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**Conference Paper**

## Productivity growth and efficiency changes in the Mongolian mobile communications industry

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**Proceedings of the 19th ITS Biennial Conference 2012  
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**Productivity growth and efficiency changes in the  
Mongolian mobile communications industry**

**By**

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Jaejeung Rho**

## PRODUCTIVITY GROWTH AND EFFICIENCY CHANGES IN THE MONGOLIAN MOBILE COMMUNICATIONS INDUSTRY

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### ABSTRACT

*In the mid 1990s Mongolia has introduced competition in the telecommunications market by deregulating it and opening up its mobile communications market to foreign direct investments. Since this policy reform, mobile service penetration has grown fast, recently exceeding 100 % penetration rate and mobile communications service has become the biggest among telecommunications services in Mongolia. Latest periods of the industry have been witnessing strong competition among the mobile service providers and challenge for reaching customers in remote areas of the country. On the other hand, the mobile service providers are uncertain for efficiency of their investments and benefits from competition. Policy and regulatory departments are unaware productivity growth of the sector which is crucial for the next policy and regulatory decisions. Considering such situation, this study estimates productivity growth and efficiency changes in the mobile communications industry of Mongolia over the period of 2007-2011 using firm level data and employing a Malmquist total factor productivity index method. By determining the changes in total factor productivity (TFP) growth and its components, technical change and technical efficiency change, we find that the productivity increased about 44.7 percent during the study period or nearly 9 percent annually. Our research identifies that a scale change component played as a most significant source of the TFP growth in the market. In addition, our study reveals a fluctuation pattern of the productivity growth caused by catch-up effect and technology-change components during the study period. The results of the study indicates effectiveness of a competition policy for the mobile telecommunications market with shared telecommunications network for gaining the productivity growth which may provide some lessons for similar economies as Mongolia.*

**Key words:** *Mongolian mobile communications, Total factor productivity, Malmquist TFP index.*

### INTRODUCTION

Telecommunications industry has been seen as one of most innovative and highly productive but heavily regulated industries in many economies (17). The productivity growth of the telecommunications industry has been studied widely and for various time periods (18). Most of research in this domain have been focused mostly on the productivity of the industry at the global or regional levels (13, 28), or the telecommunications of developed countries (1, 9, 11, 15).

Since the mid-1990s, telecommunications policy reform in Mongolia has begun by deregulating the market and opening it to foreign investors. As a new service, the mobile communications market of Mongolia has been opened for competition and foreign direct investments. A first license for mobile service in Mongolia was issued to Mobicom in 1996. Another license for the mobile service was issued to Skytel in

1999 for promotion of competition in the market. This early period of the market with the two mobile operators was highly concentrated and the mobile service was not widely adopted.

Later on, the Government of Mongolia has issued two more licenses to meet growing demand for the wireless communications and to boost mobile service penetration into sparsely populated rural and remote areas of the country. Unitel entered the market in 2005 and G-mobile in 2006. Now, four mobile service providers are competing in Mongolia.

In addition, the government has established the universal service obligation fund for developing and supporting telecommunications networks and services in rural areas and to support shared telecommunications backbone networks. As a result, communities in the rural and remote geographic areas of the country are all covered by the mobile communications service and mobile subscription rate has reached more than 100 percent by 2011 (29). In addition, service charges have also been decreasing over the years, allowing subscribers to benefit from low priced affordable communications services.

However, there has been lack of relevant study assessing performance, productivity, and efficiency of the Mongolian mobile communications sector even though studies on productivity growth and efficiency changes provide valuable insights on policy and regulatory effects on the performance of industries such as telecommunications. Until now, both the government and mobile service providers have been unaware of the productivity and efficiency changes in the mobile communications sector. Empirical studies on the productivity of the Mongolian telecommunication industry is likely to be of great help to policy makers and other developing countries, especially those belonging to transition economies from former socialist economies.

The objective of this study is to estimate the productivity growth and efficiency changes in the Mongolian mobile communications sector over the period of 2007-2011 by employing a Malmquist total factor productivity index method. By measuring the changes in total factor productivity (TFP) and its components, technical change, and technical efficiency change, this study finds out that the Mongolian telecommunications industry recorded about 44.7 percent of the productivity growth for four year period or 8.94 percent per year.

The paper is organized as follows. Section 2 introduces policy changes and market developments in the Mongolian mobile communications industry, Section 3 reviews previous studies on the productivity and efficiency changes in the telecommunications industry, and Section 4 is devoted to methodologies adapted to this study. Section 5 reports outcomes of empirical analyses, while Section 6 presents conclusions and implications of the study.

## **POLICY CHANGES AND MARKET DEVELOPMENTS IN THE MONGOLIAN MOBILE COMMUNICATIONS INDUSTRY**

Since the early 1990s, Mongolia had been experiencing a transition period from the state controlled planned economic system to the market oriented competitive system. In 1995, the Government of Mongolia (GoM) had adopted the first law on communications industry regulation which significantly impacted on the reform and further development of the industry. The law had mandated fair and equal competition in the communications market for the both private and public communications service providers. In addition, in 1995 the GoM undertook an initial step for separating Mongolia Telecom, a fixed telecommunications company, into a partially privatized, a fixed telecommunications services provider and the state owned

monopoly backbone telecommunications network operator up until 2007. Such a policy of the GoM had been pursuing for shared telecommunications networks to avoid duplicated infrastructure and investments.

A distinctive policy of the GoM for the mobile communications market is the fact that the market was fully opened for private and foreign direct investments, and no public firm, even Mongolia Telecom, was allowed to enter the mobile communications market. Following this policy stance, the GoM had firstly issued a mobile service license to Mobicom, a Mongolian-Japanese joint venture, established by Mongolian NewCom Co., Japanese Sumitoma, and KDDI. At the beginning, Mobicom's GSM based mobile service was provided within the capital city Ulaanbaatar and most populated other cities and province centers. Meantime, service charges and prices of handsets were high so that low and middle income customers could not afford to buy them. In addition, the limited capacities of the analogue transmission technologies of existing telecommunications backbone networks had been major barriers for the penetration of the mobile services throughout the country.

To increase mobile service penetration, the GoM established a universal service obligation fund (USOF) in 2001, aimed at facilitating mobile telecommunications service penetration in the rural and remote areas of Mongolia. Additionally, the GoM tried to promote mobile service penetration by boosting competition in the mobile communications industry. It issued the second mobile communications service license to Skytel, a Mongolian-Korean joint venture, established by Mongolian MCS Co., Altai Trading Co., and Korean SK Telecom. Skytel started its mobile services in 1999.

Even though competition was adopted in the mobile communications market, the two players' service was still focused on province centers and relatively high populated remote districts. In addition, prices of the mobile communications service were not falling and low and middle income people could not afford to subscribe the service.

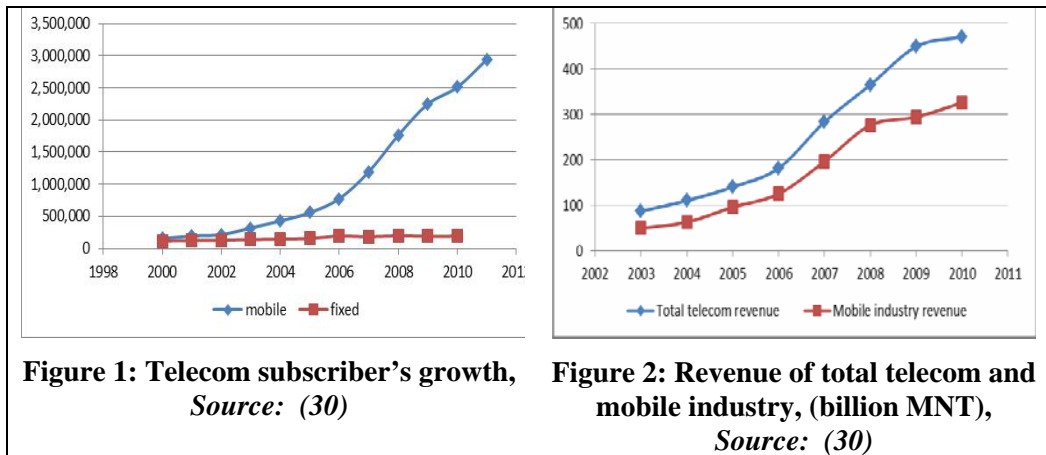
To deliver telecommunications services to customers in the sparsely populated remote areas and to set up financially viable telecommunications industry in Mongolia, the GoM in 2006 began to levy universal service fees, two percent of telecommunications service revenue, on all telecommunication service providers including mobile service providers. To facilitate fair competition among the telecommunications service providers, in 2007 the GoM adopted another policy measure, separating the backbone networks from the fixed telecommunications service provider, Mongolian telecom. Newly established public firm, Information and Communications Network Company became a sole owner and provider of the telecommunications backbone networks in Mongolia and was obliged to provide telecommunications infrastructure to all communications service providers on equal footing. In addition, the GoM had issued two more licenses; one to Unitel in 2005 and the other to G-Mobile in 2006, to intensify competition in the market and to make the mobile services affordable to customers at reasonable prices. As shown in Table-1, four mobile telecommunications service providers have been competing in Mongolia since 2006.

	Mobicom (since 1996)	Skytel (since 1999)	Unitel (since 2005)	G-Mobile (since 2006)
Mobile technologies	GSM (1996) HSDPA (2010)	AMPS (1999) CDMA 2000 1x (2001) HSPA+ (2011)	GSM (2005) HSDPA (2010)	CDMA2000 1x/EVDO (2006) WCDMA HSDPA + (2012)

Site coverage	All 21 aimag-province centers and 370 rural and remote soums - villages	All 21 aimag-province centers and 300 rural and remote soums - villages	All 21 aimag-province centers and 210 rural and remote soums - villages	All 21 aimag-province centers and 265 rural and remote soums - villages
Branches	50	15	10	32
Dealers	1950 contract based dealers and 13280 mobile dealers	1800 contract dealers	2450 contract dealers	4000 contract dealers, more than 40 overseas dealers

**Table-1: Summary of the mobile operators, Source: (30)**

As a result of these policies, the Mongolian mobile market has been growing rapidly in terms of the number of subscribers and revenue as shown in Figure 1 and Figure 2, eventually becoming the biggest sector in the telecommunications industry (Table-2).



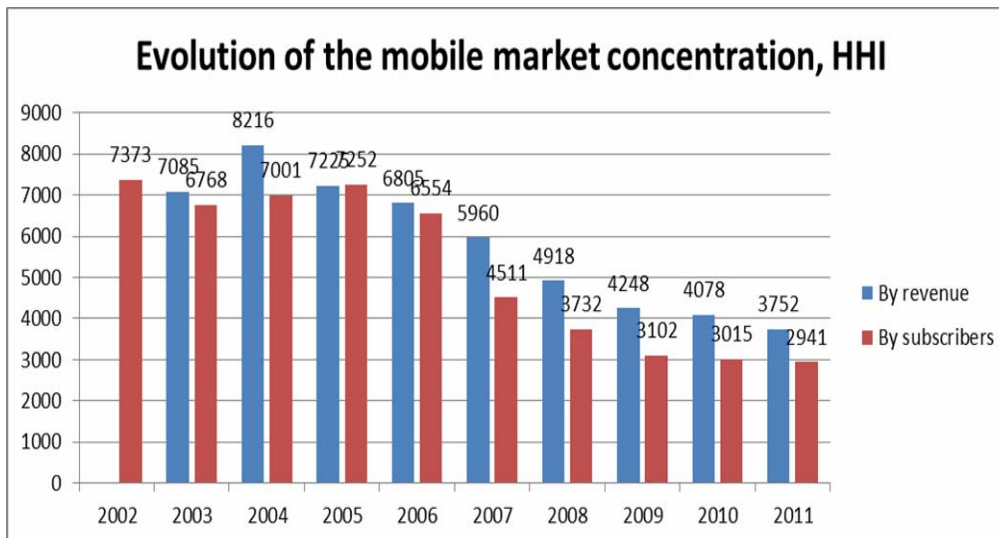
**Figure 1: Telecom subscriber's growth, Source: (30)**

**Figure 2: Revenue of total telecom and mobile industry, (billion MNT), Source: (30)**

Mobile	Fixed	NetCo	Internet	TV	CaTV	Post	VOIP	Other
72.84%	7.12%	5.29%	4.83%	2.82%	2.01%	2.47%	1.92%	0.70%

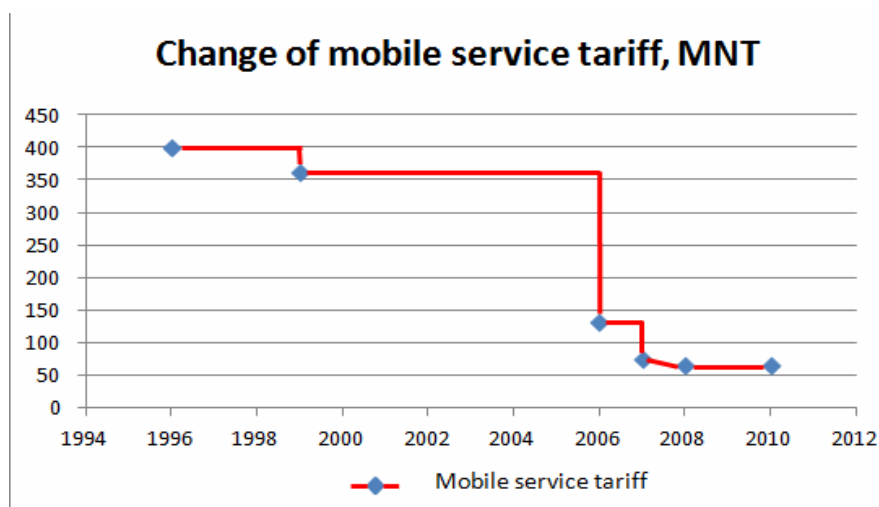
**Table-2: Telecommunications revenue share, Source: (30)**

Figure 3 shows changes in the HHI and reveals that as competition increases, concentration in the Mongolian mobile telecommunications market has declined.



**Figure 3: Evolution of the mobile market concentration, HHI index**

Intensified competition in the market induced mobile service providers to upgrade their technologies as shown in Table-1. Mobile operators offer a range of the basic and value added services for different age and demographic groups. Most importantly, subscribers had been witnessing price reduction benefits of the mobile services as presented in Figure 4 and even free calls over the own network. Price in this figure presents changes of published tariffs averaged across the mobile service providers.



**Figure 4: Changes in average mobile service tariff, MNT, Source: (31)**

### LITERATURE STUDY

An assessment of the productivity performance of telecommunications was started in the early 1970s. According to Kiss et al (10), most of those studies are devoted to evaluation of the North American telecommunications firms, AT&T and Bell Canada. The studies employed various functional forms of production and cost functions and aimed at finding out scale efficiency measures such as economies of scale and economies of scope (25) along the line of TFP.

However, recent studies tend to measure productivity and efficiency of the telecommunications firms and industry using mostly four types of analytical methods: an econometric based growth accounting approach, an index number method, a

stochastic frontier analysis (SFA) method and a data envelopment analysis method (DEA).

Numerous research studies have applied growth accounting and conventional econometric least square methods to measure productivity growth. This category includes studies of Rushdi (23), Lam et al (11). Rushdi (23) adopted a Divisia index method for the estimation of the TFP growth of Telstra in Australia for the years 1980-1997. The results indicated higher TFP growth after the telecom reform, 10.1 percent for the years 1992–1997, than pre-reform period, 4.9 percent per annum for the period 1980–1991. Applying both growth accounting and a Divisia index methods, Lam et al (11) investigated the TFP growth of the Hong Kong Telephone Company (HKTC) for the period 1964-1998. The result of the study revealed 2.31–3.56 percent growth of the TFP per year over the period.

With the popularization of the efficiency measurement methods, research trends in evaluation of efficiency and productivity have acquired a new look. Production technology based DEA have been found a wide range of applications due to the opportunities to accommodate multiple inputs and outputs while freeing researchers from dealing with price data for inputs and output(s). DEA method is applicable at any level of analyses starting from national level and firm specific analyses to global and regional as well as analyses of group of countries. Examples of national level studies include Noel (21), Sueyoshi (26), Kang (9), Lee (14), Hisali et al (8), Banker et al (1). Noel (21) has reported 3 percent annual growth of the TFP for the 19 US LEC during the period 1988-1998 using the DEA method. Sueyoshi (26) employing the DEA method investigated scale efficiency (SE) and return to scale (RTS) effect of NTT during the period 1953-1994. The study found increased SE/RTS of NTT without price reducing benefits to final consumers. Lee et al (14) investigated technical and allocative efficiencies and overall efficiency of KT using the DEA methods. The result of the study found an increase in overall efficiency due to allocative efficiency while technical efficiency indicates little improvement. Kang (9), using both CCR and BCC (*CCR – technology proposed by Charnes, Cooper, Rhode in 1978, BCC – technology proposed by Banker, Charnes, Cooper in 1984*) approaches for the DEA, found no progresses in production efficiencies of the Chunghwa Telecom company before and after privatization since in all technical efficiencies are less than unity for the period 1966-2007. Hisali et al (8) reported slight improvements in TFP, 4.6 percent, of the Ugandan telecommunications industry for the period 2001-2006 using a DEA based Malmquist index method.

While all the above mentioned studies are devoted to fixed telecommunications sector or its combinations with other types of telecom services, only Banker et al (1) has investigated productivity growth of the US mobile communications industry. This study revealed, with the use of the DEA method and sample data of the 16 US mobile operators for years 2000-2002, significant improvements of the productivity, 11.4 percent, in the period 2001-2002 than the growth the productivity change, 4.4 percent for the period 2000-2001.

Studies of the global and regional level studies for the efficiency and productivity of telecommunications include Sueyoshi (25), Madden et al (16), Lam et al (13). Sueyoshi (25) employed a combined least absolute value (LAV) and DEA method for analysis of the productivity of public telecommunications operators (PTO) of 24 OECD countries for the year 1987. The result revealed that not only large PTO countries but also small PTO countries had achieved high productivity growth. Madden et al (16) analyzed productivity performance of 12 Asia-Pacific telecom carriers for the period 1987-1990 using cost function based the Tornqvist approximation for the Divisia index. The result indicated competition, private



ownership, technology change and scale economies improved TFP which accounted for 1.65 percent per annum. Madden et al (17) examined TFP of telecommunications industry of 74 countries for the period 1991-1995 using the Malmquist index method. The TFP varied depending on a region and economic development of the countries in the sample; highest values showed a group of industrialized countries (10.2 percent per annum) and European developing countries (8.9 percent per annum) while TFP in Asia and Middle East were moderate (1.2 percent per annum) and in Africa and Western Hemisphere were lowest (-3.7 percent and -11.9 percent, respectively). In addition, the study identified the way of enhancing innovation through private ownership of the dominant local-exchange carrier. Lam et al (13) investigated TFP growth of telecommunications of 112 countries for the period 1994-2005. The study identified that countries in the upper-middle income group achieved a higher average of the TFP growth, 9.6 percent per annum, than other countries, lower-middle income group – 7.5 percent per annum, high income group – 6.6 percent per annum, and low income group – 4.2 percent per annum respectively.

## METHODOLOGY AND DATA

In this study, the Malmquist productivity index method, a well-known and widely accepted non-parametric method, is used for the evaluation of productivity growth and efficiency changes in the Mongolian mobile telecommunications industry. The method allows one to separate a technical efficiency component from a technical change component, thus it helps to distinguish catching-up effects from shifts in the frontier.

Proposed by Caves et al (2), the Malmquist method provides significant flexibility for the choice of input and output variables; the method requires only quantity data but not price data of input and output variables. In terms of theoretical foundation, the method is based on distance functions originated from Malmquist (20).

According to Shephard (24), the output distance function with respect to a time period  $q$  is defined as:

$$D_{oq}(a_q, b_q) = \inf(\theta: (a_q, b_q/\theta) \in J_q), \quad (1)$$

where  $\inf$  (infimum) – the greatest element of some subset of  $\theta$ s of the technology set  $J_q$ ,  $a_q$  – the input vector,  $b_q$  – the output vector, and  $J_q$  – the technology set for producing the outputs from the inputs,  $\theta$  – efficiency of the observation relative to the frontier of the technology set  $J_q$ . The above formulated distance function expresses maximum proportional change in output necessary to make  $(a_q, b_q)$  observation realistic in regard to the technology in period  $q$ . At the same time, the distance function fully describes the technology. Particularly,  $D_{oq}(a_q, b_q) \leq 1$  if and only if  $(a_q, b_q) \in J_q$  and  $D_{oq}(a_q, b_q) = 1$  if and only if  $(a_q, b_q)$  is on the boundary of the technology.

However, the complete expression of the Malmquist index requires defining the distance functions with respect to two time periods, such that additionally we need another distance function with respect to a period  $q+1$  at the same technology level in the period  $q$  (6):

$$D_{oq}(a_{q+1}, b_{q+1}) = \inf(\theta: (a_{q+1}, b_{q+1}/\theta) \in J_q), \quad (2)$$

This distance function expresses the maximum proportional change in output necessary to make  $(a_{q+1}, b_{q+1})$  observation realistic in regard to the technology in the period  $q$ .

Similarly, it is possible to define a distance function that expresses the maximum proportional change in outputs to make  $(a_q, b_q)$  observation realistic in regard to the technology in period  $q+1$ . Such a function takes a form  $D_{o(q+1)}(a_{q+1}, b_{q+1})$ .

Estimation of the above presented distance functions can be implemented by using either parametric stochastic frontier analysis or non-parametric data envelopment analysis methods.

Based on the above formulation of the distance functions, the output-based Malmquist productivity index is defined as (Fare et al, 1994):

$$M_o(a_{q+1}, b_{q+1}, a_q, b_q) = D_{oq}(a_{q+1}, b_{q+1}) / D_{oq}(a_q, b_q), \quad (3)$$

Following Fare et al (1994), the above formula can be rewritten:

$$M_o(a_{q+1}, b_{q+1}, a_q, b_q) = [(D_{oq}(a_{q+1}, b_{q+1}) / D_{o(q+1)}(a_{q+1}, b_{q+1})) \times D_{oq}(a_q, b_q) / D_{o(q+1)}(a_q, b_q)]^{1/2}, \quad (4)$$

The last formula allows decomposing an efficiency change component of the output distance function into scale and pure technical change components. The value of this measurement greater than unity indicates improvements in productivity and less than unity – decline in productivity.

The empirical calculations of the Malmquist productivity index are included into several well known software applications such as LIMDEP, STATA, DEAP 2.1. In this study, DEAP 2.1 is employed (3).

For the analysis of productivity growth and efficiency changes, the choice of appropriate variables presents great importance (7). Researchers approach to this problem differently; some researchers follow previous research while others rely on available data for proxies of input and output variables. Most researchers note that there is no widely agreed framework for the choice of variables.

To be consistent with previous research in the telecommunications and given the specifics of the Malmquist productivity index method, this study involves two inputs – the number of employees of mobile telecommunications companies in Mongolia and the amount of annual investment of these companies– and three outputs – call to own network, call to other networks, and call termination.

The data for the analysis were collected from the statistical database of Communication Regulatory Commission of Mongolia and cover the period 2007-2011, a period of the full competition in the mobile communications market of the country. Descriptive statistics and a Pearson correlation of the input and output variables are presented in Table - 3 and Table - 4 respectively.

Statistics	x1	x2	y1	y2	y3
Mean	327	14513	634033423	212066579	252487527
Standard error	19	2650	139837655	24939203	43709819
Standard deviation	86	11850	625373006	111531507	195476254
Kurtosis	-0.373	1.125	-0.373	-0.101	-0.323
Skewness	0.389	1.333	-0.742	-0.140	0.751
Range	320	41777	1881361868	423205203	670119847
Minimum	192	122	2207270	8586408	3027016
Maximum	512	41900	188356913 8	431791611	673146863

Sum	6534	290267	12680668456	4241331573	5049750534
Count	20	20	20	20	20

x1 - number of employees, x2 - amount of investment, y1 - call to own network, y2 - call to other networks, y3 - call termination.

**Table -3. Descriptive statistics of the input and output variables (n=20), 2007-2011**

	x1	x2	y1	y2	y3
x1	1				
x2	.197	1			
y1	.368	.530*	1		
y2	.590**	.348	.773**	1	
y3	.489*	.651**	.855**	.806**	1

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

**Table -4. Pearson correlation matrix of the input and output variables (n=20), 2007-2011**

### EMPIRICAL RESULTS

As previously mentioned, the output-oriented Malmquist productivity index method can provide the characteristics of changes in productivity and efficiency of the Mongolian mobile communications industry.

The result of calculation of the total factor productivity change (TFPCH) and its decomposed efficiency measurements are presented in a Table -5.

YEAR	TECHCH	EFFCH (PECH*SECH)			TFPCH
			PECH	SECH	
2007-2008	1.141	2.091	1.136	1.841	2.386
2008-2009	2.814	1.037	0.920	1.127	2.918
2009-2010	0.453	1.241	1.087	1.142	0.562
2010-2011	1.083	1.036	1.000	1.036	1.121
Mean	1.120	1.292	1.032	1.251	<b>1.447</b>

**Table – 5. Malmquist index summary of annual means**

TECCH – (Technology Change), EFFCH – (Technical Efficiency Change), PECH – (Pure Efficiency Change), SECH – (Scale Efficiency Change), TFPCH – (Total Factor Productivity Change)

As shown in Table 5, TFPCH has increased on average 44.7 percent during the study period or nearly 9 percent annually. Certainly, this growth is caused by the increases in all types of the efficiencies as they are expressed by their mean values. Among these values, the technical efficiency change (EFFCH) and scale efficiency change (SECH) components are dominantly contributed to the growth of the TFPCH. However, a closer look at the TFPCH provides a fluctuation pattern of the productivity change in the sector.

A substantial increase of the EFFCH, more than 100 percent, was experienced during the 2007-2008 period when a fourth mobile operator started its business. However, next periods followed by the sharp declines of this measurement falling to 3.6 percent increase in the last period of the study.

The technical change component, TECHCH, has substantial impacts on the TFPCH. The sharp decline of the TECHCH component at the period 2009-2010, - 55 percent, resulted in substantial fall of the TFPCH, - 44 percent. At this period, pure efficiency change (PECH) and scale efficiency change (SECH), decompositions of the EFFCH, provided positive contributions to the TFPCH and saved it from deeper decline. It is worthwhile to note the fact that the SECH component has always positive growth indicating expansion of the mobile services leads to productivity growth of the Mongolian mobile industry.

Despite these fluctuations and zigzags in TFP growth and its sources, the above measurements present that the mobile communication industry of Mongolia has witnessed rapid growth, technology progress and intention for the growth due to the increased competition in the sector.

This pattern provides a clear picture and insights to understand a situation of the industry in the most recent years. First of all, benefits and efficiencies of the mobile service were shifted from the industry to its subscribers in the form of service with low prices and even free call over own networks of some operator companies. On the other hand such favorable growth of the productivity and efficiency changes is the result of the efficiency improvements related with the incentives of the mobile service providers to expand the services by offering low prices and attracting customers in the rural and remote areas of the country which, in turn, to impacted on the scale efficiency.

## **DISCUSSION AND CONCLUSION**

Studies on productivity growth in telecommunications have been focusing on global, regional levels (13, 27) or among a group of countries such as OECD (15) at various time periods using mainly national level input and output data. Those studies have been devoted merely to the fixed telecommunications of developed countries (9, 11, 15, 21). Thus far, there has not been an analogous study for developing countries such as Mongolia. Our study tries to fill this gap in research.

This paper finds that despite the challenging factors for the mobile communications, such as small market size, low population density, and low income, Mongolia has been experiencing annual TFP growth of about 9 percent.

This study features the use of firm level data and output variables directly related to the main outcomes of the mobile communications service. Also, the study covers all the commercial companies of the market and the time period of the full competition. Such an approach allows us to understand the characteristics of the growth in the mobile communications market of the country.

The findings of this paper suggest that government policy promoting competition in the market has been effective. Competition in the market has resulted in reduction in retail price of the mobile communication service, expansion of the market, and increases in efficiency and productivity. It can be said that subscribers in Mongolia eventually benefited from efficiency gains of the mobile communication market.

However, the TFP growth and efficiency changes have been fluctuating during the study period. This indicates that the growth is achieved due to the growth in the EFFCH and SECH components. Such a phenomena clearly points to the managerial incentives of the mobile service providers toward leveraging innovations in the market, high consumer demand for mobile communications services as well as affordability of the services by subscribers in rural and remote areas.

Even though the study deals with optimal choice of the output variables and input variables consistent with previous research, it needs, in the future, to examine with appropriate input variables for capital proxy as well as other material expenses directly reflecting operation of the mobile service as applied in other research such as Banker et al (1), and Noel (21). In addition, future research needs to examine other productivity evaluation methods, such as Hicks-Moorsteen Index (22) in order to avoid methodological bias and inherent nature of constant return to scale assumption in the DEA method. Such approaches for the TFP of communications service may provide more rigorous assessment of productivity growth of the industry.

Finally, the study deals with only the measurement of the productive efficiency of the Mongolian mobile communications industry; it does not cover cost, revenue, or profit efficiencies which might be of interest for the regulator as well as policy makers of the country.

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