Research of the Urban Green Economy Efficiency and Its Influencing Factors in Taiwan

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Abstract. In this paper, the environmental factor is introduced as an input index, the DEA-Malmquist model is evaluated the urban green economy efficiency in Taiwan from 1998 to 2016. Then establishes the Tobit regression model, and analyzes the influencing factors. The conclusion shows that the improving of urban management level is the main driving factor to enhance the urban green economy efficiency in Taiwan, but in the northern area, the technical changes play a significant role. The urban management level can promote the urban green economy in Taiwan. The percentage of the secondary industry and wage level are significant positively correlations. Except for urban scale, the technology and education are negatively correlated with the index of DEA-Malmquist. Other factors, including the percentage of the tertiary industry, the economic development investment and the environmental protection investment do not play a role in developing the urban green economy.

Introduction

Urbanization has increased in speed following the initiation of the industrialization. But in the process of urbanization, human focus on the economic development, have consumed lots of natural resources to bring the problem of pollution. Recently, human began to focus on the environmental and resource issue. In the past, the evaluation of sustainable development included sustainability indicator, ecological footprint, and environmental spaces. Most of them lack of effective combining the aspect of economic and environment. In the 1990s, the World Business Council for Sustainable Development considered environmental factors to measure economy efficiency as an effective tool for sustainable development.

Because energy supply is inevitable for economic growth, sustainable development has to be considered with the environment policy. The research on the urban green economy efficiency began to concentrate the environmental factor, and it takes the environmental cost as an input index. In order to estimate energy efficiency, other inputs together with environmental factor should be considered. Studies have shown that DEA (Data Envelopment Analysis) method is an effective analytical tool to evaluate the efficiency of the same type of the decision making unit. Both DEA-CRR and DEA-RCC models have widely used in relevant areas. The DEA models are used to measure the green economy efficiency.

Using the typical DEA models widely, a weak point is not over time that the DEA-CRR and DEA-RCC models only study the performance within a cross-sectional framework. It is necessary to apply a tool for a time series analysis of the efficiency. In recent years, DEA-Malmquist model, which has many advantages, has become the standard approach to measure dynamic efficiency. More research topics have been studied with DEA-Malmquist model.

In terms of measuring the urban green economy efficiency and with above different research methods, this paper adopted the DEA-Malmquist index method which can analyze the dynamic change of efficiency to measure the efficiency change in urban green economy from 1998 to 2016 in Taiwan. In order to evaluate the determinants of the urban green economy efficiency in Taiwan, the method of Tobit regression model was used to explore the impact of factors. The method being used to study the urban green economy efficiency in this paper can also provide a new analysis method and a perspective for subsequent researches on the urban green economy efficiency in future.
Methods and Theory

DEA-Malmquist

In this section, we introduce the basic DEA model. DEA has been recognized as an effective model to assess the relative efficiencies of a set of DMUs (Decision Making Units) which consume some inputs to produce some outputs. DEA, as a non-parametric approach to efficiency measurement, was originally established by Farrell in 1957. DEA was firstly produced by Charnes, Cooper and Rhodes in 1978, provided a new approach to the estimation of relative efficiencies of decision making units.

DEA-Malmquist index is applied to change the calculation of production efficiency. In 1994, Rolf, Fare et al. linked a method of non-parametric linear program with the theory of DEA to develop the method of DEA-Malmquist index analysis. The DEA-Malmquist index is based on the directional technology distance function. As a non-parametric method, the DEA-Malmquist index can be divided into the technological progress and the efficiency change, which is a help to find the sources of productivity change. A typical DEA-Malmquist model is given:

$$m(y_{t+1}, x_{t+1}, y_t, x_t) = \left[\frac{d^{t+1}(x_{t+1},y_{t+1})}{d^t(x_t,y_t)} \times \frac{d^t(x_t,y_t)}{d^{t+1}(x_{t+1},y_{t+1})}\right]^{1/2}$$

(1)

This equation may also be expressed in the following form:

$$m(y_{t+1}, x_{t+1}, y_t, x_t) = \frac{d^{t+1}(x_{t+1},y_{t+1})}{d^t(x_t,y_t)} \times \left[\frac{d^t(x_t,y_t)}{d^{t+1}(x_{t+1},y_{t+1})} \times \frac{d^{t+1}(x_{t+1},y_{t+1})}{d^t(x_t,y_t)}\right]^{1/2}$$

(2)

From this equation, it is seen that from the period of t to t+1 phase, the production efficiency of DMUs is changing. It means that the DEA-Malmquist productivity index measures the changes in total factor productivity (TFP). Total factor productivity index which is over 1 indicates an increase from t to t+1, and which is lower than 1 shows a decrease.

The DEA-Malmquist total productivity index is divided into two components, technical efficiency change (TECH) and technical change (TCH):

$$TFP = TECH \times TCH$$

(3)

$$TECH = \frac{d^{t+1}(x_{t+1},y_{t+1})}{d^t(x_t,y_t)}$$

(4)

$$TCH = \left[\frac{d^t(x_t,y_t)}{d^{t+1}(x_{t+1},y_{t+1})} \times \frac{d^{t+1}(x_{t+1},y_{t+1})}{d^t(x_t,y_t)}\right]^{1/2}$$

(5)

TECH > 1, it shows that the DMU is closed to the frontier and the relative technical efficiency is improved. TCH is technical progress. If the index equals to 1, it indicates technical unchanged; if it is greater than 1, it indicates technical progress; if it is less than 1 it indicates technical backward.

Moreover, the TECH can be rearranged:

$$TECH = PTECH \times SCH$$

(6)

Here, PTECH is pure technical efficiency change, which reflects the change of management level in DMUs. The value is equal to 1, it means management level unchanged and efficiency unchanged; the value is greater than 1, it means efficiency improvement; the value is less than 1, it means efficiency backward. SCH is scale efficiency change. If the value of SCH is greater than 1, it means that the DMU is closer to the optimal production scale. Contrarily, the value is less than 1 means that it is far from the optimal production scale.

Data and Variables

In this paper, it was used the DEAP2.1 computer program to analysis the data. The data set covers a 19-year period from 1998 to 2016 in Taiwan. The Input index includes three aspects: Resource Input, Non-resource Input and Environment Input. Due to the data availability, Land and Energy
consumption are taken for the Resource Input, Capital and Labor are taken for the Non-resource Input, The Environmental Pollution is taken for the Environment Input. The economy development is considered as the Output. The data were taken from the Taiwan’s statistical book.

Table 1. Area in Taiwan.

<table>
<thead>
<tr>
<th>Area</th>
<th>City or County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern Area</td>
<td>New Taipei City, Taipei City, Taoyuan City, Hsinchu City, Hsinchu County, Miaoli County, Keelung City</td>
</tr>
<tr>
<td>Middle Area</td>
<td>Taichung City, Changhua County, Nantou County, Yunlin County</td>
</tr>
<tr>
<td>Southern Area</td>
<td>Tainan City, Kaohsiung City, Chiayi City, Chiayi County, Pingtung County</td>
</tr>
<tr>
<td>Eastern Area</td>
<td>Yilan County, Hualien County, Taitung County</td>
</tr>
</tbody>
</table>

Results

The DEA-Malmquist index analysis is applied in this research to achieve the urban green economy efficiency in Taiwan, and the data spans 19 years from 1998 to 2016. The DEA-Malmquist index results of the urban green economy efficiency in Taiwan are shown in Table 2.

Table 2. Results of DEA-Malmquist index.

<table>
<thead>
<tr>
<th>Area</th>
<th>Technical efficiency change (TECH)</th>
<th>Technical change (TCH)</th>
<th>Pure technical efficiency change (PTECH)</th>
<th>Scale change (SCH)</th>
<th>Malmquist index</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern area</td>
<td>1.011</td>
<td>1.022</td>
<td>1.009</td>
<td>1.001</td>
<td>1.034</td>
<td>1</td>
</tr>
<tr>
<td>Middle area</td>
<td>1.012</td>
<td>1.016</td>
<td>1.07</td>
<td>1.002</td>
<td>1.028</td>
<td>2</td>
</tr>
<tr>
<td>Southern area</td>
<td>1.004</td>
<td>0.95</td>
<td>1.007</td>
<td>0.998</td>
<td>0.954</td>
<td>4</td>
</tr>
<tr>
<td>Eastern area</td>
<td>1.009</td>
<td>1.012</td>
<td>1</td>
<td>1.009</td>
<td>1.021</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>1.009</td>
<td>0.999</td>
<td>1.007</td>
<td>1.002</td>
<td>1.008</td>
<td></td>
</tr>
</tbody>
</table>

The average Malmquist index is 1.008 from 1998 to 2016, the urban green economy efficiency in Taiwan has an upward tendency, which the annual growth is 0.8%. The technical change index is 0.999, but the pure technical efficiency change index and scale change index are 1.007 and 1.002. This shows that the main factor to promote the urban green economy efficiency is the improving of urban management level, not the technical change. The values of pure technical efficiency change are not less than 1, the urban management level in Taiwan is improving annually and is useful to promote the urban green economy.

The result of Malmquist index shows that the urban green economy efficiency in the Northern area is the highest and grows annually 3.4%. In the northern area, the technical change and the pure technical efficiency change are the highest, it means the technical change and urban management level are improve the urban economy efficiency.

In the southern area, the value of technical change and scale change are less than 1, it means the development of technology cannot promote economy growth and is far from the optimal production scale. This brought about a slow economy development in recent years.

Factors

Based on empirical results above, the urban green economy efficiency (UGEE) is more clear difference among different areas. Which factors can affect the urban green economy efficiency? How can the relevant factors be quantified? Because the urban green economy efficiency is a fractional
variable bounded between 0 and 1, Tobit regression with several factors is applied. Reference to the relevant research and the availability to data, we examine urban scale, industrial structure, financial investment, technology and education, wage level and regional variables as independent variables.

The Tobit regression model can be formulated as follows:

\[ UGEE_{it} = \beta_0 + \beta_1 US_{it} + \beta_2 IS_{it} + \beta_3 FI_{it} + \beta_4 TE_{it} + \beta_5 RV + u_{it} \quad (7) \]

Where \( i \), area index; \( t \), time index; \( u \), disturbance term with mean zero and finite variance; \( US \), urban scale, we take the urban population \((US)\); \( IS \), that is industrial structure, which is defined as the percentage of the secondary industry \((IS_2)\) and the tertiary industry \((IS_3)\); \( FI \), includes the economic development investment \((EDI)\) and the environmental protection investment \((EPI)\); \( TE \), that is technology and education, we take the population of college education level \((TE)\) as variable; \( WL \), that is the wage level, we take the household disposable income as variable; \( RV \), that is a regional variable, if the area is a city, the value is 1, the area is a county, the value is 0. Results are carried out by \textsc{STATA} computer program.

Table 3 summarizes the regression results. The results show that the Tobit regression equations are of great significance for estimation passing the test at 1% significance level. The model has got higher explanatory ability \((\text{Log likelihood} = 172.10974, \text{Prob} > \text{chi}^2 = 0.0000)\). AS for these results, we can get more information.

| Variable | Coef.   | Std. Err. | t     | P>|t| |
|----------|---------|-----------|-------|-----|
| US       | -0.0560287 | 0.0173664 | -3.23 | 0.001 |
| IS_2     | 0.1099693  | 0.025714  | 4.28  | 0.000 |
| IS_3     | -0.0490816 | 0.0341998 | -1.44 | 0.152 |
| EDI      | -0.0107683 | 0.0153111 | -0.71 | 0.477 |
| EPI      | 0.0191512  | 0.0131668 | 1.45  | 0.147 |
| TE       | -0.0589579 | 0.0251714 | -2.34 | 0.02  |
| WL       | 0.1022104  | 0.0538393 | 1.9   | 0.058 |
| RV       | 0.0028145  | 0.0101654 | 0.28  | 0.782 |

Note: Significant at 10% level \((p < 0.1)\)

(1) The percentage of the secondary industry and wage level are significant positive correlations with the index of DEA-Malmquist.

In the industrial structure, improving the percentage of the secondary industry, it will develop the economy, but it will make environmental pollution worse. Under the affection of two aspects, the influence of the percentage of the secondary industry on the urban green efficiency is uncertain. The empirical results show that the raise of the percentage of the secondary industry is positive to the urban green efficiency in Taiwan, it may be the result of green production technology application and energy conservation in the development of the secondary industry. Though the percentage of the tertiary industry is theoretically positive to the urban green economy efficiency, the affection is not obvious in Taiwan. Wage level also is negatively correlated that shows the wage is used to improve life, and play an effective incentive to economy.

(2) Not only urban scale, but also the technology and education is negatively correlated with the index of DEA-Malmquist.

Urban scale is negatively correlated with the DEA-Malmquist index, it shows the development of the urbanization in Taiwan cannot enhance the urban green economy efficiency. Because Taiwan has highly urbanized, the development of the urbanization is not importance to economy development. Though the development of technology and education can bring advanced technology and raise the awareness of environmental protection, the effect is minimal and it cannot promote the urban green economy efficiency in Taiwan.

(3) There is no significant correlation in the three factors, including the percentage of the tertiary industry, the economic development investment and the environmental protection investment.
It means the improvement of three factors do not have an effective impact on enhance the urban green economy efficiency in Taiwan. However, as early as the 1980s, Taiwan became a serviced-oriented society. The economy in Taiwan develops slowly, and the changes in the percentage of the tertiary industry have a slight impact on the economy. So the role of the percentage of the tertiary industry and the economic development investment is not obvious, but it is important and is the need of industrial upgrading. The environmental protection investment is also necessary.

Conclusion
This paper makes full use of DEA-Malmquist index approach and Tobit regression model for measuring the urban green economy efficiency from 1998 to 2016 in Taiwan. Based on the original data collected at the beginning, there is a regional disparity in urbanization in Taiwan. Under the sustainable development, the development of urban economy is extremely uncoordinated. The northern area and the middle area have a good development in economy, but the southern area and the eastern area have developed slowly.

The result of dynamic analysis shows that the urban green economy efficiency in the northern and middle area is higher than the southern and eastern area. The main driving factor to enhance the city green economy efficiency is the improving of urban management, not the technological progress, but in the northern area, the technical change still play a significant role. The urban management level can promote the urban green economy in Taiwan. The percentage of the secondary industry and wage level are significant positively correlations. Except for the urban scale, the technology and education are negative correlation. The percentage of the tertiary industry, the economic development investment and the environmental protection investment do not have an effective impact on enhance the urban green economy efficiency.

Based on the empirical results, in order to develop the urban green economy in Taiwan, improving the urban management level is very necessary. Upgrading the industrial structure, especially the secondary industry which develop in the direction of environmental protection, improve the urban green economy in Taiwan.

References