

A Comparative Study on the Operation Efficiency of Wireless Operators in the US, China, Japan and South Korea

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Abstract

This paper aims to find out whether the Chinese wireless operators have high efficiency in operation or not by comparing them with other major carriers from the US, Japan and South Korea. A DEA (Data Envelopment Analysis) model is established to assess the selected wireless operators' operation efficiency. "Operating Expenses before D&A (Depreciation and Amortization)" and "Plant, Property and Equipment, Net" are taken as input measures, and "Operating Revenue", "Total Voice Usage", and "Subscriber Number" are taken as output measures of the DEA model. Data about 7 wireless carriers are collected and processed, including China Mobile and China Unicom from China, AT&T/Cingular, Verizon, and T-Mobile from the US, NTT DoCoMo from Japan and SK Telecom from South Korea. The overall efficiencies are calculated respectively. In addition, partial efficiencies considering different output measures, including "Operating Revenue", "Total Voice Usage", "Data Service Revenue" and "Subscriber Number" are calculated respectively. The results show that China Mobile has improved its efficiency greatly in the past 5 years and has reached a high level in 2006. The efficiency of China Unicom is lower than China Mobile but still have a high overall efficiency. No obvious gap in operation efficiency is found between Chinese wireless operators and operators in the developed countries.

1. Introduction

The wireless communications services have gained a rapid growth globally in the past two decades. The wireless carriers are holding an improving status in the telecom industry. In China, China Mobile and China Unicom own the No. 1 and No. 3 largest mobile networks in the world respectively (MII, 2008). But it has been argued that the Chinese operators present low efficiency because of the lack of fair competition in China market (e.g. Xia, 2006; Zhang, 2008). Unfortunately, most judgments of this kind are from subjective observations.

The operation efficiency is affected by many factors including the elements in the environment and the strategies and management processes of the company. It is undoubted that a competitive market can effectively force operators to improve their efficiency. But for the telecom industry, the scale economy is also an important factor to gain high economic efficiency. Therefore, people always expect a balance between scale and competition in the telecom market. It is unreasonable to assert that lack of competition necessarily results in inefficiency. The operation efficiency should be measured on the basis of practical data instead of only by analyzing the competition status.

This paper aims to find out whether the Chinese carriers have high efficiency in operation or not by comparing them with other major carriers from the US, Japan and South Korea. To make the comparison objective and feasible, the methods of efficiency measurement and data availability are studied. A DEA (Data Envelopment Analysis) model is established. Data about 7 wireless carriers are collected and processed, including China Mobile and China Unicom from China, AT&T/Cingular, Verizon, and T-Mobile from the US, NTT DoCoMo from Japan and SK Telecom from South Korea.

This paper is organized as follows. The next section provides a literature review on the operation efficiency measurement, which is the basis of developing the methodology of this paper. The following section presents the DEA model giving the input and output measures selected for the efficiency assessment. Then the data about the selected wireless operating companies are collected and applied to the model. And the results of the comparison are presented and discussed. Finally, conclusions are summarized.

2. Literature Review

In measuring the efficiency of a firm, we focus primarily on its inputs and outputs. There are a number of methods to do that. They can be divided into three main categories: ratio indicators, parametric and nonparametric methods (Bai & Dai, 2006; Vincová, 2005).

The simplest measure is the ratio of outputs to inputs. With the consideration of different inputs of resources, such as labor, capital, material, and energy, many ratio indicators can be built. But they are just partial indicators and cannot reflect the overall corporate efficiency. In recent years, more appropriate measures for comprehensive ratio indicators are developed (Hannula, 2002). But it is difficult to give objective conclusions because of the coexistence of several evaluation (Braglia, Zanoni, & Zavanella, 2003).

Nonparametric methods including Data Envelopment Analyses (DEA) and Free Disposal

Hull (FDH), do not need to define specific production function or to estimate parameters. They are used to measure technical (technological) efficiency, looking at the level of inputs or output. Being technically efficient means to minimize inputs at a given level of outputs, or maximize outputs at a given level of inputs. DEA is a linear programming model, which is used to measure relative efficiency of DMUs (Decision Making Unit) with multiple inputs and outputs. Efficient firms are those that produce on the best-practice frontier as compared with other firms in the test group. That means that efficient firms produce a certain amount of or more outputs while spending a given amount of inputs, or use the same amount of or less input to produce a given amount of outputs. FDH is another nonparametric and non-stochastic method, which can be regarded as a generalized DEA model with variable returns to scale. This particular model does not require the estimated efficiency boundary to have a convex shape (Mortimer, 2002; Vincová, 2005).

Parametric methods of efficiency measurement include the Stochastic Frontier Approach (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA). These methods need to define production function according to different assumptions and to estimate parameters (Bai & Dai, 2006). They are used to measure economic efficiency. Economic efficiency is a broader term than technical efficiency, covering an optimal choice of the level and structure of inputs and outputs based on reactions to market prices. Being economically efficient means to choose a certain volume and structure of inputs and outputs in order to minimize cost or maximize profit. Economic efficiency requires both technical efficiency and efficient allocation (Vincová, 2005).

The description above shows that nonparametric methods have advantages in validity and practicality over the other two categories in efficiency measurement for systems with multiple input and output measures. They can handle several dimensions in an integrated and comparative manner but require less data and assumptions than parametric methods. Therefore, as a basic nonparametric method, DEA are widely used in many industries, including main manufacturing industry and some service sectors, and non-profit organizations (Bai & Dai, 2006; Braglia et al., 2003; Mlima & Hjalmarsson, 2002). It can be used on the firm level or productive units in a company. By adopting the DEA approach for efficiency measurement, it is possible to find out the causes of gaps in inefficient firms so as to suggest new strategies to make improvement and reach efficiency.

In the literature, DEA method is applicable to the telecom industry to help telecom operators find problem areas and improve efficiency (Lam & Shiu, 2008; Resende, 2008). It is also applied to international comparison study in the telecom field (Taiwan Telecom Bureau, 2003; Tsaia, Chenb, & Tzeng, 2006). But different indicators of inputs and outputs are used to fulfill different research objectives.

3. Methodology

The evaluation methodology used in this study is based on a nonparametric method known as DEA, as briefly mentioned in Section 2. The DEA is a linear programming-based methodology, and can be used to determine how efficiently a decision making unit (DMU) converts inputs to outputs when compared with other DMUs.

3.1 DEA Model

The CCR-DEA model was first proposed as a research tool in 1978 (Charnes, Cooper, & Rhodes), it is often called Primary CCR model which is a constant returns to scale (CRS) DEA model. However, the inefficiency results not only from allocation inefficiency but rather from scale and technical inefficiency. For solving those cases, BCC model is developed as a variable returns to scale (VRS) model (Banker, Charnes, & Cooper, 1984). This model reflects the scale efficiency and technical efficiency by variable return to scale (VRS). From those two basic modes, various DEA models are developed for specific needs of different organization. For example, Radial Models, Ratio Models, Additive Models, Multiplicative Models and etc.

The DEA models present either input-oriented or output-oriented. The input-oriented model optimizes the input usage while the outputs are fixed at their current levels. The output model will indicate the same units as inefficient as the input model. It is often used on increasing the output situation.

A DEA model assumes that there are n DMUs, and there are m inputs and s outputs for each DMU. Then the efficiency is defined as the ratio of the weighted sum of outputs to the weighted sum of inputs (Braglia et al., 2003; Charnes, Cooper, & Rhodes, 1978), i.e.,

$$E_j = \frac{\sum_{r=1}^s \alpha_r y_{rj}}{\sum_{i=1}^m \beta_i x_{ij}} \quad j = 1, 2, \dots, n,$$

where,

E_j is the efficiency of DMU j

α_r is the weight of output r

β_i is the weight of input i

y_{rj} is the amount of output r of DMU j

x_{ij} is the amount of input i from DMU j

The efficiency is a value constrained to the interval $[0, 1]$. Based on this definition of efficiency, the problem of evaluating the relative efficiency of DMU j can be translated into a line programming model.

$$\text{MAX } E_j \quad (1)$$

$$\text{s.t. } \frac{\sum_{r=1}^s \alpha_r y_{rj}}{\sum_{i=1}^m \beta_i x_{ij}} \leq 1 \quad \text{for each DMU } j = 1, 2, \dots, n$$

$$\alpha_r \geq 0 \quad r = 1, 2, \dots, s$$

$$\beta_i \geq 0 \quad i = 1, 2, \dots, m$$

The solution of model (1) produces the set of weights most favorable to DMU j with respect to the other DMUs, and the E_j value obtained represents the possible maximum relative efficiency. The overall performance of the entire DMU group requires the resolution of a model focusing on each DMU in turn. Model (1), a fractional model, can be easily transformed into a general linear programming one (Charnes et al., 1978), which is commonly adopted in the literature.

$$\text{MAX } H_j = \sum_{r=1}^s \alpha_r y_{rj} \quad (2)$$

$$\text{s.t. } \sum_{i=1}^m \beta_i x_{ij} = 1$$

$$\sum_{r=1}^s \alpha_r y_{rj} - \sum_{i=1}^m \beta_i x_{ij} \leq 0 \quad \text{for each DMU } j = 1, 2, \dots, n$$

$$\alpha_r \geq 0 \quad r = 1, 2, \dots, s$$

$$\beta_i \geq 0 \quad i = 1, 2, \dots, m$$

This study adopts the input-oriented CCR-DEA model. The input-oriented model shows the result in between 0 to 1 which is clear and easy to adjudge the efficiency, the scoring value equals to 1 means the operator is relatively efficient, while a value less than 1 is considered as relatively inefficient. The CCR model reflects the relative efficiency without scale adjustment. The results could fairly compare the operating efficiency between different scale markets.

The input-oriented CCR-DEA model formulation is demonstrated as following.

$$\text{Min } H_o = \theta - \varepsilon \left(\sum_{i=1}^m s_i^- + \sum_{r=1}^s s_r^+ \right)$$

$$\text{s.t. } \sum_{j=1}^n \lambda_j x_{ij} + s_i^- = \theta x_{io} \quad i = 1, 2, \dots, m;$$

$$\sum_{j=1}^n \lambda_j y_{rj} - s_r^+ = y_{ro} \quad r = 1, 2, \dots, s;$$

$$\lambda_j \geq 0 \quad j = 1, 2, \dots, n.$$

where,

i =inputs; r =outputs; j =DMUs

s_i^- and s_r^+ are input and output slack variables, respectively

θ is the ratio of minimum input to actual input

x_{ij} is the value of input i of DMU j

y_{rj} is the value of output r of DMU j

For any DMU, $\theta = 1$ and $s_i^- = s_r^+ = 0$ indicate the score value equals to 1 and the operator is 100% efficiency; $\theta < 1$ indicate a relatively low efficiency. For achieving the 100% efficiency, the input needs to be decreased by $(\theta x_{io} - s_i^-)$ and the output increases $(y_{ro} + s_r^+)$ (Sherman & Zhu, 2006).

3.2 Measures of the Model

This paper aims to compare the operation efficiency of China Mobile and China Unicom with some foreign operators. To set up an applicable DEA model, we should define the measures of inputs and outputs in the model. For wireless operators, the commonly adopted measures in the literature include:

Inputs:

- Total number of employee
- Fix assets
- Total assets
- Net assets
- Operating expenses
- Annual investment

Outputs:

- Operating revenue
- EBITDA
- Operating profit
- Subscriber number
- Voice service usage/revenue

The situations of the telecom industry vary among the countries, which makes the international comparison complicated. Some measures can not reflect the real efficiency. For example, the average labor cost and service prices in China are much lower than those in Europe and US. Using more employees in China does not mean low efficiency and the indicators involving pricing factors are not comparable among countries. Therefore, the indicators of inputs and outputs of the DEA model should be selected carefully in order to eliminate as much as possible the influence from the country-sensitive factors, such as special resources, currency exchange rate, pricing and tax policies.

Moreover, we have to consider the availability and accuracy of data. It could be ideal to use the number of physical core equipment, common resources (e.g. spectrum), service usage volume. But it is difficult to obtain credible data for some measures. For example, most operators announce their voice usage minutes, but do not report the data usage volume. And the existence of a large number of temporary employees makes it difficult to have accurate employee number. In addition, most telecom operators in the world are providing wireless services as well as wired services. To evaluate the efficiency of wireless segment, we have to identify and separate the data directly related to wireless services.

Under the requirements and limitations above, we take the measures listed in Table 1.

Table 1 Input and Output Measures of the DEA Model

Input measures	Output measures
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Operating Expenses before D&A (Depreciation and Amortization)	Operating Revenue
Plant, Property and Equipment, Net (PPEN)	Total Voice Usage
	Subscriber Number
	Data Service Revenue

Although value measures are influenced by pricing factors, they are most important indicators of inputs and outputs for companies. Therefore operating expenses and operating revenue are considered into the model. To separate the influences from fixed assets and intangible assets from current expenses, two measure “Operating Expenses before D&A” and “Plant, Property and Equipment, Net” are finally taken. “Plant, Property and Equipment, Net” represents the value of long-lived assets that a firm uses in its production.

As for the output measures, it is reasonable to take more indicators of service volume besides value measures. So “Subscriber Number” and “Total Voice Usage” as commonly recorded measures are selected. As the mobile communication industry is transiting from 2G to 3G age, the usage volume of data services should also be considered. Unfortunately, there is no available data for the indicator. With this limitation, “Data Service Revenue” is eventually taken as the output measure to evaluate the data service efficiencies.

3.3 Data Collection

In selecting the foreign operators, we consider three main countries, the US, Japan and South Korea. The US has the largest communications market scale by value in the world. And it is widely believed that operators in its effective competitive market have high efficiency. Japan and South Korea are currently leading in the wireless communication industry. Therefore, the major players in the three countries, including AT&T, Verizon, T-Mobile, NTT DoCoMo and SK Telecom are selected to be compared with China Mobile and China Unicom. Data about the 7 wireless operators from 2002 to 2007 are collected from U.S. SEC (Securities and Exchange Commission) filings, their annual reports and official websites and processed according to the established DEA model (see Appendix).

With these inputs and outputs, the overall efficiencies of the operators are calculated. Besides, by using one output at one time, the revenue efficiency, voice service efficiency, data service efficiency and subscriber efficiency are calculated respectively. Therefore, totally five kinds of efficiency in different years are calculated respectively for these operators.

4. Results

The calculation adopted input-oriented CCR-DEA model described in section 3 and used DEA Frontier software (www.deafrontier.com). The DEA Frontier software is an add-in for Microsoft Excel and uses the Excel Solver. The results are shown in Table 2. The scoring value equals to 1 means the operator is relatively efficient, while a value less than 1 is considered as relatively inefficient.

In this study, all models have the same inputs (Operating Expenses before D&A and PPEN). The “Overall Efficiency” model adopts three outputs (Operating Revenue, Total Voice Usage and Subscriber Number). The “Data Service Revenue” is not used as an independent output in

this model since it is part of "Operating Revenue". In "Operating Revenue" and "Data Revenue" model, the inputs and outputs has same unit "US\$" which eliminate the currency exchange rate influence. The two models fairly compare the efficiency of generating revenue. The "Voice Volume" and "Subscriber Number" model directly indicate the operating efficiency rather than creating revenue which is significantly influenced by pricing power.

5. Discussions

From Table 2, we can see that most of the 7 wireless operators have relatively high efficiency.

China Mobile has presented a high efficiency. Its DEA efficiency was very close to 1 from the year 2002 to 2004, and reached 1 in 2005. China Unicom experienced a drop in efficiency but quickly got back to 1 in 2007. It is known that China Unicom began to launch CDMA service and it didn't earn any profit until 2006. To built a new network and promote new services reduced the profitability of China Unicom. This is reflected by the calculation results. The efficiency of AT&T/Cingular has changed a lot from 2001 to 2007 because of the M&A event. But the efficiency has been improved quickly from 2005 to 2007, which shows that AT&T has promoted the development of the wireless segment very well. Verizon wireless segment has relatively low efficiency, but in the past years its efficiency has kept improving. T-Mobile and NTT DoCoMo show a fluctuation in their efficiencies but there are no significant gaps compared to others. SK Telecom presents very high efficiency with 1 or very close to 1 in consecutive 5 years, which is consistent with its leading position in the world.

Table 2 The results of DEA efficiencies of the wireless operators

Overall efficiency							
Inputs: Operating Expenses before D&A, PPEN							
Outputs: Operating Revenue, Total Voice Usage, Subscriber Number							
Operators	2002	2003	2004	2005	2006	2007	Average
China Mobile	0.94810	0.96578	0.96809	1.00000	1.00000	1.00000	0.97805
China Unicom	1.00000	0.82860	0.95988	0.96367	0.98151	1.00000	0.95912
Cingular-ATT wireless	0.74268	0.72775	0.61674	0.72839	0.88447	1.00000	0.75572
Verizon wireless	0.73401	0.75543	0.79909	0.81170	0.83414	0.85655	0.80795
T-Mobile USA	0.56828	0.66584	0.80315	0.72415	0.79370	0.86560	0.75288
NTT DoCoMo	0.84978	0.84926	0.80037	0.80129	0.78363	0.80266	0.81266
SK Telecom Co.,Ltd	0.94842	1.00000	0.98061	0.98541	1.00000	0.96471	0.97107
Revenue efficiency							
Inputs: Operating Expenses before D&A, PPEN							
Outputs: Operating Revenue							
Operators	2002	2003	2004	2005	2006	2007	Average
China Mobile	0.94810	0.96578	0.96809	0.99667	0.97658	1.00000	0.97805
China Unicom	1.00000	0.77065	0.70179	0.68480	0.69478	0.69093	0.72532
Cingular-ATT wireless	0.74268	0.72775	0.61674	0.71687	0.81523	0.95461	0.74919
Verizon wireless	0.73401	0.75543	0.79909	0.81170	0.83414	0.85655	0.80795
T Mobile USA	0.56828	0.65946	0.74331	0.72415	0.74066	0.75970	0.71016
NTT DoCoMo	0.84978	0.84926	0.80037	0.80129	0.78363	0.80266	0.81266
SK Telecom Co.,Ltd	0.94842	1.00000	0.95755	0.98116	1.00000	0.96471	0.95525
Voice service efficiency							
Inputs: Operating Expenses before D&A, PPEN							
Outputs: Total Voice Usage							
Operators	2002	2003	2004	2005	2006	2007	Average
China Mobile	0.31965	0.42026	0.65727	0.76820	0.84897	1.00000	0.72903
China Unicom	0.30606	0.38851	0.49704	0.52059	0.58959	0.60573	0.51901
Cingular-ATT wireless	0.19491	0.22330	0.14526	0.30355	0.48743	0.56480	0.33404
Verizon wireless	0.14070	0.20289	0.25413	0.31021	0.36616	0.43271	0.29766
T Mobile USA	0.22775	0.31817	0.44473	0.38912	0.49331	0.60081	0.44100
NTT DoCoMo	0.07201	0.06677	0.06403	0.06791	0.06740	0.06602	0.06727
SK Telecom Co.,Ltd	0.30350	0.31786	0.30922	0.29063	0.29321	0.27276	0.29617
Data revenue efficiency							
Inputs: Operating Expenses before D&A, PPEN							
Outputs: Data Service Revenue							
Operators	2002	2003	2004	2005	2006	2007	Average
China Mobile	0.16596	0.28891	0.45933	0.63862	0.72136	0.86643	0.59227
China Unicom	0.08400	0.13249	0.27364	0.40412	0.52701	0.59479	0.39549
Cingular-ATT wireless	0.05382	0.08097	0.11949	0.20429	0.32719	0.55019	0.26187
Verizon wireless	0.02583	0.06145	0.12788	0.21995	0.37911	0.54587	0.27346
T Mobile USA	0.03312	0.07425	0.11761	0.18649	0.25118	0.33950	0.19844
NTT DoCoMo	0.61388	0.66122	0.63405	0.69563	0.75493	0.87289	0.70499
SK Telecom Co.,Ltd	0.40424	0.62661	0.70127	0.92963	1.00000	0.94160	0.77550
Subscriber efficiency							
Inputs: Operating Expenses before D&A, PPEN							
Outputs: Subscriber Number							
Operators	2002	2003	2004	2005	2006	2007	Average
China Mobile	0.64592	0.71722	0.92362	0.97179	1.00000	1.00000	0.88612
China Unicom	1.00000	0.81749	0.95988	0.96331	0.98017	1.00000	0.95742
Cingular-ATT wireless	0.19735	0.20060	0.12545	0.22721	0.28298	0.33487	0.23037
Verizon wireless	0.16700	0.18029	0.19499	0.20517	0.21888	0.23103	0.20249
T Mobile USA	0.17752	0.19697	0.23537	0.18341	0.20919	0.23270	0.20774
NTT DoCoMo	0.18127	0.17529	0.17833	0.19028	0.19371	0.19662	0.18605
SK Telecom Co.,Ltd	0.43020	0.42988	0.41756	0.39127	0.39061	0.37466	0.40299

When we consider the revenue efficiency, we find that for most operators, the revenue efficiency is very close to its overall efficiency and changes in the same directions with its overall efficiency. It is reasonable because the operating revenue is determined largely by voice usage and subscriber number.

Focusing on the voice services, the relative efficiency of China Mobile used to be pretty low (but still higher than others) in 2002. It improved very fast and finally reached 1 in 2007. With the largest subscriber base in the world, China Mobile supports the most voice usage as well. China Unicom and the operators in the US exhibit an increasing trend, but their voice service efficiencies are much lower than their overall efficiencies, reflecting the decline of mobile voice services. On the contrary, SK Telecom shows a declining trend in voice service efficiency, but we can find the reason in its very high efficiency in data services. It should be noticed that NTT DoCoMo presents very low efficiency in voice service. The numbers under 0.1 seem abnormal. But the original data show that the voice usage of NTT DoCoMo subscribers is much lower than others (see appendix). There might be two reasons for that: one is that the statistical method in Japan might be different from other countries; the other is voice services are seriously replaced by data services, as what is happening in South Korea. But we need further research to find the real reason.

When we focus on the data service efficiency, it is easy to be impressed by the high efficiency of SK Telecom. NTT DoCoMo also has presented relatively high efficiencies since 2002. The 3G services have been developed best in South Korea. The ratios of data service revenue to the total revenue of main wireless operators are commonly in the range of 20%~30%, while this ratio is lower than 14% in the US (FCC, 2008). The gap in developing mobile data services among the operators are clearly reflected in the results. China Mobile and China Unicom also present satisfying efficiency in data services.

Finally, considering the subscriber development, we find results much different from the overall efficiency. As we expected, China Mobile and China Unicom present high efficiency in this dimension because of the large potential market in China. To support the largest scale of subscribers in the world, the Chinese operators are forced to make good use of their networks, equipment and frequency resources.

Another angle to analyze the results is to focus on one certain operator, following its four kinds of efficiency in different years. Then we can find the efficiency changes of this operator and the problem in its operation. For example, the efficiencies of China Mobile and China Unicom are shown in Fig. 1.

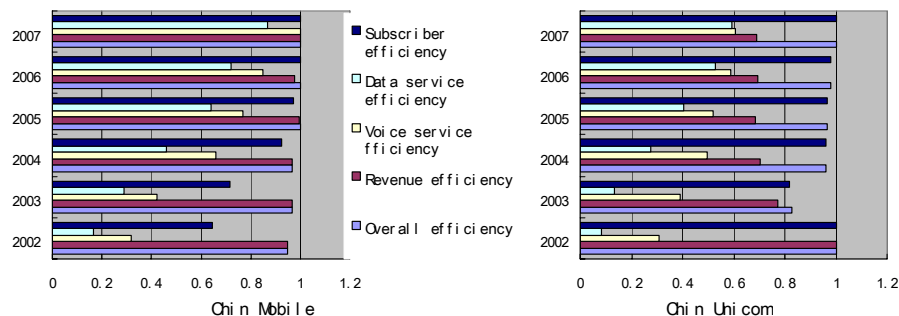


Fig. 1 The DEA efficiencies of China Mobile and China Unicom

China Mobile presents very high efficiency in 2007 except data service efficiency. But

compared to other operators, its data service efficiency also reaches a satisfying level. From 2002 to 2006, China Mobile has improved its operation efficiency quickly in all the five aspects, reflecting success in operations and market expansion.

China Unicom presents high overall efficiency and subscriber efficiency. Its voice service efficiency is a little low, reflecting that it should stimulate and support more voice usage. The lowest efficiency is in its data service operation. Its data services have not earned as much revenue as expected. The efficiency is improving, but the speed is still low. To improve the profitability of mobile data services should be the major parts of China Unicom's strategies.

6. Conclusions

The comparison results based on the DEA model show that China Mobile has improved its efficiency greatly in the past 5 years. Now its efficiency has reached a high level. The efficiency of China Unicom is lower than China Mobile but still have a high overall efficiency. No obvious gap in operation efficiency is found between Chinese wireless operators and operators in the developed countries.

The decline of mobile voice services in the world are clearly reflected by the results. Most operators showed low efficiency in operating voice services. In such a situation, it is very important for wireless operators to turn their attention from voice service to data and multimedia services. NTT DoCoMo and SK Telecom, with high efficiency in operating data services and stable high overall efficiency, have provided valuable experience for other operators.

Appendix: Original Data

The indicators of the DEA model and original data about the 7 wireless operators

Indicator Wireless Operator	Input Measures		Output Measures			
	Operating Expenses before D&A (\$ Billion)	PPEN (\$ Billion)	Operating revenue (\$ Billion)	Total voice Usage (Billion Minutes)	Data Service revenue (\$ Billion)	Subscriber Number (Millions)
ChinaMobile2002	9.77	23.57	20.25	260.10	0.82	117.70
ChinaMobile2003	10.66	24.58	22.48	373.24	1.55	141.60
ChinaMobile2004	12.07	26.01	25.45	660.90	2.79	204.30
ChinaMobile2005	14.11	26.69	30.50	903.10	4.54	246.70
ChinaMobile2006	18.30	27.51	38.16	1252.10	6.65	301.20
ChinaMobile2007	21.84	33.92	47.09	1818.90	9.52	369.30
China Mobile Average	14.46	27.05	30.65	878.06	4.31	230.10
ChinaUnicom2002	2.66	14.35	6.09	67.75	0.11	59.70
ChinaUnicom2003	5.16	14.47	8.76	167.09	0.34	80.83
ChinaUnicom2004	6.31	14.53	9.66	261.12	0.87	112.08
ChinaUnicom2005	7.36	14.12	10.93	319.19	1.50	127.80
ChinaUnicom2006	8.14	14.44	12.24	399.90	2.16	142.37
ChinaUnicom2007	9.13	15.90	13.65	460.68	2.73	162.49
China Unicom Average	6.46	14.64	10.22	279.29	1.29	114.21
Cingular2002	10.56	10.15	14.90	106.03	0.29	21.93
Cingular2003	11.14	10.94	15.48	130.96	0.45	24.03
Cingular2004	14.83	21.96	19.44	171.02	0.89	30.16
Cingular2005	26.03	21.75	34.43	353.90	2.68	54.10
ATTwireless2006	26.50	19.69	37.54	514.50	4.25	61.00
ATTwireless2007	28.59	19.12	42.68	578.94	6.95	70.10
Cingular-ATT Average	19.61	17.27	27.41	309.22	2.58	43.55
VerizonWireless2002	12.69	17.77	19.47	134.08	0.17	32.50
VerizonWireless2003	14.52	19.00	22.49	206.64	0.45	37.50
VerizonWireless2004	17.34	20.51	27.66	279.51	1.12	43.80
VerizonWireless2005	20.16	22.79	32.30	379.05	2.23	51.20
VerizonWireless2006	23.53	24.66	38.04	484.11	4.49	59.10
VerizonWireless2007	26.93	25.97	43.88	602.52	7.40	65.70
Verizon Wireless Average	19.20	21.78	30.64	347.65	2.64	48.30
T_Mobile_USA2002	5.27	5.10	5.70	62.29	0.09	9.92
T_Mobile_USA2003	6.76	6.09	8.36	103.84	0.25	13.13
T_Mobile_USA2004	9.17	6.72	11.68	160.19	0.52	17.31
T_Mobile_USA2005	10.62	10.81	14.81	225.42	1.00	21.70
T_Mobile_USA2006	12.40	10.93	17.14	289.14	1.57	25.04

T_Mobile_USA2007	13.94	11.26	19.29	362.65	2.38	28.69
T_Mobile_USA Average	9.69	8.48	12.83	200.59	0.97	19.30
NTT DoCoMo2002	25.03	22.10	39.71	85.32	7.73	43.86
NTT DoCoMo2003	28.47	23.93	44.70	85.66	9.47	45.93
NTT DoCoMo2004	30.99	25.00	45.16	85.85	9.89	48.83
NTT DoCoMo2005	28.25	24.55	42.12	89.37	9.89	51.14
NTT DoCoMo2006	27.96	24.81	40.95	89.65	10.62	52.62
NTT DoCoMo2007	27.36	24.80	41.22	87.78	12.02	53.39
NTT DoCoMo Average	28.01	24.20	42.31	87.27	9.94	49.29
SK Telecom Co.,Ltd2002	4.17	3.66	7.38	59.48	0.85	17.22
SK Telecom Co.,Ltd2003	4.64	3.89	8.57	66.30	1.46	18.31
SK Telecom Co.,Ltd2004	5.71	4.11	9.20	68.11	1.90	18.78
SK Telecom Co.,Ltd2005	6.15	4.56	10.46	71.03	2.80	19.53
SK Telecom Co.,Ltd2006	6.22	4.74	11.08	74.51	3.13	20.27
SK Telecom Co.,Ltd2007	7.94	5.35	12.08	78.31	3.33	21.97
SK Telecom Co.,Ltd Aver	5.81	4.38	9.80	69.62	2.25	19.35

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