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Bootstrapped Total Factor Productivity Analysis of International Tourist Hotels in Taiwan

Hui Meng[a], Shew-Huei Kuo[b], Yang Li [c,d,*], and Yu-Jung Chen[e]

Abstract

The Malmquist productivity index (MPI), proposed by Fare et al. (1994) and based on the data envelopment analysis (DEA), is commonly used to measure total factor productivity (TFP). Being a linear-programming-based measure and lack of statistical nature, MPI may give incomplete information about TFP and its components and thus, guides incorrect policy and/or managerial implications. This study uses the bootstrapping approach, proposed by Simar and Wilson (1998, 1999) which takes into account the time-dependence structure of the data, to generate the appropriate bootstrap samples for analyzing productivity changes of Taiwan's International Tourist Hotels (ITHs). The dataset, obtained from the annual Operating Report of International Tourist Hotel in Taiwan published by the Taiwan Tourism Bureau during 2010-2015, consists of 67 ITHs and 402 observations. Empirical results indicate that it is apparent to overstating the situation of changes in efficiency of Taiwan's ITHs, and even worse in the case of changes in technology.

Keywords: DEA, total factor productivity, Malmquist indices, quasi-fixed inputs, bootstrap methods

1. Introduction

Due to greater global awareness of environmental pollution, the tourism industry is known as an "industry without a chimney" and has thus been heavily promoted by many governments in recent years. In addition, the rise of emerging markets, the increase of global income, and more convenient transportation links have also helped boost this sector's growth. Benefitting from the expansion of the international tourist market, topic of the internationalization of the tourist hotel industry has attracted many scholars. According to the World Travel and Tourism Council (WTTC), the global tourist revenue reached seven trillion U.S. dollars (about 9.5% of global GDP) in 2013, which had created 4.7 million new employment opportunities around the world. It predicted that there will be average annual 4.2% of growth rate of contribution to GDP for future two decades and continuously outpaces the economic rate of growth over the world. This mainly results from the increasing demand of emerging markets and the rise of overall consumption expenditures in the tourist industry. Growth of the tourist industry also drives developments of transportation, commerce, construction, accommodation and catering industries (Proenca and Soukiazis, 2008). Indicated from 2013 Report issued by Inter-Continental Hotels Group (IHG), there were approximate 14.6 million rooms supplied in the hotels globally in 2013, where average room revenue grew up by 4.4% compared with that of 2012.

To pursue the development of its tourism market, Taiwan has actively promoted tourism policies such as "Doubling Tourist Arrivals Plan" and "Taiwan Ecotourism" in 2002, "2008-2009 Taiwan Tour Year," "Top Tourist Pilot Program" in 2009, "Traditional Hotel for One Thousand Stars Plan" in 2012, etc. In particular, Taiwan opened up to Chinese tourists in 2008, and from the statistics of the Taiwan Tourism Bureau more than 8 million tourists came to the country in 2013, representing an average annual growth rate of 16.44% since 2008. The rapid growth of tourists coming to Taiwan has resulted in the establishment of more international tourist hotels in the country, with a rise of 18% in the number of ITHs during the period

[a]Shanxi University of Finance and Economics, Shanxi, China.
[b]Department of Finance, National Yunlin University of Science and Technology, Yunlin, Taiwan.
[c]New Huadu Business School, Minjiang University, Fujian, China.
[d]Research Center of Efficiency and Productivity, Fujian College's Research Base of Humanities and Social Science, Fujian, China.
[e]Institute of Business and Management, National University of Kaohsiung, Taiwan.
**Corresponding Author: Prof. Yang Li, Email:* isu.yangli@nbs.edu.cn

2008-2014 (an increase from 61 ITHs to 72 ITHs). Moreover, there are 26 ITHs being planned currently. When facing a rapid growth of tourists and increasing intra-industry competition in Taiwan, fully understanding the total factor productivity (TFP) and its corresponding components on the tourist hotel industry not only can effectively improve the operating performance of Taiwan's ITH industry, but also can be a reference for policy implementation and development by the government sector.

Data envelopment analysis (DEA), proposed by Charnes *et al*. (1978), is essentially a linear programming model to evaluate the efficiencies of decision making units (DMUs) by calculating the best multiplier for inputs and outputs. Since it can deal with multiple inputs and outputs without assuming any particular functional form, it has been widely applied in many different fields, including the tourist hotel industry (Anderson *et al*., 2000; Barrors, 2004; Hwang and Chang, 2003; Yang and Lu, 2006; Wu and Song, 2011). The Malmquist productivity index (MPI), proposed by Fare et al. (1994) and based on the data envelopment analysis (DEA), is commonly used to measure total factor productivity (TFP). The primary problem is that being a linear-programming-based measure and lack of statistical nature, MPI may give incomplete information about TFP and its components and thus, guides incorrect policy and/or managerial implications. Hence, this study uses the bootstrapping approach, proposed by Simar and Wilson (1998, 1999) which takes into account the time-dependence structure of the data, to generate the appropriate bootstrap samples for analyzing productivity changes of Taiwan's ITHs.

The rest of the paper is organized as follows. Section II describes the methodology used in this study. Section III consists of the description of the data and the variables and the empirical results. The final section offers conclusion.

2. Methodology

Suppose that there are H decision making units (DMUs). Each DMU employs k inputs $\underset{\sim}{\mathbf{x}} = [x_1,\ldots,x_k]' \in \Re_+^k$ to produce m outputs $\underset{\sim}{\mathbf{y}} = [y_1,\ldots,y_m]' \in \Re_+^m$. The production possibility set at time t is given by the closed set:

$$\mathbf{\Omega}^t = \{(\underset{\sim}{x}, \underset{\sim}{y}) \mid \underset{\sim}{x} \text{ can produce } \underset{\sim}{y} \text{ at time } t\} \subset \Re_+^{k+m} \tag{1}$$

Shephard (1970) defines the output distance function for DMU h at time t by

$$D^{ht} = \inf\{\theta \mid (\underset{\sim}{x}_{ht}, \underset{\sim}{y}_{ht}/\theta) \in \mathbf{\Omega}^t\} \tag{2}$$

The output distance function considers a maximal proportional expansion of output $\underset{\sim}{\mathbf{y}}_{ht}$ given input $\underset{\sim}{\mathbf{x}}_{ht}$ in the sense that $(\underset{\sim}{\mathbf{x}}_{ht}, \underset{\sim}{\mathbf{y}}_{ht}/D^{ht})$ is on the frontier of $\mathbf{\Omega}^t$.

Equation (2) cannot be evaluated since $\mathbf{\Omega}^t$ is unknown. Hence, we have to first estimate $\mathbf{\Omega}^t$ from the observed input-output set. Charnes et al. (1978) proposed the data envelopment analysis (DEA) estimator of $\mathbf{\Omega}^t$, known as the CCR model, as follows:

$$\hat{\mathbf{\Omega}}^t = \left\{(\underset{\sim}{x}, \underset{\sim}{y}) \mid \underset{\sim}{x} \geq \mathbf{X}_t \underset{\sim}{\lambda},\ \underset{\sim}{y} \leq \mathbf{Y}_t \underset{\sim}{\lambda},\ \underset{\sim}{\lambda} \geq \underset{\sim}{\mathbf{0}}\right\} \subset \Re_+^{k+m}, \tag{3}$$

where $\mathbf{X}_t = [\underset{\sim}{x}_{1t},\ldots,\underset{\sim}{x}_{Ht}]$, $\mathbf{Y}_t = [\underset{\sim}{y}_{1t},\ldots,\underset{\sim}{y}_{Ht}]$, $\underset{\sim}{\lambda}$ is an (H×1) vector of intensity variables, and $\underset{\sim}{\mathbf{0}}$ is an (H×1) vector of zeros. Equation (3) reveals that $\hat{\mathbf{\Omega}}^t$ is the smallest free disposal convex set containing all the data. The output-oriented technical efficiency of the CCR model for DMU h at time t, $\hat{\theta}_h^t$, is defined as:

$$(\hat{\theta}_h^t)^{-1} = \sup_{\delta,\, \underset{\sim}{\lambda}}\{\delta \mid (\underset{\sim}{x}_{ht}, \delta \underset{\sim}{y}_{ht}) \in \hat{\mathbf{\Omega}}^t\}. \tag{4}$$

Given the DEA estimator $\hat{\mathbf{\Omega}}^t$ of $\mathbf{\Omega}^t$, the corresponding estimator of the output distance function is given by

$$\hat{D}_h^t = \inf_{\gamma,\, \underset{\sim}{\lambda}}\{\gamma \mid (\underset{\sim}{x}_{ht}, \underset{\sim}{y}_{ht}/\gamma) \in \hat{\mathbf{\Omega}}^t\} \tag{5}$$

Note that the output-oriented technical efficiency $\hat{\theta}_h^t$ coincides with the output distance function $\hat{D}_h^t$.
Färe et al. (1994) employed the concept of output distance functions to define the Malmquist output-oriented total factor productivity (TFP) change index for DMU h from period s to period t as follows:

$$\hat{\boldsymbol{M}}_h^{s\to t} = \left[\left(\hat{D}_h^{t|s} / \hat{D}_h^{s|s} \right) \times \left(\hat{D}_h^{t|t} / \hat{D}_h^{s|t} \right) \right]^{1/2} \tag{6}$$

where $\hat{D}_h^{t|s}$ represents the output distance function for DMU h from the period t observation to the period s technology; i.e.,

$$\hat{D}_h^{t|s} = \inf_{\gamma, \underset{\sim}{\lambda}} \left\{ \gamma \,\middle|\, \left(\underset{\sim}{\boldsymbol{x}}_{ht}, \underset{\sim}{\boldsymbol{y}}_{ht} / \gamma \right) \in \hat{\boldsymbol{\Omega}}^s \right\}. \tag{7}$$

If s = t, then $\hat{D}_h^{t|t}$ is a measure of efficiency relative to the contemporaneous technology and $\hat{D}_h^{t|t} (= \hat{D}_h^t) \le 1$. If s ≠ t, then we have a measure of distance function relative to the intertemporal technology and both $\hat{D}_h^{t|s}$ and $\hat{D}_h^{s|t}$ could be ≤ 1 or ≥ 1. Equation (6) is, in fact, the geometric mean of two TFP indices: the first in the square bracket is evaluated with respect to period s technology and the second with respect to period t technology. A value of $\hat{\boldsymbol{M}}_h^{s\to t}$ greater than one will indicate positive TFP growth from period s to period t, while a value less than one indicates a TFP decline.

The Malmquist TFP change index can be further decomposed as the product of efficiency change and technical change as follows:

$$\hat{\boldsymbol{M}}_h^{s\to t} = \left(\hat{D}_h^{s|s} \;/\; \hat{D}_h^{t|t} \right) \times \left[\left(\hat{D}_h^{t|s} / \hat{D}_h^{t|t} \right) \times \left(\hat{D}_h^{s|s} / \hat{D}_h^{s|t} \right) \right]^{1/2} \tag{8}$$

The parenthesis of the right hand side of equation (8) measures the efficiency change:

$$\widehat{\boldsymbol{Ef}}_h^{s\to t} = \hat{D}_h^{s|s} \;/\; \hat{D}_h^{t|t}, \tag{9}$$

while the square brackets evaluates the technical change, which is the geometric mean of the shift in technology between two periods, evaluated at time t and also at time s:

$$\widehat{\boldsymbol{TC}}_h^{s\to t} = [(\hat{D}_h^{t|s} / \hat{D}_h^{t|t}) \times (\hat{D}_h^{s|s} / \hat{D}_h^{s|t})]^{1/2} \tag{10}$$

Simar and Wilson (1998) proposed a bootstrap procedure to generate bootstrap samples for DEA models. Unfortunately, it is not applicable in the analysis of productivity change because the time-dependence structure of the data has to be taken into account. Simar and Wilson (1999) recommended another bootstrap procedure, taking into account the time-dependence structure of the data, to generate the appropriate bootstrap samples for analyzing productivity change. This algorithm can be summarized as follow:

[1] Use all DMUs in period s and t, respectively, to calculate $\hat{D}_h^s$ and $\hat{D}_h^t$ by the CCR model; then, we have $\hat{\underset{\sim}{\boldsymbol{\alpha}}} = [(\hat{D}_1^s)^{-1}, \ldots, (\hat{D}_H^s)^{-1}]'$ and $\hat{\underset{\sim}{\boldsymbol{\beta}}} = [(\hat{D}_1^t)^{-1}, \ldots, (\hat{D}_H^t)^{-1}]'$.

[2] Define $\boldsymbol{\Lambda} = \begin{bmatrix} \hat{\underset{\sim}{\boldsymbol{\alpha}}} & \hat{\underset{\sim}{\boldsymbol{\beta}}} \\ 2\underset{\sim}{\boldsymbol{1}} - \hat{\underset{\sim}{\boldsymbol{\alpha}}} & \hat{\underset{\sim}{\boldsymbol{\beta}}} \\ 2\underset{\sim}{\boldsymbol{1}} - \hat{\underset{\sim}{\boldsymbol{\alpha}}} & 2\underset{\sim}{\boldsymbol{1}} - \hat{\underset{\sim}{\boldsymbol{\beta}}} \\ \hat{\underset{\sim}{\boldsymbol{\alpha}}} & 2\underset{\sim}{\boldsymbol{1}} - \hat{\underset{\sim}{\boldsymbol{\beta}}} \end{bmatrix}_{4H\times 2}$ and $\begin{cases} \hat{\boldsymbol{\Sigma}} = \begin{bmatrix} \hat{\sigma}_{ss} & \hat{\sigma}_{st} \\ \hat{\sigma}_{st} & \hat{\sigma}_{tt} \end{bmatrix} \\ \hat{\boldsymbol{\Sigma}}_R = \begin{bmatrix} \hat{\sigma}_{ss} & -\hat{\sigma}_{st} \\ -\hat{\sigma}_{st} & \hat{\sigma}_{tt} \end{bmatrix} \end{cases}$ where $\begin{cases} \hat{\sigma}_{ss} = \operatorname{cov}(\hat{\underset{\sim}{\boldsymbol{\alpha}}}, \hat{\underset{\sim}{\boldsymbol{\alpha}}}) \\ \hat{\sigma}_{st} = \operatorname{cov}(\hat{\underset{\sim}{\boldsymbol{\alpha}}}, \hat{\underset{\sim}{\boldsymbol{\beta}}}) \\ \hat{\sigma}_{tt} = \operatorname{cov}(\hat{\underset{\sim}{\boldsymbol{\beta}}}, \hat{\underset{\sim}{\boldsymbol{\beta}}}) \\ \underset{\sim}{\boldsymbol{1}} \text{ is an } (N\times 1) \\ \quad \text{vector of ones} \end{cases}$.

[3] Randomly draw with replacement H rows from Λ to form a matrix $\boldsymbol{\Lambda}^* = [\delta_{hi}]_{H\times 2}$.

[4] Compute $\boldsymbol{\Pi} = (1+h^2)^{-0.5} \left(\boldsymbol{\Lambda}^* + h\boldsymbol{\Psi}^* - \boldsymbol{J} \begin{bmatrix} \bar{\delta}_{\bullet s} & 0 \\ 0 & \bar{\delta}_{\bullet t} \end{bmatrix} \right) + \boldsymbol{J} \begin{bmatrix} \bar{\delta}_{\bullet s} & 0 \\ 0 & \bar{\delta}_{\bullet t} \end{bmatrix}$, where $\boldsymbol{\Pi} = [\pi_{hi}]_{H\times 2}$, $h = (4/5H)^{1/6}$, $\bar{\delta}_{\bullet i} = H^{-1} \sum_{h=1}^{H} \delta_{hi}$ (i = s, t), $\boldsymbol{J} = [\underset{\sim}{\boldsymbol{1}} \;\; \underset{\sim}{\boldsymbol{1}}]_{H\times 2}$, and $\boldsymbol{\Psi}^*$ is an (H×2) matrix with the hth row to

be a random draw from bivariate normal $N(\underset{\sim}{\mathbf{0}}, \hat{\Sigma})$ if the hth row of Λ^* was drawn from $\begin{bmatrix} \hat{\underset{\sim}{\alpha}} & \hat{\underset{\sim}{\beta}} \\ 2\underset{\sim}{\mathbf{1}} - \hat{\underset{\sim}{\alpha}} & 2\underset{\sim}{\mathbf{1}} - \hat{\underset{\sim}{\beta}} \end{bmatrix}$, or a random draw from bivariate normal $N(\underset{\sim}{\mathbf{0}}, \hat{\Sigma}_R)$ if the hth row of Λ^* was drawn from $\begin{bmatrix} 2\underset{\sim}{\mathbf{1}} - \hat{\underset{\sim}{\alpha}} & \hat{\underset{\sim}{\beta}} \\ \hat{\underset{\sim}{\alpha}} & 2\underset{\sim}{\mathbf{1}} - \hat{\underset{\sim}{\beta}} \end{bmatrix}$.

[5] For each element π_{hi} of Π, define $\pi^*_{hi} = \begin{cases} 2 - \pi_{hi}, & \text{if } \pi_{hi} < 1 \\ \pi_{hi}, & \text{if } \pi_{hi} \geq 1 \end{cases}$.

[6] set $\underset{\sim}{x}^*_{hi} = \underset{\sim}{x}_{hi}$ and $\underset{\sim}{y}^*_{hi} = (\hat{D}^i_h)^{-1} \underset{\sim}{y}_{hi} \big/ \pi^*_{hi}, \; h = 1, \ldots, H; \; i = s, t$.

[7] Calculate the bootstrap estimates $\hat{D}^{s|i}_{h^*}$ and $\hat{D}^{t|i}_{h^*}$ by the CCR model with technology $(\mathbf{X}^*_i, \mathbf{Y}^*_i)$, where $\mathbf{X}^*_i = \left[\underset{\sim}{x}^*_{1i}, \ldots, \underset{\sim}{x}^*_{Hi} \right]$ and $\mathbf{Y}^*_i = \left[\underset{\sim}{y}^*_{1i}, \ldots, \underset{\sim}{y}^*_{Hi} \right]$ for i = s, t.

[8] Redo the above steps [3]~[7] B times to get bootstrap estimates $\{\hat{D}^{s|s}_{h^*b}\}^B_{b=1}$, $\{\hat{D}^{s|t}_{h^*b}\}^B_{b=1}$, $\{\hat{D}^{t|t}_{h^*b}\}^B_{b=1}$, and $\{\hat{D}^{t|s}_{h^*b}\}^B_{b=1}$ for h = 1,…, H.

After obtaining bootstrap samples of $\{\hat{D}^{s|s}_{h^*b}\}^B_{b=1}$, $\{\hat{D}^{s|t}_{h^*b}\}^B_{b=1}$, $\{\hat{D}^{t|t}_{h^*b}\}^B_{b=1}$, and $\{\hat{D}^{t|s}_{h^*b}\}^B_{b=1}$ for h = 1,…, H, we can use equation (8) ~ (10) to construct the corresponding bootstrap samples of Malmquist TFP indices such as $\{\hat{M}^{s\to t}_{h^*b}\}^B_{b=1}$, $\{\widehat{TC}^{s\to t}_{h^*b}\}^B_{b=1}$, and $\{\widehat{Ef}^{s\to t}_{h^*b}\}^B_{b=1}$ for h = 1,…, H. Then we can construct confidence intervals for output distance functions and Malmquist TFP indices.

Take $M^{s\to t}_h$ as an example. If we knew the distribution of $(\hat{M}^{s\to t}_h - M^{s\to t}_h)$, it is easy to find the values a and b such that

$$\text{Prob}\left(a \leq (\hat{M}^{s\to t}_h - M^{s\to t}_h) \leq b\right) = (1-\alpha) \tag{11}$$

to obtain the (1–α)% of confidence interval of $M^{s\to t}_h$. Fortunately, the bootstrap sample $\{\hat{M}^{s\to t}_{h^*b}\}^B_{b=1}$ offers an empirical distribution of $(\hat{M}^{s\to t}_{h^*} - \hat{M}^{s\to t}_h)$ and allow us to locate the values a* and b* such that

$$\text{Prob}\left(a^* \leq (\hat{M}^{s\to t}_{h^*} - \hat{M}^{s\to t}_h) \leq b^*\right) = (1-\alpha). \tag{12}$$

Since $(\hat{M}^{s\to t}_h - M^{s\to t}_h)$ approximates $(\hat{M}^{s\to t}_{h^*} - \hat{M}^{s\to t}_h)$, we use the bootstrap approximation

$$\text{Prob}\left(a^* \leq (\hat{M}^{s\to t}_h - M^{s\to t}_h) \leq b^*\right) \approx (1-\alpha) \tag{13}$$

to get an estimated (1–α)-percent confidence interval of $M^{s\to t}_h$ as:

$$[(\hat{M}^{s\to t}_h - b^*), \quad (\hat{M}^{s\to t}_h - a^*)] \tag{14}$$

3. Empirical Analysis

3.1 Data and Input-Output variables

The dataset, obtained from the annual *Operating Report of International Tourist Hotel in Taiwan* published by the Taiwan Tourism Bureau during 2010-2015, consists of 67 ITHs and 402 observations. All nominal variables are deflated by the tourist price index with 2011 as the base year. This study includes four inputs and three outputs. Four Inputs are: (1) The number of employees (including guest rooms, catering, and management staff); (2)The number of guest rooms; (3) Areas of the F&B department; (4) Other expenditures (containing water and electricity fuel expenses, F&B costs, insurance premium, and maintenance and repair costs). Three outputs include: (1) Revenues of guest rooms; (2) Revenues of F&B, consisting of that from sales of food, snacks, alcohol, and beverages in the dining room, coffee room, banquet room, and night club; (3) Other revenues, including operating revenues from the lease of store spaces, laundry, swimming pool, ball courts, barbershop, beauty salons, bookstores, etc. Table 1 reports the descriptive statistics of the inputs and outputs used in the analysis.

Table 1. **Descriptive Statistics of Inputs and Outputs (2010-2015)**

	Mean	Std. Dev.	Min	Max
Input variables				
Number of employees (persons)	323.18	207.38	43.00	1,058.00
Area of F&B department (square feet)	3,819.68	4,424.25	210.00	52,966.00
Number of guest rooms (number of rooms)	292.69	151.68	50.00	865.00
Other expenditures (NT$ million)	265.85	244.29	18.06	1,302.41
Output variables				
Revenues of guest rooms (NT$ million)	256.67	199.78	31.75	1,145.87
Revenues of F&B (NT$ million)	280.94	281.70	8.84	1,456.26
Other revenues (NT$ million)	79.92	123.71	0	757.40

Note: All nominal variables are deflated by the tourist price index with 2011 as the base year.

Input and output variables in the DEA model should satisfy the property of isotonicity - that is, increased inputs cannot reduce outputs. Table 2 presents the Pearson correlation coefficients of input and output variables. All values are significantly positive at the 0.1% level of significance, indicating that our selected input and output variables indeed meet the property of isotonicity.

Table 2. **Pearson Correlation Coefficients between Input and Output Variables**

	Number of employees	Area of F&B department	Number of guest rooms	Other expenditures
Revenues of guest rooms	0.8545(< 0.001)	0.4613(< 0.001)	0.8116(< 0.001)	0.8722(< 0.001)
Revenues of F&B	0.9160(< 0.001)	0.4462(< 0.001)	0.6556(< 0.001)	0.8395(< 0.001)
Other revenues	0.7035(< 0.001)	0.3178(< 0.001)	0.4426(< 0.001)	0.6098(< 0.001)

Note: Values in parentheses are *p*-value, and all correlation coefficients are significant at the 0.1% level of significance.

3.2 Empirical Results

The output-oriented efficiency, technology, and TFP change estimates from 2011 to 2015 are reported in Table 3, Table 4, and Table 5, respectively. We employed the bootstrap methods, proposed by Simar and Wilson (1999) and outlined in section two, to obtain estimates of bias and variance, and to test for significant differences from unity, while setting B = 2,000 as suggested by Simar and Wilson (1998, 1999). Comparing the variance and estimated biases, this study found that most of the bias correction for the TFP, efficiency, and technology change indices would increase mean-square error and hence, we do not report the bias corrected estimates. Since this study construct output-oriented MPI, numbers greater than unity represent progress, while numbers less than unity symbolize regress. In addition, we use single asterisks (*) and double asterisks (**) to indicate significantly different from unity at the 10% and 5% level of significance, respectively.

Examining efficiency changes between all successive pairs of year in Table 3, the traditional method suggests that there are 106 and 118 observations experienced efficiency improvement and regression, respectively, while the bootstrap result reveals that they are only 32 and 38, respectively. In all, of the 224 estimates of efficiency change reported in Table 4 that are not equal to unity, only 70 (31.25%) are significant at 10% level of significance. It is apparent to overstating the situation of changes in efficiency of Taiwan's ITHs.

It is even worse for changes in technology. There is almost no technology change estimate in

Table 4 to be unitary and among them, there are 133 and 134 observations encountered technology enhancement and deterioration, respectively. In all, of the 267 estimates of technology change reported in Table 4 that are not equal to unity, only 34 (12.73%) are significant at 10% level of significance.

Turning to the results for TFP change index in Table 5, traditional method indicates that all observations are different from unitary and among them, there are 135 and 133 observations experienced TFP augmentation and descents, respectively. However, bootstrap results argue that there are only 33 and 134 observations encountered TFP enrichment and decreases, respectively.

Table 3. **Changes in efficiency**

DMU	2011/12	2012/13	2013/14	2014/15	DMU	2011/12	2012/13	2013/14	2014/15
1	1.2859	0.8495**	0.8600*	1.0146	35	1.1699**	0.7439**	0.8827**	1.2071**
2	1.0384	1.0000	1.0000	1.0000	36	1.0297	0.9425	1.0710	1.0037
3	1.1054	1.0299	1.1005	1.0122	37	0.9405	0.9510	1.1176	0.9603
4	1.0436	0.9955	0.9367	0.9401	38	0.9345*	1.0074	0.9744	1.0556
5	1.2071**	0.9903**	0.7976**	1.3136**	39	0.9931	0.8648	1.0177	1.0276
6	1.2405**	0.8618	0.9898	0.9922	40	0.9772	1.1035	1.0091	0.9472
7	1.1489*	1.0000	1.0000	1.0000	41	0.9797	0.9818	1.0261	0.9322
8	1.1223	0.9345	0.9098	1.1692**	42	0.9177	0.9455	1.0405	0.9875
9	0.9873	0.9753	0.9694	0.9665	43	1.1221	0.9720	1.1675	0.8904**
10	1.0000	1.0000	1.0000	1.0000	44	1.0000	1.0000	1.0000	1.0000
11	1.2322**	1.0000	1.0000	0.8306**	45	1.1348	0.9281	1.3813**	0.8887**
12	1.0346	0.9592	0.9179	0.9705	46	0.9048*	1.0136	1.1383*	0.9349
13	1.1249**	1.0000	1.0000	1.0000	47	0.8692**	0.8740**	0.9784	1.1534**
14	1.0699	0.9798	1.0206	0.8232**	48	1.0944	1.0310	0.9898	1.1744**
15	1.0890	1.1131	0.9760	1.0246	49	0.8862	0.9357	1.1768**	1.0106
16	1.0416	0.9127	0.9803	1.0153	50	1.2556**	0.9907	1.0562	1.0429
17	0.9219	0.8852**	1.3224**	0.7683*	51	0.7991**	1.2967**	1.1044*	0.9482
18	1.0000	1.0000	1.0000	1.0000	52	1.0000	1.0000	1.0000	1.0000
19	1.0418	1.0000	1.0000	0.9226	53	1.0662	0.9777	1.0228	1.0000
20	1.0120	0.9061	0.9504	0.9607	54	1.4299**	1.2438**	0.8968**	1.1028*
21	0.6894**	1.0043	1.3688**	0.8577	55	1.0000	1.0000	1.0000	1.0000
22	0.7812**	0.9638	1.1440	0.9182	56	0.9583	1.0203	1.0378	1.0368
23	0.9094	0.9979	1.0399	0.9384	57	1.0031	1.0618	1.0207	1.1053
24	1.0000	1.0000	1.0000	1.0000	58	0.9479*	0.8765**	1.0035	0.9520
25	0.8501**	0.9612	0.9717	0.8897	59	1.1178**	1.0000	1.0000	1.0000
26	1.1027	0.8475**	0.7217**	0.8088**	60	0.9185**	0.9117**	0.8661*	0.8424**
27	1.0959	0.9518	0.9676	0.9171	61	0.8982	1.0805	1.1442**	0.8294**
28	0.9903	0.9104*	0.9768	0.9407	62	1.2326**	0.9685	0.9327	0.9883
29	1.3552**	1.0000	1.0000	1.0000	63	1.4653**	1.0896**	1.3416**	1.1328*
30	0.9539	1.1114	0.8466**	0.8144**	64	1.2130	0.9797	1.0221	1.0453
31	1.0078	0.9884	1.0976	0.9047	65	1.1008	0.9739	0.9014**	1.0342
32	0.9830	0.9834	1.0328	0.7885**	66	1.0500	1.0469	1.0711	1.0270
33	1.1198	1.0334	0.9836	0.9205	67	1.1826**	0.9646	1.1379**	0.7684**
34	1.0578	1.0226	0.6900**	1.0823					

Note: Single asterisks (*) and double asterisks (**) indicate significantly different from unity at the 10% and 5% level of significance, respectively.

In summary, traditional Malmquist methodology, based on estimations of distance functions made through DEA models, a non-stochastic procedure, does not provide any insight into the statistical significance of its results and could sometimes lead to biased results

IV. Conclusions

Due to the rapid development of the international tourist market, the topic of the internationalization of ITHs has attracted many scholars. The Malmquist productivity index, proposed by Fare et al. (1994), is commonly used to measure TFP. One major problem is that the Malmquist index is primarily based on the DEA method, which is a non-statistical technique and thus does not take into account the error of measurement in the estimation of efficiency and thus, does not provide any insight into the statistical significance of its results. Hence, our study employs the bootstrapped method, proposedby Simar and Wilson (1999) which takes into account the time-dependence structure of the data, to analyze the TFP change and its components of Taiwan's ITHs.

The dataset, obtained from the annual *Operating Report of International Tourist Hotel in Taiwan* published by the Taiwan Tourism Bureau during 2010-2015, consists of 67 ITHs and 402 observations. Empirical results indicate that it is apparent to overstating the situation of changes in efficiency of Taiwan's ITHs, and even worse in the case of changes in technology.

Table 4. **Changes in technology**

DMU	2011/12	2012/13	2013/14	2014/15	DMU	2011/12	2012/13	2013/14	2014/15
1	0.9879	1.0197	1.0722	0.9715	35	0.8275**	1.0812	1.0525	0.9357
2	1.0446	1.0436	0.9592	1.0714	36	0.9526	1.0220	1.0401	0.9936
3	0.8064**	1.1074	0.9127	1.0563	37	1.0183	0.9947	0.9245	0.9878
4	0.9000	1.0257	1.0598	1.0360	38	0.9346	1.0485	1.0528	0.9555
5	0.8659**	1.0685	1.1585*	0.8413	39	0.9281	1.0456	0.9430	0.9738
6	0.8228**	1.0610	1.0777*	0.9406	40	0.9622	0.9947	1.0145	1.0176
7	0.8321*	1.1493	0.9242	0.9577	41	0.9838	1.0318	0.9871	1.0684
8	0.8617**	1.0719	1.1218**	0.9137	42	0.9768	1.0063	0.9998	1.0627
9	1.0310	0.9941	0.9693	1.0286	43	0.8086**	1.0739	1.0049	0.9610
10	0.9494	1.0196	1.0662	1.0725	44	1.0589	1.0197	1.0221	0.9491
11	0.8482	1.0771	1.1487	0.9064	45	0.9293	1.0118	1.0564	0.9311
12	0.9482	1.0019	1.0128	1.0331	46	0.9230	0.9750	0.9977	1.0557
13	0.9032*	1.0368	1.0657	0.9402	47	0.8499**	1.0571	1.1158**	0.9005*
14	0.9561	1.0324	0.9037	1.1596	48	0.9200	1.0461	0.9639	1.0008
15	0.9553	0.9961	1.0257	1.0762	49	0.9739	0.9757	0.9439	0.9973
16	0.9727	1.0094	1.1039	0.9733	50	0.7984*	1.0483	0.9839	1.0243
17	0.8878*	1.0343	0.9222	1.2798**	51	0.9642	1.0085	0.9068	1.1349
18	1.0121	0.9846	0.9754	0.9665	52	0.9940	0.9324	1.0367	0.9315
19	0.9845	1.0114	1.0010	1.0825	53	0.9459	0.9945	1.0418	1.2460
20	0.9369	1.0179	0.9701	1.0088	54	0.9819	0.9644	1.0514	1.0130
21	0.7620	1.0559	0.8883	1.1198	55	0.7862*	1.0168	1.0078	0.9723
22	1.2403**	0.9936	1.0110	0.9867	56	0.7935**	1.0645	1.0190	0.9680
23	1.1110	0.9915	1.0242	1.0123	57	0.9933	1.0061	1.0322	1.0323
24	1.0454	1.0617	0.9121	1.0375	58	0.7411**	1.0692	1.0576	0.9609
25	0.9688	1.0355	0.9687	1.1280	59	0.9979	0.9912	1.1454**	0.8132**
26	0.9454	1.0098	1.0201	1.1118	60	0.8916**	1.0561	1.1319**	0.9509
27	0.9309	1.0388	0.9737	1.0502	61	0.9760	0.9631	0.9226	1.0588
28	0.9333	1.0253	1.0402	1.0172	62	0.8226**	1.0700	1.0948*	0.9310
29	1.7312**	0.9236	0.9966	1.0234	63	0.8551	1.0668	1.0057	0.9951
30	0.9375	1.0040	1.0232	1.1114	64	0.8434**	1.0353	1.0912	0.9391
31	0.9683	1.0268	0.9300	1.1095	65	0.8703**	1.0629	1.0869*	0.9769
32	0.9735	0.9715	0.9007*	1.1545	66	0.9874	0.9624	0.9065	0.9943
33	0.8998	1.0273	1.0293	1.0025	67	0.9245	1.0000	0.9119**	1.1945**
34	0.8697	1.0482	1.1025	0.9108					

Note: Single asterisks (*) and double asterisks (**) indicate significantly different from unity at the 10% and 5% level of significance, respectively.

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Table 5. **Changes in TFP**

DMU	2011/12	2012/13	2013/14	2014/15	DMU	2011/12	2012/13	2013/14	2014/15
1	1.2703**	0.8663**	0.9220**	0.9858	35	0.9681	0.8043**	0.9290**	1.1295**
2	1.0847**	1.0436**	0.9592	1.0714	36	0.9809**	0.9633**	1.1139**	0.9973
3	0.8913	1.1405**	1.0044**	1.0692**	37	0.9577	0.9459**	1.0332	0.9486**
4	0.9393**	1.0211**	0.9927	0.9739	38	0.8734**	1.0562**	1.0258**	1.0087**
5	1.0452**	1.0581**	0.924**	1.1051**	39	0.9217**	0.9042**	0.9597**	1.0007
6	1.0208**	0.9144**	1.0667**	0.9332*	40	0.9403**	1.0976**	1.0237	0.9639**
7	0.9560	1.1493**	0.9242**	0.9577**	41	0.9638**	1.0130	1.0129	0.9959
8	0.9670**	1.0017	1.0206*	1.0683**	42	0.8964**	0.9515**	1.0402**	1.0494**
9	1.0179	0.9695**	0.9396**	0.9941	43	0.9073**	1.0438**	1.1733**	0.8556**
10	0.9494**	1.0196**	1.0662**	1.0725**	44	1.0589	1.0197*	1.0221**	0.9491**
11	1.0451**	1.0771**	1.1487**	0.7529**	45	1.0546**	0.9390	1.4593**	0.8274**
12	0.9810	0.9610**	0.9296*	1.0026	46	0.8351**	0.9883	1.1357**	0.9870**
13	1.0161**	1.0368**	1.0657**	0.9402**	47	0.7387**	0.9240**	1.0917**	1.0387**
14	1.0229	1.0115	0.9223**	0.9546**	48	1.0069	1.0786**	0.9541**	1.1754**
15	1.0403**	1.1087**	1.0011	1.1026**	49	0.8631**	0.9130**	1.1108**	1.0079
16	1.0132	0.9213**	1.0821**	0.9882	50	1.0024	1.0385**	1.0392**	1.0682
17	0.8185**	0.9156**	1.2196**	0.9833	51	0.7705**	1.3078**	1.0015*	1.0762**
18	1.0121	0.9846	0.9754	0.9665**	52	0.9940	0.9324**	1.0367**	0.9315**
19	1.0257**	1.0114	1.0010	0.9987	53	1.0085	0.9724**	1.0655**	1.2460**
20	0.9481**	0.9223**	0.9220**	0.9691	54	1.4041**	1.1995**	0.9429**	1.1171**
21	0.5253**	1.0605**	1.2159**	0.9605	55	0.7862**	1.0168**	1.0078*	0.9723**
22	0.9689**	0.9575**	1.1566**	0.9060**	56	0.7604**	1.0862**	1.0575**	1.0037
23	1.0103	0.9894	1.0651**	0.9500**	57	0.9963	1.0683**	1.0536**	1.1410*
24	1.0454**	1.0617**	0.9121**	1.0375	58	0.7025**	0.9372**	1.0614**	0.9148**
25	0.8236**	0.9953	0.9413**	1.0036	59	1.1155**	0.9912	1.1454**	0.8132**
26	1.0425**	0.8558**	0.7363**	0.8992**	60	0.8189**	0.9628**	0.9804	0.8010**
27	1.0202	0.9887**	0.9421**	0.9632	61	0.8766**	1.0406**	1.0556**	0.8782**
28	0.9243**	0.9334**	1.0161*	0.9569	62	1.0139**	1.0362**	1.0211**	0.9202**
29	2.3461**	0.9236**	0.9966*	1.0234	63	1.2530**	1.1624**	1.3493**	1.1272**
30	0.8943**	1.1159**	0.8663**	0.9052	64	1.0230	1.0143	1.1153**	0.9816**
31	0.9758**	1.0149	1.0208**	1.0038	65	0.9580**	1.0352**	0.9797**	1.0103**
32	0.9569**	0.9554**	0.9302**	0.9104**	66	1.0367	1.0075	0.9710**	1.0212**
33	1.0076	1.0616	1.0124	0.9228**	67	1.0933**	0.9646**	1.0376**	0.9179**
34	0.9200**	1.0718**	0.7608**	0.9857**					

Note: Single asterisks (*) and double asterisks (**) indicate significantly different from unity at the 10% and 5% level of significance, respectively.

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