Efficiency Comparison of Telecommunications Industry among Asia-Pacific Region Countries

Shota Moriwaki （森脇祥太）

Special Researcher, Institute for Information and Communications Policy

Akira Era （江良亮）

Special Researcher, Institute for Information and Communications Policy

Makoto Osajima （筬島専）

Special Researcher, Institute for Information and Communications Policy

Atsushi Umino （海野敦史）

Senior Researcher, Institute for Information and Communications Policy

1. Introduction

The purpose of this study is to confirm whether the privatization of a state-owned telecommunications carrier would, in all cases, be beneficial to the economic welfare to the country covered and whether such deregulation would lead to improvement in developed as well as in developing countries. Specifically, regardless of what stage economic development has reached, our concern is whether or not privatization will inevitably achieve quality results. Gains and/or losses from privatization may differ from country to country, depending on such factors as the degree of industrialization, penetration, and per capita GDP.

In examining the question posed above, we accordingly applied the stochastic frontier (SF) production function to the telecommunications industry in the Asia-Pacific region utilizing a panel data set covering the 1993-2004 period. We can derive the values of the technical efficiency (TE) through estimation of the SF production function, after which we attempted to compare the TE values among countries. In addition, we examined what kind of factors would affect TE. Such factors would illuminate the characteristics defining the privatization system of each country.

Telecommunications carriers operate essential facilities as key infrastructures for the utilization of information and communication technology (ICT). And as many empirical studies show, ICT has been defined as one of the crucial factors for generating economic growth of many countries after the 1990s and as such the telecommunications industry has recently been recognized as playing a more significant role in the economic development of both developed and developing countries[1]. Importantly, as the Asia-Pacific region is made up of many developing countries, it is expected that the telecommunications industry will provide a springboard in the pursuit of further economic development.

Several studies estimate the SF production function for telecommunications carriers in industrialized countries. Battistoni et al. (2006) estimate the SF translog production function for the EU countries using a panel data set covering the period 1995-2002. The results of their studies denote that the average values of TE in the new EU members are somewhat higher than those of existing members. In addition, such convergence of the TE values is observed in the EU countries[2]. Similarly, Erber (2006) estimated the SF Translog and Cobb-Douglas production function for four EU countries (Germany, France, UK, Netherlands) and the US by the use of a panel data set covering the 1981-2002 period. The main difference in the estimation between Battistoni et al. (2006) and Erber

1 See ITU (2006).
2 Battistoni et al. (2006) also endeavored to estimate TE utilizing data envelopment analysis, with the result that the β convergence of TE is observed in the EU countries as in the case of the SF production function.

(2006) lies in the decomposition of capital stock, which the latter broke up into ICT capital and non-ICT. According to the estimation results of Erber (2006), in the case of the Cobb-Douglas production function, the ICT capital constitutes a positive contribution. Furthermore, estimates of TE have formed the shape of the J-curve over the studied period[3]. This type of "J-curve" means in this context that at first the effects of ICT capital may be negative; however, with time, such effects will become more visible and apparent. The subject of both studies above focused on developed countries like EU countries and the US with the developing regions not being addressed.

In view of the preceding studies, we would therefore like to focus on the telecommunications field, more especially in the developing countries. The Asia-Pacific region has been developing economically since the 1990s when compared with the rest of the world, especially compared to this region. The question thus arises as to whether or not the telecommunications industry including incumbent carriers can provide more efficient management to ensure higher quality and affordable services and hence is the key to additional and sustainable growth.

Through the estimation of the SF production function, we endeavored to ascertain whether there are common technologies across the countries of the Asia-Pacific region in the telecommunications field. Most technologies used in the telecommunications industry are comparatively advanced ones, or to put it differently, ICT seems to be intensively used, and thus the estimates of TE implicate the efficiency of the process of diffusing advanced technology from the developed to the developing across countries in the Asia-Pacific region.

[3] The J-curve, which is defined by Paul David, indicates the adoption process of the General Purpose Technology of an industry over the economic development. See *e.g.* Helpman (1998) for the General Purpose Technology.

Generally speaking, since most of the advanced technologies are exploited mainly in developed area, the estimated TE is expected to be higher in the industrialized countries than in developing countries.

In the telecommunications industry, by reason of natural monopoly, a few enterprises were previously owned by the state, with their size of business being large consequently. After the 1980s, however, the technologies associated with the telecommunications industry have made considerable strides. It is commonly believed that such rapid changes in technology resulted in a more competitive environment. At that time, some of the governments of developed countries faced serious budget deficits, which forced them to introduce more efficiency to state-owned enterprises. This barrier proved to be inadequate and many state-owned enterprises were privatized. Privatization trends in developed countries continued with negotiations on entry to WTO in the 1990s, resulting in more prevalence in developing countries [4]. In the Asia-Pacific region, privatization became more pronounced after the 1990s in the telecommunications industry. We thus empirically evaluated the degree of achievement of the sequential privatization. Many econometric analysis studies examine whether privatization positively contributes to the performance of the telecommunications industry[5]. Among other aspects, using a panel data set covering the period 1981-1998 in more than 100 countries in the world, Li and Xu (2002) estimated the Translog production function utilizing the fixed effect model, and then obtained results that show privatization positively contributes only if they estimate the production function in which both of the privatization and the exclusivity are included as the explanatory variable. Unlike Li and Xu (2002), we used the privatization as the explanatory variable of the TE which is a derivative of the SF production function. In addition, we specifically focus on

4 For the relation between WTO and the telecommunications reform, see Cowhey and Klimenko (2001).
5 See *e.g.* Wallsten (2003), Wallsten (2004) and Lee (2008).

the Asia-Pacific region and then estimated the regional production function.

2. The model

According to Coelli (1996), we define the SF production function as follows:

$Y_i = x_i\beta + V_i - U_i$ ・・・ (1)

where Y_i is the production of the i-th country (i = 1,…, n); x_i is the input vector; β is the vector of parameters to be estimated; V_i and U_i are both random variables; with the former especially representing the statistical noise, and the latter non-negative, additionally, meaning inefficiency. Furthermore, U_i and V_i are mutually independent. V_i, independently and identically, follows the normal distribution with the means 0 and the variances σ_V^2. On the other hand, U_i is also independent and identical, but unlike V_i, follows the half normal distribution with the means 0 and variances σ_U^2. In equation (1), the part of the deterministic component is $x_i\beta$, and on account of the statistical noise, the frontier output is ($x_i\beta$+ V_i); the point at which the frontier output is placed over or under the $x_i\beta$, if it is depicted on the figure[6]. Consequently, we define the inefficiency U_i as the distance between the point of the frontier output and the point of the real output.

In the estimation of this study, we select the SF Cobb-Douglas production function as follows:

$\ln(Q)_{it} = b_0 + b_K \ln(K)_{it} + b_L \ln(L)_{it} + b_M \ln(M)_{it} + v_{it} - u_{it}$ ・・・(2)

where Q_{it} is the output of the i-th country and t-th year; K_{it} is the capital stock; L_{it} is the labor power; M_{it} is the raw material; the Cobb-Douglas production function is the special form of the Translog production function and the function is in the restrictive form. However, for the possibility of multicolliniarity, we do not estimate the Translog production function. There are several SF models for

[6] See Coelli et al. (2005), Figure 9.1.

the panel data set, but in these models we select the model presented in Battese and Coelli (1992) and Battese and Coelli (1995) because the former can estimate the continuous values of TE over the studied period, whereas the latter examines the explanatory variables for the values of TE.

In the case of equation (2), we define the values of TE in the following:

$$TE_{it} = \frac{Q_{it}}{b_0 K_{it}^{b1} L_{it}^{b2} M_{it}^{b3} \exp(v)_{it}} = \exp(-u)_{it} \quad \cdots \quad (3)$$

The inefficiency term u_i is independent and identical, but unlike the case of equation (1), follows the truncated normal distribution with the means μ and variances σ_U^2. In Battese and Coelli (1992) model, u_{it} is

$$u_{it} = f(t)\, u_i \quad \cdots \quad (4)$$

where $f(t)$ is the function that continuously changes over years and as a result, the inefficiency comes to be changed, wherein it can be indicated as

$$f(t) = \exp\,[(\eta - T)] \quad \cdots \quad (5)$$

Furthermore, we examine several factors that have the impact on TE_{it} using the estimation method for the panel data[7].

The TE_{it} can be indicated as

$$TE_{it} = \rho z_{it} \quad \cdots \quad (6)$$

[7] Coelli et al. (2003) confirmed the explanatory factors for the TE estimated by the B&C model in Bangladesh crop agriculture.

where z_{it} is the vector of the explanatory variables for TE_{it}; and ρ is the vector of the estimated parameter. In this study, z_{1it} is the population in the studied countries, and therefore, z_{1it} denotes the potential scale of the telecommunications market; z_{2it} is the GDP per capita, and is the variable that indicates the stage of the economic development of the countries to be studied; z_{3it} is the ratio of the mobile cellular phone subscribers over all telephone subscribers. This is the variable to be tested to confirm whether the diffusion of cellular phone services that are considered to be more advanced-technology-based positively impacts TE; z_{4it} is the ratio of the Internet users to the inhabitants. The variable indicates the effect that the diffusion of the ICT impact; z_{5it} is the dummy variable for whether the privatization is accomplished in the telecommunications industry of the country to be studied[8]. If the coefficient of the privatization dummy variable to be estimated is a significantly positive value, we can say that the privatization in the countries telecommunications industry has a positive impact on TE.

3. Data

In this article, we apply the semi-macro level, in other words, the industry level data. The data of our estimation of the SF production function comes from the three databases of the WDI, World Telecommunication/ICT Indicators Database and PWT, version 6.2. In this study, though we mostly used the data from the WDI, some WDI data are missing in some countries. In such cases, we collected the data from the PWT instead. The details are as follows.

Aggregate output: Telecommunications revenue at 2000 prices. We can not obtain the deflator for the telecommunications industry in the Asia-Pacific countries. Therefore, the deflator used in the construction of the output is the GDP deflator of the studied countries in every year from the WDI.

[8] Of course, we do not use any dummy variables to explain to the extent of the privatization.

Capital stock: The level of the capital stock in any given year is the sum of the investment accumulated from the previous year. The estimates are obtained by the perpetual inventory method, and are constructed as $\sum_{t=0}^{T} I_t (1-\delta)^{T-t}$, where I is the telecommunications investment at 2000 prices, δ is the depreciation rate (0.115), and T is the durable years (18). δ is obtained from the value for the communications equipment of the KLEMS Database (Timmer et al., 2007), and T is derived from the durable years for the capital stock of the Japanese telecommunications industry as provided in Social Capital of Japan 2007 (Cabinet Office, 2007). The deflator used in the construction of the capital stock is the value estimated by the ratio of the current gross capital formation over the real gross capital formation from the WDI. Additionally, when there are some missing data in the investment data, we estimate as far back as 1975 as $I_0(1+r)$, where I_0 is investment of the initial time and r is the average growth rate of the investment for the first 3 years[9].

Labor force: The number of total telephone employees.

Law materials: The total fixed telephone subscribers and the mobile cellular phone ones. The raw materials in the telephone industry appear to be all those except for the expenses for the labor force and capital input, but we could not obtain them from any published databases like those that we use here. Therefore, we apply the number of the total telephone subscribers as the proxy of the raw materials in accordance with Nemoto and Asai (2002)[10].

---

[9] The other missing data are estimated by the linear interpolation method.

[10] According to Nemoto and Asai (2002), the expenses for the raw materials in the telecommunications industry vary proportionally to the telephone subscribers.

Year dummy: The year after 2000 is 1 and the year before 1999 is zero.

PPP: The local currency per international dollar at 2000 from the WDI.

The data for the explanatory variables of TE are as follows in Table 1.

Table 1. Data description of input and output variables

	1993	1994	1995	1996	1997	1998	1999	2000	2001
Output (million US$)									
Mean	16,600	17,082	19,078	21,108	24,105	26,075	28,895	33,521	35,000
Std. dev.	41,095	41,668	43,596	46,839	55,671	59,110	63,871	70,424	71,642
Min	11.39	18.28	25.78	37.85	63.04	92.53	127.82	187.18	215.92
Max	175,735	182,783	189,782	202,461	242,282	255,401	274,358	292,762	294,701
Capital stock (million US$)									
Mean	25,019	26,046	28,597	31,104	33,759	37,805	42,290	52,227	56,718
Std. dev.	46,833	46,229	47,965	49,955	52,226	60,159	69,350	92,686	101,599
Min	16.22	32.84	34.81	72.18	115.69	113.17	104.27	101.14	99.27
Max	185,070	184,899	185,205	184,107	183,693	211,197	244,578	304,349	330,536
Labor power (thousand)									
Mean	132	132	133	136	136	136	153	157	167
Std. dev.	231	244	246	250	261	269	302	317	330
Min	1.01	1.03	0.98	0.99	0.99	0.96	0.96	1.00	1.24
Max	879	961	976	997	1,060	1,108	1,180	1,263	1,302
Raw material (million US$)									
Mean	16.68	17.87	20.56	24.01	27.69	31.52	37.50	55.28	64.50
Std. dev.	39.49	41.64	45.76	50.89	56.46	62.34	71.02	113.56	136.08
Min	0.07	0.07	0.08	0.08	0.09	0.11	0.14	0.27	0.32
Max	164.12	177.58	193.44	210.49	229.18	249.06	275.55	420.23	532.70

Source: ITU World Telecommunication/ICT Indicators Database

GDP per capita: The GDP per capita at 2000 prices from the WDI.

The penetration ratio of cellular phone subscribers over all telephone subscribers: The number of subscribers is obtained from the World Telecommunication/ICT Indicators Database of the ITU.

The privatization dummy: The dummy variable where the year after the privatization is 1 and zero otherwise. The time of the privatization is obtained from Wallsten (2003). When we could not obtain the data concerning the time of the privatization from the above, we ourselves collected them from the documents of the relevant telecommunications carriers.

4. Estimation results

We estimate the B&C model, using FRONTIER 4.1. which is a free software for estimating SF analysis provided by the Center for Efficiency and Productivity Analysis (CEPA). As many studies have been using FRONTIER 4.1, for the estimation of SF analysis, we give the details of the estimation results using FRONTIER 4.1 in the following.

4.1 Estimation results of the B&C model and the hypothesis tests

Estimation results of the SF Cobb-Douglas production function utilizing the B&C model are reported in Table 2. From the table, the estimated parameters of the factor of production are all significantly positive. Among other aspects, the estimated parameter of the capital input is the largest in all of the factors of production. We can verify that the estimated SF production function illuminates the features of the telecommunications industry that is capital-intensive. Conversely, the sum of the estimated parameters of the production factor indicates a value of 0.8957, falling below unity, and enabling us, therefore, to say that the situation of the diminishing returns to scale is established in the telecommunications industry. When we test H_0: $\beta_K + \beta L + \beta_M = 1$ utilizing the likelihood ratio test, we can reject the H_0 at the 5% level. Though the telecommunications industry was formerly thought to be a natural monopoly, such a characterization appeared to be unsuitable for the estimated results in the Asia-Pacific region. The result of being diminishing returns to scale is similar to the estimated results of Erber (2006).

Table 2. Results of estimation of SF production function

parameters	*coefficient*	*t-value*
β_0	5.1024	8.0177
β_K	0.6535	16.3889
β_L	0.1200	2.5238
β_M	0.1222	2.4604
δ_s^2	0.0989	4.9028
γ	0.7038	22.0077
μ	0.5277	3.3337
η	0.0377	3.2291
log likelihood function	27.5221	

We next need to test some hypothesis to use the estimated results of the B&C model for the calculation of TE. The results that examine whether the null hypothesis can be rejected by the likelihood ratio test are accordingly reported in Table 3. From the results in the first column of Table 3, we can confirm that the B&C model is a better estimation method than the ordinary least square method. Additionally, the result in the second column indicates that inefficiency u follows the half normal distribution or the truncated normal distribution. Moreover, the result in the third column demonstrates that the inefficiency u varies with the time trend. According to these results, we can say that the estimation result of the SF Cobb-Douglas production function by utilizing the B&C model is quite excellent.

Table 3. Hypothesis Tests

Null hypothesis	χ^2 statistics	Critical $\chi^2_{V,0.95}$	Decision
(1) $H_0 : \gamma = \mu = \eta = 0$	148.0372	$\chi^2_{3,\ 0.95} = 7.045$	Reject H_0 :
(2) $H_0 : \mu = 0$	5.9961	$\chi^2_{1,\ 0.95} = 3.841$	Reject H_0 :
(3) $H_0 : \eta = 0$	6.5076	$\chi^2_{1,\ 0.95} = 3.841$	Reject H_0 :

Note: Mixed $\chi^2_{V,0.95}$ values are taken from Table 1 (Kodde and Palm, 1986).

4.2 Comparative analysis of TE between the studied countries and year-by-year changing pattern of TE

We report estimation results of TE using the Cobb-Douglas SF production function in Table 4. The mean value of TE in the US indicates the largest one in the studied countries, and the US mean value is much larger than the mean value in Singapore that has the second largest value. We can thus say that the US is the technological frontrunner of the telecommunications industries. In addition, we can observe the trend that TE in the developed region is larger than it is in the developing region. Particularly, the mean value in the south Asian countries are quite low, and as a result, it can be suggested that in these countries, the efficiency of technological utilization in telecommunications is quite low.

The value of TE in all countries has risen with the advance of time and in addition, the standard deviation of TE in the studied countries has fallen during the studied years. The technological progress of the respective telecommunications industries in the Asia-Pacific region has advanced and the technological gap between these countries has been reduced during the estimated years. However, the value of TE in the US, which is an advanced country, is more than twice that in Mongolia, which is the latest country studied. Yet in 2004, a large gap remains in ths TEs of both these studied countries.

Table 4. The estimation results of TE

	1993	1994	1995	1996	1997	1998	1999
Australia	0.454	0.467	0.481	0.494	0.507	0.520	0.533
China	0.320	0.334	0.348	0.362	0.376	0.389	0.403
Hong Kong	0.578	0.590	0.601	0.613	0.624	0.635	0.646
Indonesia	0.296	0.310	0.324	0.337	0.351	0.365	0.379
Japan	0.564	0.576	0.588	0.600	0.611	0.622	0.633
Korea	0.386	0.400	0.414	0.427	0.441	0.455	0.468
Taiwan	0.368	0.382	0.396	0.410	0.423	0.437	0.450
Malaysia	0.367	0.381	0.395	0.409	0.423	0.436	0.450
Macao	0.341	0.355	0.369	0.383	0.397	0.410	0.424
Mongolia	0.229	0.242	0.255	0.268	0.281	0.295	0.308
New Zealand	0.517	0.529	0.542	0.554	0.566	0.578	0.590
Philippines	0.271	0.284	0.298	0.311	0.325	0.339	0.353
Singapore	0.620	0.631	0.642	0.653	0.663	0.673	0.683
Thailand	N.A	0.358	0.372	0.386	0.400	0.414	0.427
Bangladesh	0.294	0.307	0.321	0.335	0.348	0.362	0.376
India	0.273	0.287	0.300	0.314	0.328	0.341	0.355
Pakistan	0.257	0.270	0.284	0.297	0.311	0.325	0.338
Sri Lanka	0.232	0.245	0.258	0.271	0.284	0.298	0.312
United States	0.943	0.945	0.947	0.949	0.950	0.952	0.954
Mean	0.406	0.415	0.428	0.441	0.453	0.466	0.478
	2000	2001	2002	2003	2004	2005	2006
Australia	0.545	0.557	0.570	0.582	N.A	0.605	N.A
China	N.A	N.A	0.444	0.458	0.471	0.484	0.498
Hong Kong	0.656	0.666	0.676	0.686	0.696	0.705	0.714
Indonesia	0.393	0.406	0.420	0.434	0.447	N.A	N.A
Japan	0.644	0.655	0.665	0.675	0.685	0.695	N.A
Korea	0.481	0.494	0.507	0.520	0.533	0.546	0.558
Taiwan	0.464	0.477	0.490	0.504	N.A	N.A	N.A
Malaysia	0.463	0.477	0.490	0.503	0.516	N.A	N.A
Macao	0.438	0.451	0.465	0.478	0.491	0.504	N.A
Mongolia	0.322	0.336	0.350	0.363	0.377	0.391	0.405
New Zealand	0.602	0.613	0.624	0.635	0.646	0.657	N.A
Philippines	0.367	0.380	0.394	0.408	N.A	N.A	N.A
Singapore	0.693	0.702	0.711	0.720	0.729	N.A	N.A
Thailand	0.441	0.455	0.468	0.481	0.494	N.A	N.A
Bangladesh	0.390	0.404	N.A	N.A	N.A	N.A	N.A
India	0.369	0.383	N.A	N.A	N.A	N.A	N.A
Pakistan	0.352	0.366	0.380	0.394	0.407	0.421	0.435
Sri Lanka	0.325	0.339	0.353	N.A	N.A	N.A	N.A
United States	0.956	0.957	0.959	0.960	0.962	N.A	N.A
Mean	0.494	0.507	0.527	0.550	0.574	0.556	0.522

4.3 Explanatory factors of TE

Here, in estimating the following model, we analyze factors that influence the inefficiencies of each country in the period studied:

$$TE_{it} = \alpha_0 + \beta_1 \ln(POP_{it}) + \beta_2 (YL_{it}) + \beta_3 MB_{it} + \beta_4 INTP_{it} + \beta_5 Dummy_{it} + u_{it} \quad \cdots (7)$$

where POP_{it}, $YL_{it,}$ and MB_{it} are respectively the population, GDP per capita, and cellular phone penetration compared with fixed phone of each country as mentioned above. The dummy variable means that privatization was either complimented or not, if it was done, such that the value is 1, if not, zero. $INTP_{it}$ is the penetration of Internet users compared with the whole population of each country. The estimated results of the explanatory factors in TE are reported in Table 5. The estimated parameters of the privatization dummy variable are significantly positive in all estimation methods. Accordingly it seems that the privatization has a positive impact on TE in the telecommunications industries across the Asia-Pacific region. From the results of the F test, the fixed effect estimation is preferred to the ordinary least squares method, and from the Hausman test, the fixed effects estimation is preferred to the random effects estimation. As a result, the fixed effects estimation is selected among all estimation results. According to the results of the fixed effects, the estimated parameters of the population, ratio of the mobile cellar phone to the total telephone subscribers, privatization dummy variable, and ratio of the Internet users to the inhabitants are all positive and very significant. These estimation results imply that the potential market size and the diffusion of the mobile cellar phone and the Internet have a positive impact on the value of TE. The latter factors especially demonstrate that the advance of ICT utilization improves the technical performance of the telecommunications industries.

Table 5. Estimated result of factors of TE

	OLS		*Fixed Effect*		*Random Effect*	
parameters	*coefficient*	*t-value*	*coefficient*	*t-value*	*coefficient*	*t-value*
α_0	0.0355	0.6518			0.0337	0.2192
β_1	0.0148	5.2406	0.2511	6.8674	0.0191	2.1887
β_2	0.0000	17.2609	-0.0000	-0.6641	0.0000	3.4569
β_3	0.0663	2.1439	0.1221	12.5482	0.1668	25.1684
β_4	0.0012	2.8181	0.0003	2.7501	0.0001	0.5215
β_5	0.0414	2.9127	0.0182	4.4987	0.0228	5.7339
$\bar{R}^2$		0.7687		0.9930		0.5139
	F(96,126) = 4453.8 P-value = [0.0000]		CHISQ(5) = 85.278 P-value = [0.0000]			

5 Conclusion

The estimation result of the SF Cobb-Douglas production function is statistically useful, and therefore, we can confirm that common technology is used in the telecommunications industries in the Asia-Pacific region. We can recognize that the interdependent relationship through the technology transfer within this region has been deepening in the telecommunications industries. Further the telecommunications industries are relatively capital intensive from the estimation result, though the sum of the estimated parameter are less than 1 and the case is not true of such a condition as a natural monopoly. It can thus be considered that the telecommunications industries have recently become over-competitive in terms of the deregulation and rapid technological advance, and that the estimation result reflects such a recent market condition in these industries in the Asia-Pacific region. Conversely, the value of the estimated TE in the developed countries is higher than that in the developing countries in the Asia-Pacific region. Among other aspects, it is notable that the US's TE value is the highest in the developed countries; the US is the frontrunner in ICT. This suggests that, as a first step, from the US to the other developed countries and then to the developing countries, telecommunications technologies are being transferred to the telecommunications industries in the Asia-Pacific region.

We can confirm that the differences in the TE value between countries are explained by the factors of the population size, ratio of the mobile cellar phone to the total telephone subscribers, privatization, and Internet diffusion rate from the estimation result using the panel data set. Through these factors, from the viewpoint of policymaking, we would like to emphasize the importance of the privatization. In the developing countries in the Asia-Pacific region, government implementation of privatization policy serves to enhance the telecommunications industries' efficiency. Additionally, from the estimation results for the mobile cellar phone and Internet users, we can consider that the accelerated use of ICT raises higher the TE value in the telecommunications industries.

References

Battese G E and Coelli T J (1995) "A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data", *Empirical* Economics 20, pp.325-332

Battistoni1 E, Campisi D, and Mancuso P (2006) *European Integration and Telecommunication Productivity Convergenc*e, Physica-Verlag HD

Coelli T, Rahman S, and Thirtle C (2003) "A Stochastic Frontier Approach to Total Factor Productivity Measurement in Bangladesh Crop Agriculture, 1961-92", *Journal of International Development*, 15, pp.321–333

Cowhey P and Klimenko M (2001) "The WTO Agreement and Telecommunications Policy Reform", *The World Bank POLICY RESEARCH WORKING PAPER 2601*

Cowhey P and Klimenko M (2004) "The New International Trade Regime in Telecommunications Services and Network Modernization in Transition Economies", *Emerging Markets Finance and Trade*, vol. 40, no. 1, pp.59–94.

Erber, G. (2005) "A Multi-Country Comparison of the Efficiency of the German Telecommunications Industry", *Weekly Report*, Volume 1/September 30th 2005, pp.297–309, German Institute for Economic Research (DIW Berlin)

Erber, G. (2006) "Benchmarking Efficiency of Telecommunication Industries in the US and

Major European Countries A Stochastic Possibility Frontiers Approach", *German Institute for Economic Research Discussion Papers*, 621

Fink C, Mattoo A, and Rathindran R (2003) "An assessment of telecommunications reform in developing countries", *Information Economics and Policy*, 15, pp.443–466

ITU (2006) *World Telecommunication/ICT Development Report 2006: Measuring ICT for social and economic development*

Lee S (2008) "Market liberalization and ownership status of incumbent telecom enterprises: global evidence from the telecom sector", *Economics Bulletin*, Vol. 12, No. 30 pp.1-10

Li W and Xu L (2002) "The Political Economy of Privatization and Competition: Cross-Country Evidence from the Telecommunications Sector", Journal of Comparative Economics 30, pp.439–462

Miller S M, Clauretie T M and Springer T M (2006) "Economy of Scale and Cost Efficiencies: A Panel Data Stochastic Frontier Analysis of Real Estate Investment Trusts", *The Manchester School*, Vol 74 No. 4, pp.483–499

Nemoto J, and Asai S (2002) "Scale Economies, Technical Change, and Productivity Growth in Japanese Local Telecommunications Service", *Japan and the World Economy*, Vol 14, pp.305-320

Ure J (2003) "Telecommunications Privatization: evidence and some lessons", *TRP Papers*, url: http://www.trp.hku.hk/papers/2003/apdip_031017-2.PDF

Wallsten S (2003) "Of Carts and Horses: Regulation and Privatization in Telecommunications Reforms", *Policy Reform*, Vol. 6(4), pp.217–231

Wallsten S (2004) "Privatizing Monopolies in Developing Countries: The Real Effects of Exclusivity Periods in Telecommunications", *Journal of Regulatory Economics*, 26:3, pp.303–320

Wallsten S, Clarke G, Haggarty L, Kaneshiro R, Noll R, Shirley M, and Xu L (2004) "New Tools for Studying Network Industry Reforms in Developing Countries: The Telecommunications and Electricity Regulation Database", *World Bank Policy Research Working* Paper, 3286