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考慮能源投入下之台灣各縣市生產力與效率

Regional Productivity and Efficiency in Taiwan with Energy Inputs Considered

計畫編號：NSC94－2415－H－009－002

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一、中文摘要

本研究應用資料包絡分析法 (data envelopment analysis, DEA)，在總要素架構下衡量台灣各縣市之整體技術效率、有效率的節省能源目標比率、及考慮能源投入下的各縣市的生產力變動。研究對象為台灣本島及澎湖縣在內之 23 縣市，研究期間為 1999~2003 年。DEA 及 DEA-Malmquist 模型中有一產出 (各縣市人均年度所得)及七項投入 (各縣市政府年度歲出、就業人口、垃圾處理量、家庭用電量、其他用電量、汽油銷售量及柴油銷售量)。所有名目變數皆以 GDP 平減指數轉換成以 2001 年為基期之實質變數。

我們的主要發現如下：

1. 一般而言，即使相對於台灣自己的效率前緣，多數縣市家庭用電、其他用電、汽油及柴油等能源使用上，極度缺乏效率‧
2. 家庭用電效率提升是都會區域的優先要務。

3. 工業用電效率仍存在大幅改善空間。

4. 改善機動車輛能源效率是提高汽油使用效率的關鍵。

5. 提升柴油車能源效率是非都會區域的優先要務。

6. 考慮能源投入下，1999-2003 年間台灣 23 縣市的生產力、效率、技術多半呈現衰退現象。

關鍵詞：資料包絡分析法、Malmquist 生產力指數、能源效率、有效率的節省能源目標比率

二、English Abstract

We apply the data envelopment analysis (DEA) and DEA-Malmquist approached to compute the efficient energy-saving ratios and productivity changes for twenty-three administrative regions in Taiwan from 1999 to 2003. There are one output (per capita income) and seven inputs (local government expenditure, employment, processed trash, household electricity consumption, non-household electricity consumption, gasoline sales volume, and diesel sales volume) in our DEA and DEA-Malmquist models.

Our major findings are as follows:

1. Generally speaking, most of the thirty-three administrative regions are not efficient at all for use of household electricity, non-household electricity, gasoline, and diesel, even with respect to Taiwan's own efficiency frontier.
2. Household electricity energy efficiency improvement is a priority in metropolitan regions.
3. There is still much room to improve efficiency in electricity for industrial use by means of cleaner production, energy-saving technology and equipment, etc.
4. Motor vehicle energy efficiency is the key factor for saving gasoline.
5. Energy efficiency of trucks should be continuously improved especially for non-metropolitan regions.
6. The geometric means of 1999-2003 productivity changes of 23 regions in Taiwan are generally less than 1. Both of the efficiency and technical levels generally went down.

Keywords: Data envelopment analysis (DEA), Malmquist productivity index, energy efficiency, efficient energy-saving ratios

三、英文全文報告

Total-Factor Energy Efficiency and Productivity for Regions in Taiwan

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Introduction

Many studies criticize the commonly-used indicator of energy inefficiency - the energy intensity as a direct ratio of the energy input to GDP for measuring energy efficiency (e.g., Patterson, 1996; Renshaw, 1981). The ratio is only a partial-factor energy efficiency indicator since energy input is the only input-considered factor. Another argument is that this partial-factor ratio is inappropriate to analyze the impact of changing energy use over time (APERC, 2002). Instead, we then compute the energy efficiency by a total-factor framework including other inputs such as labor and capital. A total-factor efficiency indicator can provide more information and a more realistic comparative base to examine the de facto situation across regions in an economy such as Taiwan.

In the first part of this paper, we apply the data envelopment analysis (DEA) approach to compute the efficient energy-saving ratios for twenty-three administrative

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regions in Taiwan from 1999 to 2003. There are one output (per capita income) and seven inputs (local government expenditure, employment, processed trash, household electricity consumption, non-household electricity consumption, gasoline sales volume, and diesel sales volume) in our DEA models. DEA generates the target energy inputs for each region in Taiwan in each year, from which the efficient energy-saving target ratios for regions in Taiwan are computed. This total-factor energy framework is first pioneered by Hu and Wang (2006), Hu (2006), and Hu and Kao (Forthcoming) to compute the efficient energy-saving targets of APEC economies (including Taiwan) and regions in mainland China.

In the second part of this paper, regional productivity changes with energy inputs considered can be also computed by the DEA-Malmquist model. The same data of inputs and outputs can be used. Most of the existing literature on regional productivity neglects environmental or resource factors (e.g., Färe et al. 1994). Lo et al. (2005) incorporate CO_2 emission as an undesirable output into productivity analysis for 10 Asian economies (including Taiwan). They find that after incorporating the CO_2 emission, the factor of productivity could be over-emphasized at great cost to the environment. A cross-country comparison analysis, considering CO_2 emissions, shows that the productivity of China and ASEAN-4 deteriorated while the productivity growth of Japan and NIEs (including Taiwan) performed much better. Hu et al. (2005) incorporate air pollutions into productivity analysis for Asian economies and administrative regions in mainland China. When environmental factors are incorporated, the east regions still perform better than the inland ones both from static and dynamic analysis. This phenomenon is minted as the 'double deterioration' of the inland areas in China. Double deterioration is attributed to the lack of economic resources to replace highly-polluting production equipment and technology in those less developed regions.

The data sources are the *Taiwan Statistical Data Book,* Taiwan's Bureau of Energy, and Directorate General of Budget, Accounting, and Statistics of Taiwan's Executive Yuan. All nominal variables are transformed into real variables at the 2001 price level by GDP deflators of Taiwan. Table 1 shows the summary of statistics of all inputs and the output. Table 2 shows that all inputs and the output has a positive correlation coefficient, satisfying the isotonicity property (an output must not decrease with an increase in any input).

DEA Methodology

This paper uses DEA to find out input targets for each administrative region in Taiwan by comparing with the annual efficiency frontier constituted by all the administrative regions in Taiwan in each year. Since it is an input-reducing focus, this paper uses input-orientated measures following Farrell's (1957) original ideas. In order to pursue overall technical efficiency (OTE) with energy inputs, our study adopts the constant returns to scale (CRS) DEA model (Charnes et al., 1978).

Let us first define some mathematical notations: There are K inputs and M outputs for each of N objects. For the *i*-th object these are represented by the column vectors x_i and y_i, respectively. The K×N input matrix X and the M×N output matrix Y represent the data for all N objects. The input-oriented CRS DEA model then solves the following linear programming problem for object *i* in each year:

$$D(y_i, x_i) = \mathrm{Min}_{\theta,\lambda} \quad \theta$$

$$\text{subject to} \quad -y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0,$$

$$\lambda \geq 0, \qquad (1)$$

where θ is a scalar and λ is a N×1 vector of constants. The value of θ is the efficiency score for the *i*-th object, with $0 \leq \theta \leq 1$. The weight vector λ serves to form a convex combination of observed inputs and outputs.

The summation of slack and radial adjustment is the total reducing amount ('target') that could be reduced without decreasing output levels. With respect to energy input, the above summation is called 'energy-saving target' (EST) proposed by Hu and Wang (2006) and Hu and Kao (forthcoming). The formula is as follows:

$$\text{EST}_{(i,\,t)} = \text{Slack Adjustment}_{(i,\,t)} + \text{Radial Adjustment}_{(i,\,t)}, \qquad (2)$$

where it is in the *i*-th economy and the *t*-th year.

Based on slack and radial adjustment of energy obtained from DEA, we can calculate the energy-saving target ratio considering other factors simultaneously. The target inputs of an object in a year are found by comparing its actual inputs to the efficiency frontier in that year. The formula is as below:

$$\text{ESTR}_{(i,\,t)} = \text{Energy-saving Target}_{(i,\,t)} / \text{Actual Energy Input}_{(i,\,t)}, \qquad (3)$$

where it is in the *i*-th region and the *t*-th year. Note that the value of ESTR is always between zero and one and is equal to 1 minus the value of total-factor energy efficiency (TFEE). The higher energy-saving target ratio is, the lower total-factor energy efficiency will be.

DEA-Malmquist Methodology

The Malmquist productivity index (MALM) developed by Färe et al. (1994) will be used to measure productivity of regions in Taiwan and with the incorporation of energy inputs. This method is also able to decompose the productivity change into efficiency change and technical change, which are components of productivity change.

For each time period t = 1,…, T, the Malmquist index is based on a distance function, which takes the form

$$D^t(X^t, Y^t) = \min \{ \delta : (X^t, Y^t / \delta) \in S^t \} , \tag{4}$$

where δ determines the maximal feasible proportional expansion of output vector Y^t for a given input vector X^t under production technology S^t at time period t. If, and only if, the input-output combination (X^t, Y^t) belongs to the technology set S^t, the distance function has a value less than or equal to one, i.e. $D^t(X^t, Y^t) \leq 1$. If $D^t(X^t, Y^t) = 1$, then the production is on the boundary of technology and the production is technically efficient.

The MALM change between time period s (base year) and time period t (final year), relative to the technology level at time period s, is:

$$M^s = \frac{D^s(X^t, Y^t)}{D^s(X^s, Y^s)}. \tag{5}$$

It provides a measurement of productivity change by comparing data (combination of input and output) of time period t with data of time period s using technology at time s as a reference. Similarly, the MALM relative to technology at time t can be defined as

$$M^t = \frac{D^t(X^t, Y^t)}{D^t(X^s, Y^s)}. \tag{6}$$

Allowing for technical inefficiency, Färe et al. (1994) extended the above models and propose an output-oriented MALM from time period s to period t as a geometric mean of the two MALM of (2) and (3). A constant returns to scale (CRS) technology is assumed to measure the productivity change, and the MALM is expressed as

$$\text{MALM} = \left[\frac{D^s(X^t, Y^t)}{D^s(X^s, Y^s)} \frac{D^t(X^t, Y^t)}{D^t(X^s, Y^s)} \right]^{\frac{1}{2}}. \tag{7}$$

Note that if $X^s = X^t$ and $Y^s = Y^t$ (for example, there has been no change in inputs and outputs between the periods), then the productivity index signals no change when revealing $\text{MALM}(\ ) = 1$. The above equation of productivity change can be rearranged by decomposing into two components, the efficiency change (EFFCH) and the technical change (TECHCH), which takes the following forms:

$$\text{Efficiency change (EFFCH)} = \frac{D^t(X^t, Y^t)}{D^s(X^s, Y^s)}; \tag{8}$$

$$\text{Technical change (TECHCH)} = \left[\frac{D^s(X^t, Y^t)}{D^t(X^t, Y^t)} \frac{D^s(X^s, Y^s)}{D^t(X^s, Y^s)} \right]^{\frac{1}{2}}. \tag{9}$$

The EFFCH measures the changes in relative position of a production unit to the production frontier between time period *s* and *t* under CRS technology. The TECHCH measures the shift in the frontier observed from the production unit's input mix over the period. In summary, the MALM is the product of EFFCH and TECHCH. How much closer a country gets to the 'countries' frontier' is called 'catching up', and is measured by EFFCH. How much the 'countries' frontier' shifts at each country's observed input mix is called 'innovation' shown by TECHCH. Improvements in productivity yield Malmquist indices and any components in the Malmquist index greater than unity. On the other hand, deterioration in performance over time is associated with a Malmquist index and any other components less than unity.

Empirical Findings

From Tables 3-6, we immediately observe that the cities are not more energy-efficient than counties in Taiwan. Penghu County as a group of smaller islands in the Taiwan Strait is the best performer with zero energy-saving target ratios of all kinds. Penhu County's major industries are agriculture and tourism. Generally speaking, most of the thirty-three administrative regions are not efficient at all for use of household electricity, non-household electricity, gasoline, and diesel, even with respect to Taiwan's own efficiency frontier.

Table 3 shows that Taichung City, Taipei City, Taipei County, and Tainan City where population is highly dense can save respectively up to 63.0%, 57.8%, 57.6, and 56.8% in average of their household electricity consumption. Household electricity energy efficiency improvement is a priority in metropolitan regions. Green building and community education are needed to improve household energy efficiency.

Table 4 reports that Taoyuan County and Hsinchu City are where non-household electricity can be saved most, up to 92.0% and 90.1% in average respectively. Taiyuan County is full of manufacturing industries. Hsinchu City is where the major science park of Taiwan is located. Hence, in Taiwan there is still much room to improve efficiency in electricity for industrial use by means of cleaner production, energy-saving technology and equipment, etc.

Table 5 indicates that Taichung City has the highest gasoline-saving target up to an average of 68.8%. Taipei City and Taoyuan County also have much to save for gasoline consumption, up to respectively 62% and 60.8% in average. Since these regions are where motor vehicles are concentrated, motor vehicle energy efficiency is the key factor for saving gasoline. Retiring inefficient old motor vehicles, encouraging energy-saving vehicle models, and promoting public transit systems, etc., should be more actively supported by the public policy.

As Table 6 shows, Hualien County, Miaoli County, Nantou County, Taitung

County, Hsinchu County, Taoyuan County, and Yilan County can in average save their diesel use respectively up to 79.1%, 78.5%, 77.3%, 75.9%, 75.7%, 73.2%, and 71.0%. These are non-metropolitan regions in which diesel-fueled trucks are often used for long-distance transportation. Energy efficiency of trucks should be continuously improved especially for these non-metropolitan regions.

Table 7 shows that the geometric means of 1999-2003 productivity changes of 23 regions in Taiwan are generally less 1. Both of the efficiency and technical levels generally went down. The worsening-off trend in efficiency tells that the resource use in Taiwan is becoming more inefficient even with respect to Taiwan's own frontier. This also implies that the regional total-factor energy efficiency in Taiwan was not improving during the research period. The worsening-off trend in technical level implies the gradual decline in Taiwan's efficiency frontier. With the same inputs Taiwan produces less and less even at the most efficient situation. As a result, productivity change consisting of both efficiency and technical changes gets worse for almost all regions in Taiwan. Both managerial and technological improvements are necessary for Taiwan to regain its competitiveness by improving its productivity.

Suggested Strategies

Base on the above empirical findings, we come up with the following energy efficiency policy suggestions:

1. It is a priority for metropolitan regions to save the household electricity.
2. It is a priority for regions with dense manufacturing and high-tech industries to engage in saving the non-household electricity.
3. It is a priority for metropolitan regions to improve their motor-vehicle energy efficiency in order to save gasoline.
4. It is a priority for non-metropolitan regions to improve save diesel by improving

the energy efficiency of trucks.

5. Both managerial and technological improvements are necessary for Taiwan to regain its competitiveness by improving its productivity.

References

Asia Pacific Energy Research Center (APERC), 2000. *APEC Energy Pricing Practices.* APERC, Tokyo.

Charnes, A., W.W. Cooper and E. Rhodes, 1978. “Measuring the Efficiency of Decision Making Units.” *European Journal of Operational Research* 2, 429-444.

Färe, R., S. Grosskopf, M. Norris and Z. Zhang, 1994. “Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries.” *American Economic Review* 84, 66-83.

Hu, J.-L. (2006), "Efficient Air Pollution Abatement for Regions in China," *International Journal of Sustainable Development and World Ecology*, 13, 327-340.

Hu, J.-L. and C.-H. Kao, Forthcoming. “Efficient Energy-Saving Targets for APEC Economies.” *Energy Policy*.

Hu, J.-L., H.-J. Sheu, and S.-F. Lo (2005), "Under the Shadow of Asian Brown Clouds: The Unbalanced Regional Productivities in China and Environmental Concerns," *International Journal of Sustainable Development and World Ecology*, 12, 429-442.

Hu, J.-L. and S.-C. Wang, 2006. “Total-Factor Energy Efficiency of Regions in China.” *Energy Policy* 34, 3206-3217.

Lo, S.-F., H.-J. Sheu, and J.-L. Hu (2005), "Taking CO2 Emissions into a Country's Productivity Change: the Asian Growth Experience." *International Journal of*

Sustainable Development and World Ecology 12, 279-290.

Patterson, M. G., 1996. "What Is Energy Efficiency? Concepts, Indicators, and Methodological Issues." *Energy Policy* 24, 377-390.

Renshaw, E. F., 1981. "Energy efficiency and the Slump in Labour Productivity in the USA." *Energy Economics* 3, 36-42.

Table 1. The Summary Statistics of Inputs and Outputs

Variable	Mean	Standard Deviation	Minimum	Maximum	Unit
Per capita real income (Y)	995228.122	191394.885	715332	1548207	NTD
Real local government expenditure (X_1)	28951.5509	31167.1507	5499.932985	165300.898	Million NTD
Employment (X_2)	411147.826	347387.600	31000	1578000	person
Waste (X_3)	337122.252	302580.220	28835	1416200	Thousand Degree
Household Electricity Consumption (X_4)	2128014.20	2103661.09	151663.469	9828016.423	Kilowatt Hour
Non-household Electricity Consumption (X_5)	4195453.07	4040464.73	97631.537	19504305.62	Kilowatt Hour
Gasoline Sales (X_6)	415352.791	332103.472	20087	1490009	Thousand Liter
Diesel Sales (X_7)	136980.826	96081.282	3189	417981	Thousand Liter

Table 2. Correlation coefficients of outputs and inputs

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Per capita real income (Y)	1.000							
Real local government expenditure (X_1)	0.6240	1.000						
Employment (X_2)	0.4580	0.768	1.000					
Waste (X_3)	0.4770	0.780	0.967	1.000				
Household Electricity Consumption (X_4)	0.5373	0.800	0.986	0.951	1.000			
Non-household Electricity Consumption (X_5)	0.4740	0.442	0.637	0.613	0.617	1.000		
Gasoline Sales (X_6)	0.4890	0.696	0.965	0.923	0.955	0.768	1.000	
Diesel Sales (X_7)	0.0420	0.182	0.627	0.570	0.544	0.770	0.732	1.000

Table 3. 1999-2003 Household Electricity-Saving Ratios for Regions in Taiwan (Unit: %)

Region	Number	1999	2000	2001	2002	2003	Average
Taipei County	1	44.5	78.1	37.6	51.0	76.6	57.6
Yilan County	2	3.3	59.6	1.8	0.0	59.0	24.7
Taoyuan County	3	31.7	77.3	32.8	33.3	77.1	50.4
Hsinchu County	4	0.0	58.6	1.1	0.0	56.9	23.3
Miaoli County	5	0.0	56.2	0.0	0.0	52.2	21.7
Taichung County	6	25.6	74.4	26.7	27.0	74.2	45.6
Chunghua County	7	14.7	72.5	10.4	24.6	69.8	38.4
Nantou County	8	3.3	32.7	11.5	3.2	46.3	19.4
Yunlin County	9	0.0	61.7	0.8	0.4	59.8	24.5
Chiayi County	10	0.0	51.1	0.0	0.0	50.3	20.3
Tainan County	11	0.0	68.3	1.5	11.1	65.1	29.2
Kaohsiung County	12	17.3	74.3	18.9	29.1	72.0	42.3
Pingtung County	13	1.2	67.7	0.0	0.0	61.5	26.1
Taitung County	14	0.0	36.0	0.0	0.0	29.5	13.1
Hualien County	15	0.0	54.4	0.0	0.0	48.2	20.5
Penhu County	16	0.0	0.0	0.0	0.0	0.0	0.0
Keelung City	17	10.7	54.1	16.2	11.8	52.4	29.0
Hisnchu City	18	24.3	66.8	19.3	18.2	63.7	38.5
Taichung City	19	45.6	76.0	60.1	58.5	75.0	63.0
Chiayi City	20	0.0	65.4	0.0	0.0	63.5	25.8
Tainan City	21	52.2	66.9	51.7	45.5	67.8	56.8
Taipei City	22	51.6	54.4	62.2	56.6	64.3	57.8
Kaohsiung City	23	3.5	43.5	19.2	12.6	43.9	24.5

Table 4. 1999-2003 Non-household Electricity-saving Ratios for Regions in Taiwan (Unit: %)

Region	Number	1999	2000	2001	2002	2003	Average
Taipei County	1	59.5	85.3	55.0	61.0	80.0	68.2
Yilan County	2	72.6	87.8	66.1	65.2	84.3	75.2
Taoyuan County	3	88.9	96.5	89.6	89.2	96.0	92.0
Hsinchu County	4	87.8	94.3	87.7	86.8	93.7	90.1
Miaoli County	5	80.4	91.7	79.4	78.8	89.3	83.9
Taichung County	6	70.5	90.1	70.1	69.9	89.0	77.9
Chunghua County	7	72.5	91.6	72.1	76.1	89.5	80.4
Nantou County	8	41.7	61.9	43.6	42.4	67.0	51.3
Yunlin County	9	56.7	81.9	60.0	53.1	80.2	66.4
Chiayi County	10	52.6	76.8	50.2	49.2	73.5	60.5
Tainan County	11	80.5	93.9	80.7	82.9	92.9	86.2
Kaohsiung County	12	82.5	94.5	82.0	83.7	93.1	87.2
Pingtung County	13	37.6	80.0	36.5	32.1	72.0	51.6
Taitung County	14	16.1	43.6	10.6	9.6	33.8	22.7
Hualien County	15	61.2	82.1	67.7	67.2	80.7	71.8
Penhu County	16	0.0	0.0	0.0	0.0	0.0	0.0
Keelung City	17	27.9	61.8	26.8	21.3	53.5	38.3
Hisnchu City	18	90.6	96.3	90.2	90.4	95.4	92.6
Taichung City	19	59.7	82.5	70.0	68.6	79.8	72.1
Chiayi City	20	0.0	65.7	0.0	0.0	60.4	25.2
Tainan City	21	69.7	77.8	67.4	63.5	78.5	71.4
Taipei City	22	67.0	69.1	72.9	68.5	74.1	70.3
Kaohsiung City	23	78.6	46.6	80.2	77.9	85.5	73.8

Table 5. 1999-2003 Non-household Gasoline-saving Ratios for Regions in Taiwan (Unit: %)

Region	Number	1999	2000	2001	2002	2003	Average
Taipei County	1	20.8	82.3	15.4	35.0	82.9	47.3
Yilan County	2	0.0	74.2	0.0	0.0	75.3	29.9
Taoyuan County	3	39.1	88.5	42.9	44.4	89.2	60.8
Hsinchu County	4	38.4	84.3	37.4	35.5	83.2	55.8
Miaoli County	5	20.4	78.9	24.0	23.9	77.7	45.0
Taichung County	6	18.4	84.1	35.5	25.6	85.1	49.7
Chunghua County	7	13.2	84.1	14.1	28.9	84.0	44.9
Nantou County	8	33.9	70.2	59.7	43.3	79.6	57.3
Yunlin County	9	11.3	79.0	10.4	7.4	78.7	37.4
Chiayi County	10	24.6	74.9	22.5	28.7	78.6	45.9
Tainan County	11	21.4	85.8	24.7	33.5	85.5	50.2
Kaohsiung County	12	9.4	83.5	12.6	27.1	84.3	43.4
Pingtung County	13	0.0	81.8	6.8	8.2	80.0	35.4
Taitung County	14	24.9	65.0	25.9	29.0	62.7	41.5
Hualien County	15	8.5	73.4	11.7	9.2	71.8	34.9
Penhu County	16	0.0	0.0	0.0	0.0	0.0	0.0
Keelung City	17	0.0	65.5	8.0	0.0	67.7	28.2
Hisnchu City	18	24.5	79.7	22.9	24.1	79.4	46.1
Taichung City	19	44.9	85.6	65.2	62.6	85.9	68.8
Chiayi City	20	0.0	80.6	0.0	0.0	79.4	32.0
Tainan City	21	48.9	74.0	44.5	37.6	76.5	56.3
Taipei City	22	57.6	59.4	64.8	61.0	68.3	62.2
Kaohsiung City	23	13.8	65.2	31.1	23.2	65.2	39.7

Table 6. 1999-2003 Non-household Diesel-saving Ratios for Regions in Taiwan (Unit: %)

Region	Number	1999	2000	2001	2002	2003	Average
Taipei County	1	2.8	87.4	1.6	25.5	83.1	40.1
Yilan County	2	56.9	92.7	53.9	59.8	91.7	71.0
Taoyuan County	3	53.3	94.8	58.7	65.2	94.2	73.2
Hsinchu County	4	63.0	94.0	64.0	66.0	91.7	75.7
Miaoli County	5	67.5	94.4	67.7	71.5	91.4	78.5
Taichung County	6	45.9	94.0	61.2	56.7	92.1	70.0
Chunghua County	7	42.6	94.0	47.5	58.6	91.7	66.9
Nantou County	8	55.3	89.5	82.2	70.8	88.8	77.3
Yunlin County	9	61.3	93.9	54.5	53.5	91.0	70.8
Chiayi County	10	66.1	92.3	61.6	66.3	90.8	75.4
Tainan County	11	50.4	94.5	50.2	61.6	92.5	69.8
Kaohsiung County	12	38.0	93.3	38.7	52.8	91.3	62.8
Pingtung County	13	2.3	90.0	18.7	26.2	86.1	44.7
Taitung County	14	67.4	89.0	66.9	71.3	85.1	75.9
Hualien County	15	68.7	94.1	71.1	70.6	91.0	79.1
Penhu County	16	0.0	0.0	0.0	0.0	0.0	0.0
Keelung City	17	48.0	88.8	49.3	46.0	84.0	63.2
Hisnchu City	18	0.0	84.1	1.7	0.0	75.5	32.3
Taichung City	19	0.0	85.3	45.9	44.5	82.1	51.6
Chiayi City	20	0.0	89.3	0.0	0.0	83.2	34.5
Tainan City	21	0.0	68.5	0.0	0.0	65.3	26.8
Taipei City	22	0.0	0.0	0.0	0.0	0.0	0.0
Kaohsiung City	23	0.0	74.5	27.5	31.9	74.9	41.8

Table 7. Geometric Means of 1999-2003 Regional Productivity in Taiwan with energy inputs considered

Region	Number	Effch	Techch	Tfpch
Taipei County	1	0.954	0.962	0.918
Yilan County	2	1.007	0.966	0.973
Taoyuan County	3	1.008	0.961	0.969
Hsinchu County	4	0.990	0.967	0.957
Miaoli County	5	1.007	0.966	0.973
Taichung County	6	0.978	0.960	0.939
Chunghua County	7	1.035	0.962	0.995
Nantou County	8	0.939	1.027	0.964
Yunlin County	9	1.007	0.965	0.972
Chiayi County	10	1.046	0.963	1.012
Tainan County	11	1.045	0.956	1.006
Kaohsiung County	12	0.997	0.962	0.958
Pingtung County	13	1.029	0.964	0.992
Taitung County	14	1.009	0.971	0.979
Hualien County	15	1.004	0.966	0.970
Penhu County	16	1.000	0.996	0.996
Keelung City	17	0.948	0.967	0.917
Hisnchu City	18	0.977	0.969	0.947
Taichung City	19	0.955	0.967	0.923
Chiayi City	20	1.000	0.964	0.963
Tainan City	21	1.010	0.970	0.981
Taipei City	22	1.107	0.937	1.038
Kaohsiung City	23	0.998	0.971	0.969
Average		0.998	0.971	0.970