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Efficiency and Productivity of Major Asia-Pacific Telecom Firms*

Jin-Li Hu** Wei-Kai Chu***

Abstract

This paper studies the impacts of industrial policy on efficiency and productivity of Asia-Pacific telecom firms under circumstances of competition and privatization. A two-stage method is applied to examine the efficiency scores of twenty-four telecom firms in APEC member economies during the period 1999-2004. The data envelopment analysis (DEA) is used in the first stage to measure the technical efficiency of these companies. In the second stage inefficiency scores obtained from the first stage are regressed upon the environmental variables with the Tobit regression. Finally, the Malmquist productivity index is employed to evaluate the longitudinal total factor productivity (TFP) changes. Scale and scope economies have significantly positive impacts on the efficiency improvement of Asia-Pacific telecom firms, but the influence of market competition and privatization to their telecommunications performance are insignificant. The TFP growth of these telecom firms is mainly due to technical innovation instead of from technical efficiency change.

Keywords: Productivity, Efficiency, Competition, Scale economy, Scope economy

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** Professor and Director, Institute of Business and Management, National Chiao Tung University, E-mail: jinlihu@yahoo.com.

*** Assistant Professor, Department of Finance, China University of Technology.

1. Introduction

The millennium 2000 was a watershed in Asia-Pacific telecommunications development. While most of their western counterparts were trapped in the Internet bubble, Asia-Pacific telecom operators took bold steps forward to embrace the shower of innovative technology. They introduced and promoted new services such as broadband access and wireless applications in an attempt to level up the declining revenue from their fixed-line business.

The strategy worked and the endeavors have paid off handsomely. After striving hard these past years, Asia-Pacific telecom firms have gradually played an important role on the stage of broadband and mobile telecommunications markets. According to the data of ITU (2004), of the top ten leading broadband economies, five are from the Asia-Pacific region. South Korea with a 23.3% penetration rate had the highest broadband adoption rate in 2003, followed by Hong Kong (18.0%), Canada (14.7%), Iceland (14.0%), Taiwan (13.4%), Denmark (13.3%), Japan (11.7%), Switzerland (11.4%), the Netherlands (11.4%), and Sweden (10.8%).

The same results blossomed in the mobile segments. Although Asia-Pacific telecom firms embarked on mobile businesses later than European operators, they are now striding toward a new milestone. ITU data (2004) reported that as of December 2003 there were 114.14 subscribers per 100 habitants in Taiwan, 107.92 in Hong Kong, and 85.25 in Singapore. These performance figures are comparable to the level of a developed country, not to mention the fact that the total number of mobile users in the Asia-Pacific region has surpassed many other areas.

The above facts show that newly-developed technology has created abundant revenues for Asia-Pacific telecom firms and put them on the frontier in new business activities. This process of technical innovation might not be the only source of performance improvement in the Asia-Pacific telecommunications industry. Many academic researchers have pointed out that improvement could also be attributed to the contemporarily developed process of policy reforms such as liberalization and privatization.

Over the past ten years, there have been many academic studies on the relation of policy reforms and industry productivity. These studies have focused mainly on the regions of the U.S. and Europe. For example, Gort & Sung (1999) explore the case of the U.S. telephone industry in competition and productivity growth. Koski & Majumdar (2000) study the efficiency convergence in telecommunications infrastructure development in OECD countries. Lien and Peng (2001) examine competition and production efficiency for telecommunications in OECD countries.

Research interests have gradually shifted to developing countries. Fink et al. (2003) analyze the impact of policy reforms in developing countries on telecommunications performance. Lam & Lam (2005) evaluate the total factor productivity growth for Hong Kong Telephone Company. Lee et al. (2000) investigate the efficiency change of a big Korean telecom firm after the introduction of a competitive market system. Heracleous (2001) focus on a Singapore telecom firm as a case and discuss whether privatization can lead to superior performance. However, related studies on the productivity of Asia-Pacific telecommunications are still limited and in a discrete way. There seems to be a lack of a perspective to systematically grab the rising tendency of this area.

In addition to policy reforms, there are other environmental factors which may be potential contributors to the efficiency enhancement. The most probable factors come from the characteristics of the telecom firms themselves. The telecommunications industry shares a number of important characteristics with other network industries, such as electricity and gas. They include heavy sunk costs, economies of scale and scope, ubiquitous connections, and technological change and convergence.

The characteristics mentioned above have implications for economic efficiency and the performance of the telecommunications sectors. For example, the enormous sunk costs on the one hand can deter competitors from entering the market, while on the other hand, rapid changes and new technology might at any time make these costs obsolete and become the source of operation inefficiency.

All these issues have long been important managerial challenges for the telecommunications industry and the main topics for academic research. Section 2 constructs the conceptual framework of hypotheses. Section 3 presents the methodology and data sources. Section 4 analyzes the empirical results. Section 5 concludes this study.

2. Research Hypotheses

The role of competition as a mechanism to stimulate efficiency has been emphasized in the relevant literature. Gort & Sung (1999) compare the productivity of AT&T, operating in an increasingly competitive market, with that of eight U.S. local telephone monopolies. A faster efficiency change exists for a competitive market than for the local monopolies. Ros (1999) exploits data from ITU to examine the effects of competition and privatization on network expansion and efficiency during 1986-1995. Lien & Peng (2001) examine the production efficiency of telecommunications in twenty-four OECD countries. They presented that countries allowing competition are more efficient than those countries in a less competitive environment.

Competition generally means more information transparency, thus lowering the transaction cost for firm managers to obtain the needed information of prices and profits. This in turn helps them in determining adequate inputs needed to compete effectively in the market. Therefore, this study has the following hypothesis.

Hypothesis 1: Competition has a positive effect on the technical efficiency improvement of Asia-Pacific telecom firms.

Bortolotti et al. (2002) employ pre-privatization versus post-privatization panel data to compare the operating performance of thirty-one telecommunications companies that were fully or partially privatized. Fink et al. (2003) analyze the impact of privatization, competition, and regulation on the performance of the telecommunications sectors in eighty-six developing countries during 1985-1999. Results show that both competition and privatization lead to significant improvements in performance and the sequence of reform matters. Li et al. (2004) derive a theoretical framework to explore the performance of forty-three banks including public, private, and mixed types. They found that public firms have higher efficiencies versus those of private and mixed ones when the market is imperfect. Mixed firms enjoy higher technical efficiencies than others when agency cost is high. Private firms have higher efficiencies than others when the market is relatively perfect.

Under public ownership, non-commercial objectives are likely to be pursued and individuals may have less incentive to exert their own effort to use resources efficiently. Private ownership, on the other hand, is equated with a higher level of management supervision and a sole objective of profit maximization. This study thus proposes the following hypothesis.

Hypothesis 2: Privatization has a positive effect on the technical efficiency improvement of Asia-Pacific telecom firms.

Banker et al. (1998) examine the economies of scope in U.S. local telephone companies. They found that multiple outputs from single telecom resources lead to a reduction of cost and an increase of efficiency. Based on this rationale, a higher fixed-line revenue ratio, while representing a low scope economy, would have a negative influence on the efficiency of telecom firms. This study thus proposes the following hypothesis.

Hypothesis 3: A higher fixed-line revenue ratio has a negative influence on the technical efficiency improvement of Asia-Pacific telecom firms.

Comparing with other industries, the telecom industry is known for its large amount of capital. This is exhibited in the form of equipment, plant, land, and buildings. All these assets are demanded in the provision of services. A large telecommunications firm has more business resources, allowing it to easily operate economies of scope and develop new services. As a result, a higher firm size might have a positive influence on the efficiency of Asia-Pacific telecom firms. Therefore, this study proposes the following hypothesis.

Hypothesis 4: A larger firm size has a positive influence on the technical efficiency improvement of Asia-Pacific telecom firms.

Uri (2002) measures the productivity changes of U.S. local exchange carriers for the period 1988-1999. He found that productivity increased by about 5.5% per year. The growth is due primarily to technical change and improvements in efficiency. As for

Asia-pacific telecom firms, some discussions have already observed their success in deploying new technology and creating more revenue. Therefore, this study proposes the following hypothesis.

Hypothesis 5: There exists a significant improvement of productivity in Asia-Pacific telecom firms during 1999 to 2004.

3. Method and Data

Coelli et al. (1998) recommend a two-stage method to include the influence of environmental factors into efficiency analysis. The following analysis adopts this method to explore the hypotheses discussed in the previous section: Data envelopment analysis (DEA) is used in the first stage to evaluate the technical efficiencies of Asia-Pacific telecom firms. In the second stage inefficiency scores obtained from the first stage are regressed upon the environmental variables with Tobit regression. Finally, the Malmquist productivity index is employed to evaluate the longitudinal total factor productivity (TFP) changes.

3.1 Data Envelopment Analysis

Data envelopment analysis, which was first proposed by Charnes et al. (1978), is a non-parametric method of efficiency analysis. The method measures the relative efficiency for each decision making unit (DMU) by comparing its input and output data with all other DMUs in the same dataset. Known as the CCR model, this mathematical programming method can be expressed as:

$$\begin{aligned} \text{Min}_{\,\theta,\lambda} \quad & \theta \\ \text{subject to} \quad & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned} \tag{1}$$

where θ is the technical efficiency value; λ is the intensity weight; x_i is the K×1 input vector of the *i*th DMU; y_i is the M×1 output vector of the *i*th DMU; X is the K×N input matrix; and Y is the M×N output matrix.

The CCR model has an input orientation and assumes constant returns to scale (CRS), which is appropriate when all DMUs are operating at an optimal scale. The technical efficiency score obtained by the CCR model is called overall technical efficiency (OTE). However, imperfect competition, constraints on finance, etc., may prevent a DMU from operating at an optimal scale.

Banker et al. (1984) proposed an extension of the CRS DEA model to account for variable returns to scale (VRS). This is done by adding a convexity constraint, $N1'\lambda = 1$, to equation (1):

$$\begin{aligned} &\text{Min}_{\theta,\lambda} \quad \theta \\ &\text{subject to} \quad -y_i + Y\lambda \geq 0, \\ &\qquad \theta x_i - X\lambda \geq 0, \\ &\qquad N1'\lambda = 1, \\ &\qquad \lambda \geq 0, \end{aligned} \tag{2}$$

where N1 is an N×1 vector made up of ones.

The BCC model forms a convex hull of efficiency frontier which envelops the data points more tightly than the CCR model. It thus provides pure technical efficiency (PTE) scores which are no less than those obtained using the CRS model. The relation between these two efficiency values can be summarized as: OTE = PTE × SE, where the overall technical efficiency is decomposed into pure technical efficiency and scale efficiency (SE). It is the input-orientated VRS model that this study employs during the DEA stage. Generally speaking, firms can directly control inputs, but outputs usually are subject to production as well as market demand conditions.

3.2 Malmquist Productivity Index

The Malmquist total-factor productivity (TFP) index measures the TFP change between two data points by calculating the ratio of the distances of each point to a common technology. Following Färe et al. (1994), the input-orientated Malmquist TFP change index between period *t* (the base period) and period *t*+1 is given by:

$$m_i\left(y_t, x_t, y_{t+1}, x_{t+1}\right) = \frac{d_i^t(y_t, x_t)}{d_i^{t+1}(y_{t+1}, x_{t+1})}\left[\frac{d_i^{t+1}\left(y_{t+1}, x_{t+1}\right)}{d_i^t\left(y_{t+1}, x_{t+1}\right)} \times \frac{d_i^{t+1}\left(y_t, x_t\right)}{d_i^t\left(y_t, x_t\right)}\right]^{1/2}, \quad (3)$$

where the input distance function $d_i^t(y_{t+1}, x_{t+1})$ represents the distance from the period t+1 observation to the period t technology and $d_i^{t+1}(y_t, x_t)$ represents the distance from the period t observation to the period t+1 technology. The first part in the right-hand side of equation (3) measures the technical efficiency change between period t+1 and period t. The second part of the index is a measure of technical change.

Therefore, the total factor productivity change (TFPCH) can be decomposed into overall technical efficiency change (EFFCH) and technical change (TECHCH):

$$\text{TFPCH} = \text{EFFCH} \times \text{TECHCH}. \quad (4)$$

Under the circumstance of variable returns to scale (VRS), the overall technical efficiency change can be further decomposed into pure technical efficiency change (PECH) and scale efficiency change (SECH). Equation (5) can be rewritten as:

$$\text{TFPCH} = \text{PECH} \times \text{SECH} \times \text{TECHCH}. \quad (5)$$

An attractive feature of the Malmquist index is that it allows productivity to be decomposed into technological change or innovation (shifts in the frontier technology) and changes in technical efficiency (catch-up). In the subsequent empirical implementation of this study, variable returns to scale will be assumed.

For this input-based Malmquist models of productivity change, a number greater than one equals progress, of one equals no change, and less than one equals regress, conforming to the standard interpretation in most productivity literature.

3.3 Data Sources and Description

This dataset consists of annual observations on twenty-four APEC telecom firms during 1999-2004. These companies and their main service areas are summarized in Table 1. The criteria for selecting the 24 firms in this study are dominant operators with at least two types of services offered. The public annual reports are considered first in each area.

The research theme here is the contributions from traditional and innovative

Table 1: List of Twenty-Four Telecom Firms and Their Main Service Economies

DMU	Company	Economy	DMU	Company	Economy
1	BCE (Bell Canada Enterprises)	Canada	13	PLDT (Philippine Long Distance Telephone)	Philippines
2	CHT(Chunghwa Telecom)	Taiwan	14	Qwest	U.S.A.
3	CT (China Telecom)	China	15	SingTel	Singapore
4	CTC (Telefónica Chile)	Chile	16	Sprint	U.S.A.
5	Dacom	South Korea	17	TA (Telecom Asia)	Thailand
6	Digitel	Philippines	18	Telkom	Indonesia
7	Entel	Chile	19	Telmex	Mexico
8	Indosat	Indonesia	20	Telstra	Australia
9	KDDI	Japan	21	Telus	Canada
10	KT (Korea Telecom)	South Korea	22	TM (Telekom Malaysia)	Malaysia
11	NTT (Nippon Telegraph and Telephone)	Japan	23	TNZ (Telecom New Zealand)	New Zealand
12	PCCW (Pacific Century CyberWorks)	Hong Kong	24	TT&T (Thai Telephone & Telecommunication)	Thailand

services respectively made to the efficiency performance during these years. In the stage of data envelopment analysis, this study chooses revenues of fixed-line services and non-fixed-line services as output variables. Both are measured in millions of real US dollars (with the base year as 2000). Fixed-line revenue includes local, long distance, and international telephone, telegraph, and other traditional services which are mature and declining businesses. Non-fixed-line revenue includes mobile, data, Internet, and other new-generation services which are rapidly developing businesses.

As for input variables, the number of employees and the amount of fixed assets are chosen. The latter is also measured in millions of real US dollars. The number of employees and the amount of fixed assets are fundamental input factors in efficiency and productivity analysis. The quantity of labor is the number of full-time and part-time staff employed by the firm. The fixed assets are total assets minus current assets in the balance sheet. All input and output data are collected from the annual reports of Asia-Pacific telecom firms.

In the first stage, DEA is used to estimate 24 efficiency scores of telecom firms in every single year. In each year there are 24 firms and only two inputs and two outputs, which are sufficient for getting reliable results in data envelopment analysis. In DEA, the basic requirement of discriminative power is that the number of DMUs exceeds two times the number of input plus output items. Cooper et al. (1999) further offered a rough rule of thumb which can provide guidance: $n > \max\{m \times s, 3(m + s)\}$, where n = number of DMUs, m = number of inputs and s = number of outputs. This dataset (n = 24, m = 2, and s = 2) satisfies the above conditions.

Many traditional indicators can also be used to measure the productivity of telecom firms, such as capital and labor productivity, revenue per employee, lines per employee, and revenue per line. Readers interested in those productivity indicators and their international comparisons can refer to BIE research report (1995).

In the stage of Tobit regression, the inverse of the technical efficiency score minus one (i.e., $1/\theta - 1$), which is exactly the inefficiency level, is taken as the dependent variable. Four environmental factors including market concentration, public ownership, fixed assets ratio, and fixed-line revenue ratio are employed as explanatory variables. HHI (Herfindahl-Hirschman Index) is used to indicate the status of market competition. $HHI = \Sigma_{i=1..N}(S_i \times 100)^2$. N is the number of firms. S_i is firm i's market share of subscribers. The data of market share are collected from firms' annual reports or regulators' research reports. The range of HHI is between 0 and 10,000. A large HHI represents a status of monopoly or oligopoly, and when the market is getting closer to free competition, this index becomes smaller.

This study categorizes telecommunications services into mobile, broadband, and fixed-line markets. The market concentrations are HHI_m, HHI_b, and HHI_f, respectively. Public ownership, fixed asset ratio, and fixed-line revenue ratio are described as percentages. The ranges of them are between 0 and 100. The Tobit regressions use panel data (24 firms times 6 years, making in total 144 observations) to estimate the coefficients of several environmental variables.

The descriptive statistics of relevant variables are listed in Table 2 and the correlation coefficients of inputs and outputs are in Table 3. DEA requires that all outputs must not decrease with an increase in any input, which is named the isotonicity property. As shown in Table 3, the correlation coefficients are between 0.681 and 0.976. There exist significantly positive relations between inputs and outputs, satisfying the isotonicity property in which an output should not decrease with an increase in any input.

Table 2: Descriptive Statistics of Relevant Variables

Variable	Mean	Median	Maximum	Minimum	S.D.
1. Efficiency	0.592	0.566	1.000	0.191	0.233
2. Fixed-line revenue	5,413	1,843	52,545	86	9,334
3. Non-fixed-line revenue	4,383	1,358	50,621	2	9,060
4. Fixed assets	16,291	5,907	145,379	376	27,228
5. Employees	40,432	21,723	344,360	1,743	55,628
6. HHI_m	3,573	3,598	7,599	1,201	1,209
7. HHI_b	4,199	3,857	9,190	952	1,994
8. HHI_f	5,705	5,266	10,000	1,663	2,218
9. Public ownership	30.38	15.60	100.00	0.00	31.64
10. Fixed asset ratio	80.87	82.36	99.23	47.11	8.87
11. Fixed-line revenue ratio	60.89	58.61	98.06	14.71	17.71

Table 3: Correlation Coefficients of Inputs and Outputs

Variable	Fixed-line revenue	Non-fixed-line revenue	Fixed assets	Employees
Fixed-line revenue	1.000			
Non-fixed-line revenue	0.932	1.000		
Fixed assets	0.976	0.925	1.000	
Employees	0.830	0.681	0.821	1.000

4. Empirical Results

4.1 Efficiency Scores

The first stage of this analysis applies DEA to measure the efficiency scores of Asia-Pacific telecom firms. These scores include overall technical efficiency, pure technical efficiency, scale efficiency, and the status of returns to scale (RTS). For brevity, Table 4 only reports the 2004 results.

As shown in Table 4, the mean values of OTE and PTE are respectively 0.551 and 0.751 in 2004. Out of twenty-four telecom firms, two firms (KDDI of Japan and TNZ of New Zealand) stand on the efficiency frontier. Indosat in 1999, Telmax in 2000 to 2003, and KDDI and TNZ in all years are technically efficient, which are stable and consistent results. For all years during the study period, Table 5 lists the telecom firms under

Table 4: Efficiency Scores of Asia-Pacific Telecom Firms in 2004

No.	Firm	Area	OTE	PTE	SE	RTS
1	BCE	Canada	0.455	0.479	0.950	DRS
2	CHT	Taiwan	0.340	0.369	0.921	IRS
3	CT	China	0.574	0.805	0.713	DRS
4	CTC	Chile	0.594	0.876	0.678	IRS
5	Dacom	South Korea	0.480	1.000	0.480	IRS
6	Digitel	Philippines	0.191	1.000	0.191	IRS
7	Entel	Chile	0.552	1.000	0.552	IRS
8	Indosat	Indonesia	0.424	0.738	0.574	IRS
9	KDDI	Japan	1.000	1.000	1.000	CRS
10	KT	South Korea	0.608	0.610	0.996	DRS
11	NTT	Japan	0.620	1.000	0.620	DRS
12	PCCW	Hong Kong	0.577	0.695	0.830	IRS
13	PLDT	Philippines	0.353	0.536	0.659	IRS
14	Qwest	U.S.A.	0.801	0.904	0.886	DRS
15	SingTel	Singapore	0.298	0.324	0.920	IRS
16	Sprint	U.S.A.	0.589	0.603	0.976	DRS
17	TA	Thailand	0.374	0.724	0.516	IRS
18	Telkom	Indonesia	0.651	0.700	0.930	IRS
19	Telmex	Mexico	0.921	1.000	0.921	DRS
20	Telstra	Australia	0.681	0.747	0.912	DRS
21	Telus	Canada	0.401	0.415	0.966	IRS
22	TM	Malaysia	0.445	0.499	0.893	IRS
23	TNZ	New Zealand	1.000	1.000	1.000	CRS
24	TT&T	Thailand	0.292	1.000	0.292	IRS
	Mean		0.551	0.751	0.766	

constant returns to scale (CRS) and the number of telecom firms under decreasing returns to scale (DRS) and increasing returns to scale (IRS). Table 5 shows an increasing trend in the number of telecom firms under IRS.

In order to analyze further the effect that per capita GDP has on technical efficiency, this study categorizes twenty-four telecom firms into two groups according to the level of per capita GDP at ten thousand USD. The high GDP group includes 13 firms in the high-income areas and the low GDP group includes 11 firms. The

Table 5: Telecom Firms in CRS and the Number of Telecom Firms in DRS and IRS during 1999-2004

Year	Telecom firms under CRS	No. of telecom firms under DRS	No. of telecom firms under IRS
1999	Indosat, KDDI, TNZ	15	6
2000	KDDI, KT, Telmex, TNZ	8	12
2001	KDDI, Telmex, TNZ	4	17
2002	KDDI, Telmex, TNZ	5	16
2003	KDDI, Telmex, TNZ	6	15
2004	KDDI, TNZ	8	14

Mann-Whitney U test is now used to examine if there exist significant differences between the mean values of these two groups. From the *p*-values in Table 6, the results show that the average efficiency of telecom firms in wealthy areas is significantly better than that in developing areas.

4.2 Factors of Inefficiency

In the second stage of analysis, the inverse of overall technical efficiency scores minus 1 (INEFF) from the first stage is taken as the dependent variable of the Tobit regression. Six environmental factors, including market concentrations (HHI_m, HHI_b, and HHI_f), public ownership (PO), fixed-line revenue ratio (FR), and total assets (TA), are employed as explanatory variables, respectively. In order to explore further the non-linear effect, this study includes the quadratic terms of all explanatory variables to the regression models.

4.2.1 Market Competition

As mentioned above, the status of market competition is measured by the index of market concentration, HHI. Here, this study categorizes telecommunications services into mobile, broadband, and fixed-line markets to reflect different degrees of liberalization. The regression model of mobile market concentration HHI_m on the inefficiency of Asia-Pacific telecom firms is:

$$INEFF = \beta_0 + \beta_1 HHI_m + \beta_2 (\tfrac{1}{2} HHI_m^2) + u, \qquad (6)$$

where u is the error term.

Table 6: Mean Value Test of Efficiency between Telecom Firms of Different per Capita GDP Areas

Year	Mean rank (high GDP)	Mean rank (low GDP)	U-value	Z-statistic	*p*-value
1999	8.92	16.73	118.0	2.69	0.0035***
2000	10.31	15.09	100.0	1.65	0.0493**
2001	10.38	15.00	99.0	1.59	0.0555*
2002	10.62	14.73	96.0	1.42	0.0779*
2003	10.54	14.82	97.0	1.48	0.0698*
2004	10.62	14.73	96.0	1.42	0.0779*

Note: *: 10% significance level; ** 5% significance level; and ***: 1% significance level.

Suppose the estimated equation is $INEFF^* = b_0 + b_1HHI_m + b_2½HHI_m^2$. Here, $dINEFF^* / dHHI_m = b_1 + 2b_2X_i$. To test whether $dINEFF^* / dHHI_m \neq 0$, the hypotheses are H_0: $\beta_1 + 2\beta_2 HHI_m = 0$; H_1: $\beta_1 + 2\beta_2 HHI_m \neq 0$. Note that $var(b_1 + 2b_2X_i) = var(b_1) + 4 HHI_m^2 var(b_2) + 2 HHI_m cov(b_1,b_2)$. The test statistic is -1.9082. The p-value is 0.0564 and is statistically significant under the 10% level - that is, on average it has a negative relation between HHI_m and INEFF.

Because market competition means a movement towards a small HHI_m value, it therefore moves in the same direction with efficiency scores. Competition has a negative effect on the technical efficiency scores of Asia-Pacific telecom firms. Because mobile services are newly developed business streams, there are too many firms entering the market and creating competition. Using the same method, the influences of HHI_b and HHI_f's on INEFF are not significant. Hence, the results of regressions do not support Hypothesis 1. The effect of competition on technical efficiency is insignificant.

4.2.2 Public Ownership

Public ownership is a proxy variable included in the Tobit regression to estimate the effect of privatization on the efficiency of Asia-Pacific telecom firms. The coefficients of PO and PO^2 are insignificant under the 10% level. The data also do not reject the null hypothesis H_0: $\beta_1 + 2\beta_2$ PO = 0. This shows that the impact of privatization on efficiency is limited with a decrease of public ownership.

Privately-owned companies are more profit orientated and have less policy burdens, but there is no evidence to show that privatization helps promote efficiency. Therefore, the results of regression do not support Hypothesis 2. There is no evidence either to show that privatization has a positive effect on the technical efficiency improvement of Asia-Pacific telecom firms.

4.2.3 Fixed-Line Revenue Ratio

The regression model of the fixed-line revenue ratio (FR) on the inefficiency of Asia-Pacific telecom firms is:

$$INEFF = \beta_0 + \beta_1(FR) + \beta_2 (½\ FR^2) + u. \quad (7)$$

Suppose the estimated equation is $INEFF^* = b_0 + b_1FR + b_2½FR^2$. To test whether $dINEFF^* / dFR \neq 0$, the hypotheses are H_0: $\beta_1 + 2\beta_2\ FR = 0$; H_1: $\beta_1 + 2\beta_2\ FR \neq 0$. After calculation the test statistic is 2.9235. The p-value is 0.0035 and is statistically significant under the 1% level. That is, on average the fixed-line revenue ratio (FR) is positively related to INEFF and negatively related to efficiency score. Efficiency falls with an increase of the fixed-line revenue ratio. Therefore, the result of the regression supports Hypothesis 3: A higher fixed-line revenue ratio (representing a lower degree of scope economy) has a significantly negative impact on the technical efficiency of Asia-Pacific telecom firms.

4.2.4 Firm Size

The regression model of total assets (TA) on the inefficiency of Asia-Pacific telecom firms is:

$$INEFF = \beta_0 + \beta_1(TA) + \beta_2 (½\ TA^2) + u. \quad (8)$$

Suppose the estimated equation is $INEFF^* = b_0 + b_1(TA) + b_2(½TA^2)$. To test whether $dINEFF^* / dTA \neq 0$, the hypotheses are H_0: $\beta_1 + 2\beta_2\ TA = 0$; H_1: $\beta_1 + 2\beta_2\ TA \neq 0$. The test statistic is -2.1258. The p-value is 0.0335 and is statistically significant under the 5% level. That is, on average it has a negative relation between TA and INEFF. Therefore, total assets move in the same direction with efficiency scores. The result of the regression supports Hypothesis 4: A larger firm size has a significantly positive influence on the technical efficiency improvement of Asia-Pacific telecom firms.

According to the results in subsections 4.2.1 to 4.2.4, competition or privatization cannot increase firms' technical efficiency, but a larger firm scale and wider business scope advance the technical efficiency improvement of telecom firms. As a result, promoting economies of scope and scale should be better policies for strengthening the industrial advantages, rather than making a more competitive or a more privatized market structure.

4.3 Productivity Improvement

Values for overall technical efficiency change, technical change, pure technical efficiency change, scale efficiency change, and total factor productivity change are summarized in Table 7. The average annual factor productivity growth is 0.2% over the period 1999-2004. Compared with the negative growth during the first two years, it is noteworthy that the positive growth rate continued in the last three years. As shown in Table 7, the productivity growth is due primarily to technological innovation (techch) during 2002-2004, rather than improvements in efficiency (effch). Because there is only a 0.2% average annual TFPCH, the result does not support Hypothesis 5. Therefore, there is no significant improvement of productivity in Asia-Pacific telecom firms during 1999 to 2004.

In order to analyze further the changes in productivity of the individual Asia-Pacific telecom firms over the study period, Table 8 presents the respective productivity changes. Of the twenty-four object telecom firms, twelve operators improved their productivity, while eleven declined.

The three operators that reported declining scores the most are SingTel of Singapore, Telus of Canada, and CHT of Taiwan. The range of productivity change is between -13.7% and -6.7%. Probing into the reason for the decline, Table 8 shows that all telecom firms have low pure efficiency changes (pech). Among the declining companies, SingTel has a pure efficiency change of -18.7%, followed by Telus (-16.1%) and CHT (-13%). SingTel and Telus engaged in merger and acquisition activities during the research period, and they were both in the stage of enterprise adjustments.

Table 7: Malmquist Index of Annual Productivity Change: 1999-2004

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
1999-2000	0.984	0.942	0.903	1.089	0.927
2000-2001	0.951	1.026	1.021	0.931	0.976
2001-2002	0.915	1.134	0.988	0.926	1.038
2002-2003	0.994	1.030	1.017	0.977	1.023
2003-2004	1.003	1.049	1.026	0.978	1.052
Mean	0.969	1.034	0.99	0.978	1.002

Table 8: Malmquist Index of Average Annual Productivity Change for Telecom Firms: 1999-2004

No.	Firm	EFFCH	TECHCH	PECH	SECH	TFPCH
1	BCE	0.930	1.033	0.902	1.031	0.960
2	CHT	0.889	1.049	0.870	1.022	0.933
3	CT	1.013	0.966	1.046	0.969	0.979
4	CTC	1.085	1.034	1.156	0.938	1.122
5	Dacom	0.941	1.050	1.018	0.924	0.988
6	Digitel	0.970	0.969	1.008	0.962	0.939
7	Entel	0.978	1.056	1.082	0.904	1.032
8	Indosat	0.842	1.119	0.941	0.895	0.942
9	KDDI	1.000	1.091	1.000	1.000	1.091
10	KT	1.036	1.058	1.011	1.025	1.096
11	NTT	0.938	1.066	1.000	0.938	1.000
12	PCCW	0.947	1.018	0.977	0.969	0.964
13	PLDT	1.026	1.057	1.114	0.921	1.084
14	Qwest	0.995	1.048	0.980	1.016	1.043
15	SingTel	0.804	1.074	0.813	0.989	0.863
16	Sprint	0.966	1.076	0.926	1.043	1.040
17	TA	1.038	1.015	1.079	0.961	1.053
18	Telkom	1.042	1.020	1.051	0.992	1.063
19	Telmex	1.012	0.970	1.000	1.012	0.982
20	Telstra	0.959	1.026	0.943	1.016	0.983
21	Telus	0.836	1.038	0.839	0.996	0.867
22	TM	1.015	1.006	1.020	0.995	1.021
23	TNZ	1.000	1.020	1.000	1.000	1.020
24	TT&T	1.053	0.984	1.069	0.984	1.036
	Mean	0.969	1.034	0.990	0.978	1.002

Among those telecom firms under improvement, four are prominent for at least 7% annual productivity growth. They are CTC of Chile, KT of South Korea, KDDI of Japan, and PLDT of Philippines. The productivity growth is due to a simultaneous improvement in technology innovation and technical efficiency, but a sizable fraction ensues from the former. Excluding CTC, the remaining three telecom firms shared high technical changes between 9.1% and 5.7%, which are much higher than 3.4%, or the mean value of all the samples. This could be attributed to their success in deploying broadband technology and mobile services.

As depicted in Table 9, for example, KDDI promoted mobile services and KT promoted broadband services so successfully that the average ratios of non-fixed-line revenue in these two companies are 63.3% and 53.5%, respectively, or much higher than the average level of all firms (39.1%). In addition, the non-fixed-line revenue ratio and technical change have a very high correlation coefficient of 0.892. This is because mobile and broadband services were newly developed technology and during the rapidly growing period, firms with high non-fixed-line revenue ratios certainly had faster technical progress. However, the relationships between total assets and EFFCH, TECHCH, or TFPCH are not significant.

5. Concluding Remarks

This paper applies the DEA method to measure the technical efficiency of twenty-four telecom firms of APEC member economies during 1999-2004. The technical efficiency scores under constant and variable returns to scale are calculated. Using a mean value test, this paper then infers that the per capita GDP level has a significant effect on the average efficiency of Asia-Pacific telecom firms.

The second stage analysis finds that economies of scope and scale are positively related to the efficiency enhancement of Asia-Pacific telecom firms, but the influences of market competition and privatization to telecom performances are insignificant. The Tobit regressions show that market competition cannot increase the efficiency of Asia-Pacific telecom firms, regardless of being in the fixed-line, mobile, or broadband markets. On the other hand, the economies of scope are displayed in such a way that a low fixed-line revenue ratio leads to high efficiency.

Table 9: Technical Change and Non-Fixed-Line Revenue Ratio for Telecom Firms: 1999-2004

Firm	CTC	KDDI	KT	PLDT	Mean of 24 firms
TECHCH	1.034	1.091	1.058	1.057	1.034
Non-fixed-line Revenue Ratio	42.0%	63.3%	53.5%	46.6%	39.1%

The influences of market competition and privatization are insignificant according to the Tobit regressions, which is therefore noteworthy to advocates of liberalization and privatization. This research shows that the government policies of promoting economies of scope and scale are more effective for improving the technical efficiency of telecom firms.

In the longitudinal analysis, there is only an average 0.2% annual growth rate of the Malmquist (total factor productivity) index for Asia-Pacific telecom firms. The TFP growth is mainly due to technical growth instead of from efficiency change. Of the twenty-four Asia-Pacific telecom firms, those in the areas of high broadband and mobile penetration also enjoy significant technical changes. This is an inspiring conclusion for telecom operators that are eager to improve operation productivity.

Following the path of their western counterparts, Asia-Pacific telecom firms are now under the pressure of fierce competition and the decision of privatization. Putting great efforts on the allocation and management of resources, they are constantly trying to add revenues from new services due to their declining fixed-line businesses. This study demonstrates these telecom firms that think highly of new generation services can enjoy higher technical improvement.

Another contribution of this study is its timeliness in providing a systematic performance comparison among telecom firms of most APEC member economies. Unlike past literature studying periods before 1999, this research uses a more recent period (1999-2004). It reveals the latest information of value for policy makers to take adequate steps when making regulatory decisions.

There are quite a number of limitations in using the data for comparing efficiency performance among different firms in different countries. The input and output data are collected from the annual reports of these companies, but the accounting rules are not the same in these countries. In particular, those firms facing market competition are reluctant to disclose information. The fluctuations in the exchange rate may also distort the values of input and output. Moreover, these firms are operating under different economic and institutional environments and sharing different technologies. The degree of outsourcing and government policies (taxation or subsidization) will affect the number of workers, fixed assets, and revenue of these firms. These are probably the reasons why different firms have different efficiencies. The causes of inefficiency may be the government policies, the pricing strategies of firms, technology, and managerial slackness. However, efficient telecom firms in DEA can still be benchmarks for inefficient ones.

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亞太地區主要電信業者之效率與生產力

胡均立* 朱維愷**

摘 要

本文研究產業政策如何影響電信業之效率與生產力。研究對象爲亞太經合組織會員體 24 家主要電信廠商，數據期間爲 1999 至 2004 年。第一部分以資料包絡分析法計算各電信業者之技術效率，並以 Tobit 迴歸分析影響無效率之因素。第二部分使用 Malmquist 指數來計算總要素生產力之成長率。實證結果發現：第一，規模經濟與範疇經濟均可顯著提升這些亞太電信廠商的技術效率；但開放電信市場競爭，與電信業私有化，對技術效率沒有顯著影響。第二，這些亞太電信廠商之總要素生產力成長，主要來自技術進步而非效率提升。

關鍵詞：生產力、效率、競爭、規模經濟、範疇經濟

* 國立交通大學經營管理研究所教授兼所長，E-mail: jinlihu@yahoo.com。
** 中國科技大學財務金融系助理教授。