objects may be expanded to include members of international organizations, namely, OECD and APEC for longer cross-regional comparisons with each other. This helps know about great efforts made by countries on energy and health efficiency and provide objective improvements on analysis and significance.

Appendix

Figure A1. The change of forestry area between the APT and the world, during 2011-2015. Source: World Bank.
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