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Application of DEA to Investigate Distinctive Regional Characteristics for Asia-Pacific Telco Management

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Abstract

In this paper, we present the DEA (Data Envelopment Analysis) application case study to investigate the regionally distinctive telco management characteristics of the Asia-Pacific countries. This study attempts to exploit the implications of DEA for the assessments of core process capabilities of telcos. Accordingly, we extract input variables of CAPEX (capital expenditure), operating expense, marketing expense, and number of employees, each to reflect the competitiveness of the core processes such as fixed asset utilization, operation & sales efficiency, and white collar productivity. In conjunction with the input variables, the output variables are chosen as EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortization), ARPU (Average Revenue per User), and number of subscribers. The computational testing results, conducted with total 37 telcos of the 12 Asia-Pacific countries, are analyzed in various ways to understand the distinctive performance characteristics across the region. The managerial implication captured from this study provides useful insight for using DEA as the international telco management purpose.

Keywords : DEA, Telco Management, Telco Process Capability, Asia-Pacific Region, ARPU, International Management

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1. Introduction

Telecommunication service is regarded as critical and valuable instrument necessary for socio-economic development of the nation. Indeed, information and communication services provided by telcos contribute to the growth of the national economy in the sense of reducing transaction cost, facilitating information flows [Mitra and Shankar, 2008]. So, in many countries, the policy level control is made to maintain proper numbers and total capacity of domestic telcos, and that the accurate measurement of telco's performances is regarded as important. Moreover, the international comparison of telcos performance provides more objective assessment in judging domestic telco management efficiency [Hung and Lu, 2007]. For instance, sometimes a domestic telcos yielding positive profit may not be relatively efficient when compared to other foreign telcos under similar environment.

Our research motivation stems from this worthiness of international comparison of telcos. Particularly, our interest is to compare the performances of Asia-Pacific telcos having similar cultural and socio economic environment. We think the comparison result could provide some useful insights in understanding regional characteristics which should be helpful for collaboration or establishment of telecom related new businesses in Asia-Pacific region. However, under international context, the performance comparison is not so straightforward to use financial statement only. Because there are so many factors which are different across the region, multi-faceted performance measurement scheme along with financial measures would be more appropriate. DEA (Data Envelopment Analysis) method is one useful technique for this purpose.

DEA is a non-parameter technique for evaluating the efficiency of decision making units (DMUs) [Charnes et al., 1978]. DEA distinguishes efficient versus inefficient units by employing multiple inputs and outputs variables. The critical advantage of DEA in performance measurement is it does not need some assumptions for the specific relationship between inputs and outputs. For instance, DEA can be used to identify specific inefficiencies that may not be measurable by common analysis methods such as ratio analysis or linear regression [Hong et al., 1999]. The practices of DEA for benchmarking are diverse for coffee shop [Joo et al., 2009], third party logistics [Min and Joo, 2009] and so on. In telecom industry, various DEA analysis were adopted with different purposes, which include finding best service provider [Mitra and Shankar, 2008], impact assessment of wireless communications merging [Kwon et al., 2008], performance modelling of mobile phone providers [Kwon, 2014], and others.

Most DEA telco studies for efficiency and productivity were conducted with domestic players [Yang and Chang, 2009; Lam and Shiu, 2010; Hisali and Yawe, 2011; Liao and Lien, 2012]. Some exceptions are Hung and Lu [2007] and Hu and Chu [2008]. They extended the scope of telco performance comparison internationally. However, as the authors mentioned, both studies are unclear about what are the distinguishing international factors of those operators that have

been more successful in achieving efficiency than others. They suggested this as the further work agenda. We focused on this. As a first step of this further research agenda, as for the Asia-Pacific telecom operators, we attempt to find out regionally distinctive telco management characteristics using DEA.

The remaining of this paper is organized as follow. The next section provides brief literatures on telco efficiency studies using DEA. Section 3 outlines research method of DEA application including variables selection. In Section 4, we report the computational testing and analysis result. And finally, conclusions are remarked in Section 5.

2. Literatures for Telco DEA

Several studies adopted DEA technique to measure the efficiency and productivity of the telco industries. The benefit of DEA method include the description of relative productivity among decision making units (DMU) by measuring the efficiency between the inputs and outputs having heterogeneous dimensions [Charnes et al., 1978]. DEA method has been revolutionized through development of new analysis techniques so that it has become one of the standard analytical tool for comparing performances of the various business units [Cooper et al., 2000].

There have been several studies that measure efficiency and productivity of telco industries using DEA methods. Fuss [1994] studied productivity growth of Canadian telcos by TFT (Total Factor Productivity) whcih is estimated through DEA analysis. Majumdar [1995] analyzed the impact of new technology adoption in US telco industry using DEA. The analysis was conducted in cross-sectional manner to reveal the positive relationship between the levels of new technology output and utilization and the firm performance. Koski and Majumdar [2000] reported efficiency enhancement effect in case of fixed and cellular communication convertgence through expansion and acquisition of complementary telco infrastructures.

Lien and Peng [2001] investigated the efficiency of telcos of 24 OECD countries, and verified that telcos under tough competition were more efficient. Calabrese et al. [2002] compared efficiency of 13 OECD telcos having distinctive patterns of capital accumulation. Tsai et al. [2006] verified the validity of new DEA methodology through comparison of 39 Forbes 2000 ranked global telecom operators. Hung and Lu [2007] investigate the relationship between the size of the telcos and performance, and found that consolidation of small units to grow bigger will positively impact on the telco efficiency. The empirical testing results indicated better performance for European telcos more than those of Asia Pacific and America. Hu and Chu [2008] studied the impact of industrial policy of competition and privatization of telco industry for the Asia Pacific telco firms. Yang and Chang [2009] suggested that telcos can improve scale efficiency through acquisitions but could get encountered with poor technical efficiency in the short run.

Hisali and Yawe [2011] assembled the panel data set, and adopted common set of input and output indicators to compare the estimation of

〈Table 1〉 DEA for the Telco Industry

Year	Author	Objective	Input variables	Output variables
1994	Fush	Total Factor Productivity Growth	Capital, Labor, Mainline	Local service revenue, Toll service revenue, Miscellaneous revenue
1995	Majumdar	Impact of new technology	The number of switches, Access lines, Employees	The number of local calls, The number of toll calls
2000	Koski and Majumdar	Convergence in telecommunication infrastructure	Investment of operators, Total staffs	The number of the main telephones lines, The number of cellular subscribers, Percent of digital main lines
2001	Lien and Peng	Competitions and Production Efficiency	Employee, Mainline, Investment	Revenue
2002	Calabrese et al.	Capital accumulation	Labor, Mainline	Revenue
2006	Tsai et al.	Productivity efficiency	Total assets, CAPEX, Number of employees	Revenue, EBITDA, Operating profit
2007	Hung and Lu	Examine managerial performance	Total Asset, CAPEX, Employee	Revenue, EBITDA, EBIT, Net Income
2008	Hu and Chu	Efficiency and productivity	The number of employees, The amount of fixed assets	Revenue of fixed-line services and non-fixed line services
2009	Yang and Chang	Efficiency	Asset, Operating cost, Operating expense	Operating revenue, Mobile phone, Subscribers, Mobile phone calls
2011	Hisali and Yawe	Total Factor Productivity Growth	Cost of investments, Non-wage operational cost, Number of employees, Staff costs	Telephone calls, International calls, Revenue
2012	Nigam et al.	Performance efficiency	Expenditure in crores, Call success rate, Call drop rate, Voice quality	Service access delay, Complaints per 1,000 bill, No of subscriber, Gross revenue

the Malmquist Total Factor Productivity index via input-oriented Data Envelopment Analysis. Nigam et al. [2012] adopted DEA for the purpose of benchmarking Indian mobile telecom operators. Sensitivity analysis was conducted with the DEA result to identify the differences among the efficiency and inefficient units. <Table 1> briefly lists the key variables of previous studies on DEA analysis for telco industry.

3. Research Methods

3.1 DEA Method

There are two type of DEA efficiency measurement, the CCR and the BCC model [Charnes et al., 1978; Banker et al., 1984]. The CCR model is calculated with the preconception of the constant return to scale (CRS) and BCC model is calculated with the presumption of variable return to scale (VRS). DEA efficiency measurement could consider two kinds of orientation. First, the input-oriented model minimizes input while satisfying, at least, the given outputs level. Second, the output-oriented model maximizes outputs without demanding more of any of the realized input levels. Particularly, the input-oriented model calculates to minimize the cost and output-oriented model calculates to maximize revenue.

〈Table 2〉 Regional Grouping of 37 Telcos

Group	Country	Company
Group 1	Malaysia	Maxis Communication, Celcom Axiata, DiGi Telecommunications
	Philippines	Globe Telecom, Smart Communication, Sun Celular
	Indonesia	PT Telkom Tbk, PT Indosat Tbk, PT XL Axiata Tbk
	Thailand	Advanced Info Service (AIS), DTAC, True Corporation
Group 2	Australia	Telstra, Optus, Vodafone
	Japan	KDDI, NTT, Softbank
	South Korea	SKT, KT, LGT
	Taiwan	Chungwa Telecom, FarEast Tone, Taiwan Telecom
Group 3	Singapore	SingTel, M1, Starhub
	Hong Kong	SmarTone Telecommunication, PCCW, Hutchison Telecommunication
Group 4	China	China Mobile, China Unicom, China Telecom
	India	Idea Cellular, Airtel India, Reliance Communication, Vodafone India

The analysis focus is, considering BCC model is based on VRS assumption, the θ_i (the efficiency of the DMU_i) can be pure technical efficiency (PTE) while θ_i in CCR model represents technical efficiency (TE). The BCC models generate a VRS efficiency frontier and estimates both technical efficiency and scale efficiency ($SE = \frac{TE}{PTE}$) [Nigam et al., 2012]. Nigam et al. [2012] consider that "*technical efficiency is the efficiency of converting inputs to outputs, while scale efficiency recognizes that economy of scales will not obtain at all scales of production and there is only one most productive scale size where the scale efficiency is 100%. Therefore, the DMU is said to be efficient if and only if it is both technical and scale efficient.*" When the target DMU has a SE value equal to one, it operates at constant return scale. In case SE score is less than one for the target DMU, then it is scale inefficient [Hung and Lu, 2007] and distinguished as either IRS (Increasing Returns to Scale) or DRS (Decreasing Returns to Scale).

3.2 Telco Selections and Regional Grouping

The telcos are selected from the BMI [Business Monitor International, 2015] report which list competitive telcos of Asia pacific countries. On the basis of telco scores, we 37 telcos from 12 countries. With reference to BMI information, three or four major telcos are selected from each country. Next, we classified these telcos into four groups as illustrated in <Table 2>. The classification is made as per the cultural similarity, income level and regional characteristics. Group 1 is organized with Malaysia, Philippines, Indonesia, and Malaysia, which are part of ASEAN countries in Southeast. These countries have common characteristics in their economic growth pattern and social cultural evolution. Group 2 consists of South Korea, Japan, Australia, and Taiwan. Each country in group 2 is ranked relatively high in GDP and also overall ICT technology level is advanced. Furthermore, we grouped Hong Kong and Singapore together into group 3 since they have similarities

in economic structure, size of region, and population. The last group 4 consists of India and China. They are the two biggest population countries in the world.

3.3 Variables Selection

The selection of input and output variables in DEA is very fundamental to derive meaningful and reasonable results. In previous literatures on telco DEA analysis, the input and output variable selections are diverse as illustrated in <Table 1>. With reference to variables used for telco DEA analysis and to extract performance implications of telco management, we select the four input variables and three output variables. The criteria for input variable selections is to assess the core process capabilities of telcos, which include fixed asset utilization, operation and sales efficiency, and white collar productivity. In conjunction with the input variables, the criteria for selecting output variables is to incorporate critical telco performance indicators such as operating profit, average revenue per user, and the number of subscribers.

As such, the selected input variables are the number of employees, capital expenditure (CAPEX), marketing expense and operating expense. They are already employed in other telco literature, for example, employee and capital expenditure in Koski and Majumdar [2000], Lien and Peng [2001], Tsai et al. [2006], Hung and Lu [2007], Hu and Chu [2008], Liau and Lien [2012]; operating expenses in Yang and Chang [2009], Kweh et al. [2014], Wang et al. [2014], and marketing expenses in Mason et al. [2016].

The number of employees are selected to analyze the labor productivity. Labor productivity, in some sense white collar productivity, is one of the critical benchmarking item. In this paper, we compare the original DEA result with alternative DEA result which are calculated without the number of employee variable. By comparing the changes of telco status of efficient versus inefficient, we can find out the critical role of employee productivity to make a particular telco from inefficient to efficient or vice versa. For example, if a particular telco's efficiency status is changed from efficient to inefficient after omitting number of employee as input variable, then we could judge that employee productivity of the telco plays a critical role to make it efficient. Indeed, we intend to adopt this kind of analysis to measure critical managerial variable's performance across the Asia-pacific regions, and individual telcos within a specific region.

Similarly, the input variable of CAPEX (capital expenditure) is selected to assess the relative efficiency of infrastructure and facilities utilization. The other input variables of marketing expense and operating expense are selected to analyze the relative efficiency of business processes of marketing and operations. In sum, the input variables selected in this paper are most frequently used input variable in the literature and will be used for efficiencies of labor, capital, and business processes of marketing and operation.

The output variables selected in this paper are ARPU (Average Revenue Per Subscriber), EBITDA (Earnings Before Interest, Taxes, Deprecia-

tion and Amortization), and the number of subscribers. They are widely used in telco DEA analysis, for example, ARPU in Mason et al. [2016], subscribers in Koski and Majumdar [2000]; Kwon et al. [2008], Mitra and Shakar [2008], Yang and Chang [2009], Nigam et al. [2012], Liau and Lien [2012], Mason et al. [2016]; EBITDA in Tsai et al. [2006], Hung and Lu [2007].

As the input variables are selected for the purpose of analyzing functional performance comparisons of telco management such as employee productivity, the output variable are also selected for telco management performance analysis. ARPU is selected to obtain some managerial insights to identify critical management improvement efforts of upgrading or enlarging total service portfolio items. If a telco turns out to be inefficient when DEA is run excluding ARPU from the set of output variables, then it gives us the information that the ARPU of the telco is critical to make it as efficient. In other words, the telco was inefficient without ARPU as an output, but since the ARPU of the telco is so superior, the inclusion of ARPU into the output makes it to become efficient. The same kind of analysis will be conducted for the number of subscribers and EBITDA across the region and among the telcos within the region. The details of variable selection is organized in <Table 3>.

〈Table 3〉 Selection of Input and Output Variables

Category	Variable	Description	Researcher
Input	Employee	All staffs engaged in telco operations.	Koski and Majumdar [2000], Lien and Peng [2001], Tsai et al. [2006], Hung and Lu [2007], Hu and Chu [2008], Liau and Lien [2012]
	CAPEX	The cost related to principal sources to develop telco services to customers.	Koski and Majumdar [2000], Lien and Peng [2001], Tsai et al. [2006], Hung and Lu [2007], Liau and Lien [2012]
	Operating Exp	Total administrative expenses to run the telco.	Yang and Chang [2009], Kweh et al. [2014]
	Marketing Exp	All expenses used for marketing, selling, and advertising	Mason et al. [2016]
Output	ARPU	Revenue divided by the number of subscribers; the price paid by the customer each month.	Mason et al. [2016]
	EBITDA	Firm's net operating performance result	Tsai et al. [2006], Hung and Lu [2007]
	Subscribers	Subscribers having accounts of network service provider.	Koski and Majumdar [2000], Kwon et al. [2008], Mitra and Shakar [2008], Yang and Chang [2009], Nigam et al. [2012], Liau and Lien [2012], Mason et al. [2016]

3.4 Data Collection and Descriptive Statistics

The data for 37 telcos are collected from consolidated financial report posted annually on company web site. The year 2015 annual report data are used for computation testing. <Table 4> shows the descriptive statistics for input and output variables adopted for DEA analysis. Furthermore, we conducted the correlation analysis among the input and output variables, which is organized in <Table 5>. The result shows that all the input variables are positively correlated with output variables. And, among the output variables, the correlation between ARPU and subscribers is shown to be negative. It is possible for ASEAN countries because the increase of user, for example due to the pre-paid card users, sometimes inversely related with the ARPU in telco industries [Firli et al., 2015].

Finally, we verified the number of DMUs with the number of variables. In DEA application, Cooper et al. [1999] have a rule of thumb for DMU analysis which $n > \max [3(m \times S)]$, where n is a number of DMU, m is a number of inputs, and s is a number of output. In our analysis, we used 37 telcos, and the number is larger than triple times of the number of inputs (4) and outputs (3). That is, 37 > 3(4+3) = 21.

4. Results of DEA Analysis

We used DEAP 2.1 program [Coelli, 1996] to run the DEA model. Input oriented CCR and BCC is adopted which investigates the efficiency change resulting from changing the input value against a fixed output value [Kim et al., 2014]. The computational testing results organized on group basis are presented in <Table 6>.

〈Table 4〉 Descriptive Statistics of Input and Output Variables

	Subscribers (000)	ARPU	EBITDA (million)	Employee (people)	CAPEX (million)	Marketing Exp. (million)	Operating Exp (million)
Mean	79,312	17	3,531	10,088	4,818	2,288	9,500
Median	26,340	12	860	7,101	1,009	369	1,479
Std. Dev.	148,623	14	5,891	8,957	9,350	4,799	19,907
Minimum	1,942	2	181	1,563	205	85	334
Maximum	826,241	38	27,457	29,710	39,289	21,136	91,098

(monetary units are in USD).

〈Table 5〉 Correlation Coefficients between the Variables

	Subscribers (000)	ARPU	EBITDA (million)	Employee (people)	CAPEX (million)	Marketing Exp (million)	Operating Exp (million)
Subscribers (000)	1.000						
ARPU	(0.347)	1.000					
EBITDA (million)	0.481	0.267	1.000				
Employee (people)	0.583	0.151	0.833	1.000			
CAPEX (million)	0.314	0.338	0.911	0.777	1.000		
Marketing Exp (million)	0.309	0.350	0.922	0.779	0.994	1.000	
Operating Exp (million)	0.139	0.450	0.851	0.701	0.962	0.968	1.000

〈Table 6〉 DEA results organized in 4 different groups

Group 1							
DMU	Company	Country	TE_{CRS}	PTE_{VRS}	SE	RTS	Freq
D024	PT. Telkom Tbk	Indonesia	1.000	1.000	1.000	CRS	4
D035	AIS	Thailand	1.000	1.000	1.000	CRS	2
D023	PT. Indosat Tbk	Indonesia	0.891	1.000	0.891	IRS	1
D025	PT. XL Axiata Tbk	Indonesia	0.738	1.000	0.738	IRS	0
D030	Sun Celular	Philipina	0.352	1.000	0.352	IRS	1
D027	Digi Communication	Malaysia	0.831	0.998	0.832	IRS	0
D029	Smart Comm	Philipina	0.463	0.960	0.483	IRS	0
D037	True Corporation	Thailand	0.623	0.949	0.656	IRS	0
D026	Celcom (AXIATA)	Malaysia	0.745	0.811	0.919	IRS	0
D028	Maxis Comm	Malaysia	0.693	0.797	0.869	IRS	0
D036	DTAC	Thailand	0.606	0.746	0.812	IRS	0
D031	Globe Telecom	Philipina	0.391	0.624	0.628	IRS	0
	Mean		0.694	0.907	0.765		
	Standard Deviation		0.218	0.129	0.202		

Group 2							
DMU	Company	Country	TE_{CRS}	PTE_{VRS}	SE	RTS	Freq
D019	SKT	South Korea	1.000	1.000	1.000	CRS	8
D018	LGT	South Korea	1.000	1.000	1.000	CRS	0
D015	NTT	Japan	0.987	1.000	0.987	DRS	1
D017	KT	South Korea	0.868	1.000	0.868	DRS	1
D003	Vodafone	Australia	0.780	1.000	0.780	DRS	0
D014	KDDI	Japan	0.624	1.000	0.624	DRS	0
D016	SoftBank	Japan	0.412	1.000	0.412	DRS	0
D002	Telstra	Australia	0.732	0.959	0.763	DRS	0
D021	FarEasTone	Taiwan	0.850	0.906	0.938	IRS	0
D022	Taiwan Mobile	Taiwan	0.797	0.859	0.928	DRS	0
D001	Optus	Australia	0.509	0.637	0.798	DRS	0
D020	Chunghwa Telecom	Taiwan	0.464	0.512	0.907	DRS	0
	Mean		0.752	0.906	0.834		
	Standard Deviation		0.209	0.164	0.175		

Group 3							
DMU	Company	Country	TE_{CRS}	PTE_{VRS}	SE	RTS	Freq
D008	Hutchison Global Comm	Hongkong	1.000	1.000	1.000	CRS	9
D034	Starhub	Singapore	1.000	1.000	1.000	CRS	2
D009	SmartTone Mobil Comm	Hongkong	1.000	1.000	1.000	CRS	2
D007	PCCW	Hongkong	1.000	1.000	1.000	CRS	1
D033	SingTel	Singapore	0.983	1.000	0.983	DRS	0
D032	M1	Singapore	0.921	1.000	0.921	IRS	1
	Mean		0.984	1.000	0.984		
	Standard Deviation		0.032	0.000	0.032		

Group 4							
DMU	Company	Country	TE_{CRS}	PTE_{VRS}	SE	RTS	Freq
D004	China Mobile	China	1.000	1.000	1.000	CRS	6
D012	Idea Cellular	India	1.000	1.000	1.000	CRS	4
D011	Airtel India	India	1.000	1.000	1.000	CRS	3
D010	Reliance Comm	India	1.000	1.000	1.000	CRS	1
D006	China Unicom	China	0.972	1.000	0.972	DRS	1
D005	China Telecom	China	0.915	0.964	0.949	DRS	0
D013	Vodafone India	India	0.781	0.839	0.930	DRS	0
	Mean		0.953	0.972	0.979		
	Standard Deviation		0.082	0.060	0.029		

Among the 37 telcos, 12 telcos were shown to be efficient (32%) when CCR model was applied (TE = 1), and the total number of efficient telcos when BCC model was applied, was 23 (62%). Some interesting result is that both Hutchison Global Communication in Hong Kong and SKT in Korea were shown to be highly competent, in terms of frequency shown in <Table 6>, to become a benchmark telco. The frequency of particular efficient DMU means the number of count referred by other inefficient DMUs. The count measures the DMU's importance as a benchmark [Smith and Mayston, 1987], and the high frequency referenced DMUs are considered to be reference DMUs by other inefficient DMUs.

4.1 Regional Telco Efficiency Analysis

The mean value of TE in group 1, which consists of ASEAN countries, was shown to be 0.694. As indicated in <Table 7>, TE value of group 1 was far below than the average TE score of 0.809. The group 3 which consists of telcos in Hong Kong and Singapore showed most efficient scores of TE = 0.984 and PTE = 1.000. While the number of efficient telcos in group 3 was 4 out of 6 (67%) when BCC model is applied, the number of efficient telcos in group 2 is only 2 out of 12 (16.7%). The reason why group 2 telcos of Korea, Japan, Taiwan and Australia runs relatively inefficient status could be explainable by the DRS (Decreasing Returns to Scale) operating level. Among the 10 inefficient telcos of group 2, total 9 telcos were operating at DRS. These telcos could be reduced in size to achieve better scale efficiency. The telecom capacity of group 2 on a national basis could be over capacitated to run at optimal returns of scale.

Similar performance enhancement opportunities in opposite way were available to group 1 telcos of ASEAN countries. All the total 10 inefficient telcos of group 1 run at IRS (Increasing Returns to Scale). It means that these telcos could be consolidated to achieve the scale efficiency. The CCR inefficient two telcos in group 3 showed mixed result of IRS and DRS each. With respect to PTE criterion, the mean efficiency score of group 4 is 0.972, which indicated that the telcos in group 4 were operated more efficiently under the less scale efficient environment. Furthermore, group 1's lowest mean value of scale efficiency and TE revealed strong industrial need of consolidating small scale telcos to achieve better economy of scale. Furthermore, the overall mean TE score of 0.809 and mean

〈Table 7〉 Group based Telco Efficiency Analysis

Group	Number of Telcos						Mean Score		
	Total	CCR efficient	BCC efficient	CRS	IRS	DRS	TE_{CRS}	PTE_{VRS}	SE
Group 1	12	2	5	2	10	0	0.694	0.907	0.765
Group 2	12	2	7	2	1	9	0.752	0.906	0.834
Group 3	6	4	6	4	1	1	0.984	1.000	0.984
Group 4	7	4	5	4	0	3	0.953	0.972	0.979
Total/Avg.	37	12	23	12	12	13	0.809	0.934	0.863

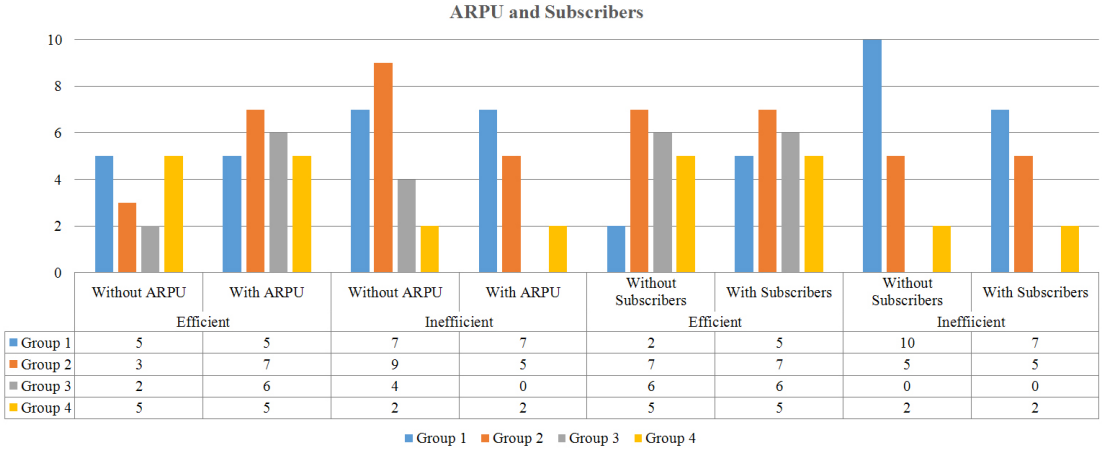
SE score of 0.863 indicated that the telco inefficiencies in Asia-Pacific countries were attributable to both the scale and pure technical inefficiencies.

4.2 Regional Telco Output Factor Analysis

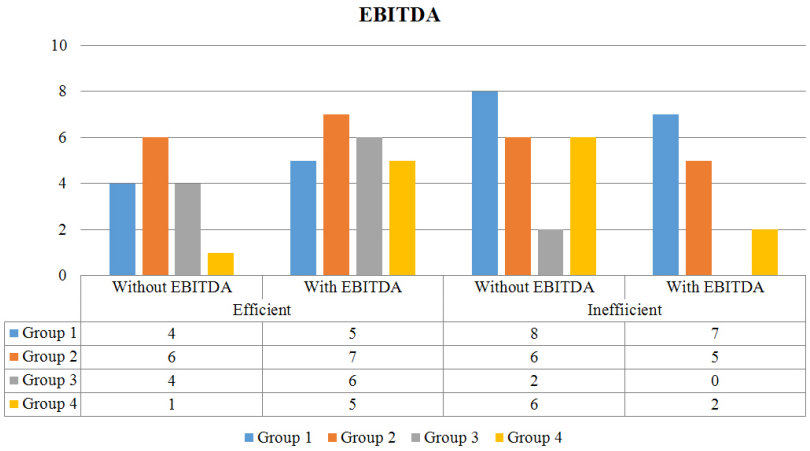
The output variables of ARPU, number of subscribers, and EBITDA are selected to represent the key performances of telco. In order to extract the contribution effect of the particular output variable on telco's efficiency, we run DEA analysis two times in stepwise manner [Wagner and Shimshak, 2007] and compare the results of the two. Considering that the scale efficiency was assessed in the former section, we used PTE figures of BCC to judge the telco efficiency. At first, we run the DEA without including focal output variable, and next run the DEA with complete variable set. The two DEA results could be different, and in any case the efficiency score of the latter DEA will always be at least higher than the score of the former DEA. It is because the number of variables of the latter DEA is higher than the former, so that the DEA model of the latter will be less constrained to result in higher efficiency score [Jenkis and Anderson, 2003].

Following the stepwise DEA output variable inclusion procedure, we first analyzed the impact of ARPU and number of subscribers on telco efficiency. In <Figure 1>, the computational testing result is illustrated. When ARPU was not included in the output variable set, the number of efficient telcos in group 2 and group 3 was three and two each. However, after ARPU was included as the output variable, the number of efficient telcos turned out to increase up-to seven and six each. Indeed, in both group 2 and 3, additional four telcos had become efficient when ARPU was included as one of the output variable. It clearly verifies that the critical competitive factor of telcos in region 2 and 3 is ARPU.

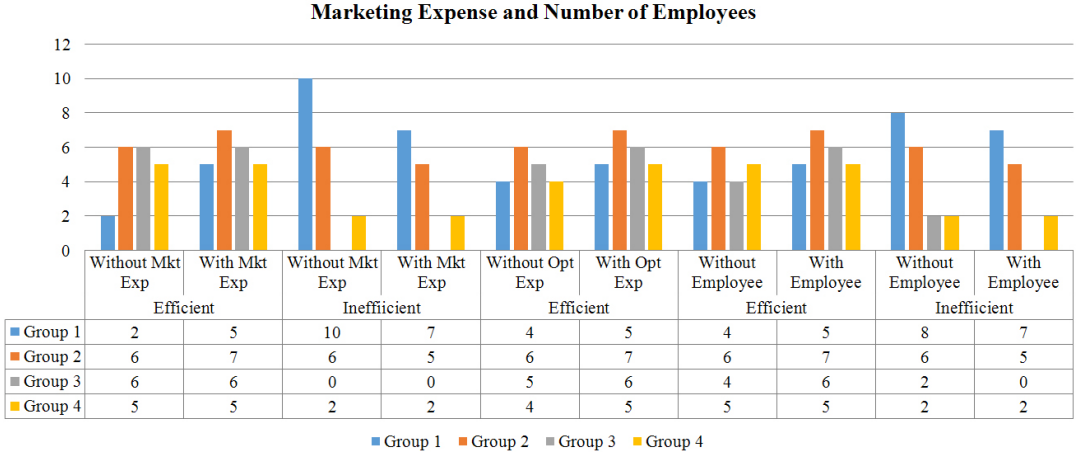
On the other hand, the similar analysis conducted with the number of subscribers revealed the contrary result. This time, without the number of subscribers, the number of efficient telcos



〈Figure 1〉 The Impact of ARPU and Subscribers



〈Figure 2〉 The Impact of EBITDA



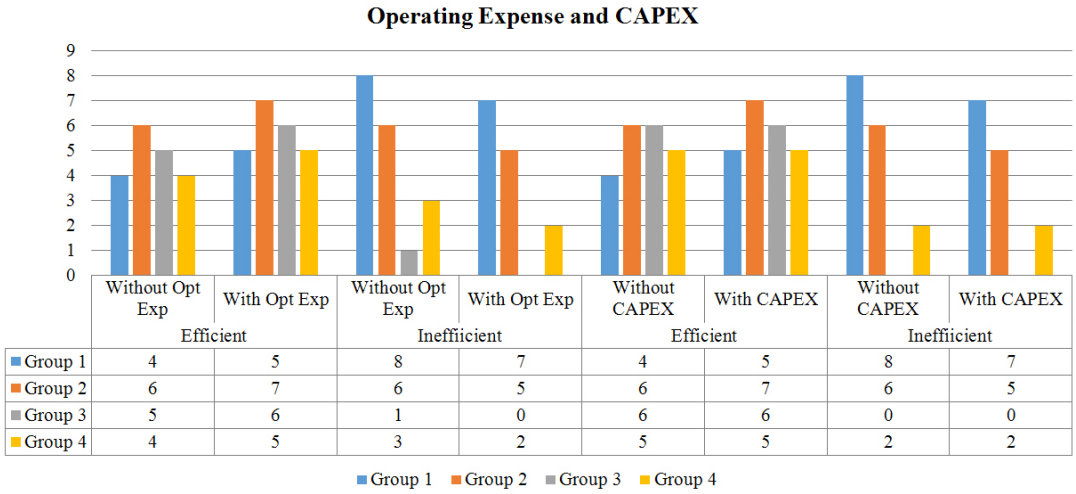
〈Figure 3〉 The Impact of Marketing Expense and Number of Employee

in group 1 was two. However, when the number of subscribers is included in the output variable, the number of efficient telco has been increased up-to five. The result definitely indicates that the major performance factor to make group 1 telco efficient is the number of subscribers. It is interesting to note that, the number of subscribers does not affect the relative efficiency of the telcos in group 2 and group 3.

The EBITDA variable analysis, as illustrated in <Figure 2>, did not indicate significant difference for the group 1, 2, 3. Only the group 3 telcos showed somewhat significant efficiency gains from EBITDA inclusion to output. The number of efficient telcos in group 3 was four without EBITDA, and the number increased up- to six after EBITDA was included in the output.

4.3 Regional Telco Input Factor Analysis

We analyzed the relative contribution effect



〈Figure 4〉 The Impact of Operating Expense and CAPEX

of managerial factors reflected as the DEA input variables. As was done with the output variables, stepwise DEA method was adopted also. We first run the DEA by omitting one focal input variable. Then, we compared the result with the other DEA result with complete input variable set. The input variables used for input factor analysis was marketing expense, operating expense, CAPEX (Capital Expenditure), and the number of employees. As with the output variable analysis, we used PTE scores, and the comparison results were presented in <Figure 3> and <Figure 4>.

Indeed, the computational testing result indicated a few notable input factor contribution effects which could be distinguishable across the region. The one was marketing expense of group 1. Without marketing expense as an input variable, the number of efficient telco in group 1 was two. And the number increased up-to five as illustrated in <Figure 3>, when the marketing expense was included as one of the input variable. We think that this is partially due to the portion of pre-paid cards since the marketing effort is required relatively less for pre-paid card subscription compared to post-paid subscription. The other notable difference is found for the number of employee variable in group 3. The number of efficient telcos in group 3 was four when the number of employees was not included, and the number was increased to up-to six.

In general, the regionally distinguishing effect of the input variables was not shown to be strong. The less constrained effect of efficiency increase attributable to the number of input variables increase was assumed to be shown for the other input variables. However, the impact of input variables on performance on telco efficiency was significant among the telcos within the group. As shown in <Table 8>, the rank of telco efficiency changed significantly across the telcos particularly in group 1 and group 2.

〈Table 8〉 Change in Ranking with and Without Variable

Group 1			PTE	Rank	Excluding each Input Variable									
DMU	Company	Country			W/O Mkt Exp	Rank		W/O Ope Exp	Rank		W/O CAPEX	Rank		W/O Employ	Rank	
D024	**PT. Telkom Tbk**	**Indonesia**	**1.000**	**1**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**
D035	AIS	Thailand	1.000	1	1.000	1	→	0.887	4	↓	1.000	1	→	0.974	2	↓
D023	PT. Indosat Tbk	Indonesia	1.000	1	0.812	5	↓	1.000	1	→	1.000	1	→	1.000	1	→
D025	PT. XL Axiata Tbk	Indonesia	1.000	1	0.712	10	↓	1.000	1	→	1.000	1	→	1.000	1	→
D030	Sun Celular	Philipina	1.000	1	0.782	8	↓	1.000	1	→	1.000	1	→	1.000	1	→
D027	Digi Communication	Malaysia	0.998	2	0.998	2	→	0.928	3	↓	0.998	2	→	0.725	4	↓
D029	Smart Comm	Philipina	0.960	4	0.960	3	↓	0.689	8	↑	0.960	3	↑	0.960	3	↑
D037	True Corporation	Thailand	0.949	5	0.949	4	↓	0.949	2	↑	0.861	4	↑	0.616	7	↓
D026	Celcom (AXIATA)	Malaysia	0.811	6	0.811	6	→	0.729	6	→	0.811	5	↑	0.646	6	→
D028	Maxis Comm	Malaysia	0.797	9	0.797	7	↓	0.717	7	↓	0.797	6	↑	0.608	8	↓
D036	DTAC	Thailand	0.746	9	0.746	9	→	0.746	5	↑	0.574	8	↑	0.507	9	→
D031	Globe Telecom	Philipina	0.624	9	0.635	11	↓	0.602	9	→	0.619	7	↑	0.711	5	↑

Group 2																
D019	**SKT**	**South Korea**	**1.000**	**1**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**
D017	**KT**	**South Korea**	**1.000**	**1**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**
D018	LGT	South Korea	1.000	1	0.781	5	↓	1.000	1	→	1.000	1	→	1.000	1	→
D015	**NTT**	**Japan**	**1.000**	**1**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**	**1.000**	**1**	**→**
D014	KDDI	Japan	1.000	1	1.000	1	→	1.000	1	→	1.000	1	→	1.000	1	→
D016	SoftBank	Japan	1.000	1	1.000	1	→	1.000	1	→	1.000	1	→	0.577	6	↓
D003	Vodafone	Australia	1.000	1	1.000	1	→	0.802	3	↓	0.951	2	↓	1.000	1	→
D002	Telstra	Australia	0.959	2	0.959	2	→	0.959	2	→	0.830	5	↓	0.922	2	→
D021	FarEasTone	Taiwan	0.906	3	0.906	3	→	0.718	5	↓	0.906	3	→	0.906	3	→
D022	Taiwan Mobile	Taiwan	0.859	4	0.859	4	→	0.691	6	↓	0.859	4	→	0.859	4	→
D001	Optus	Australia	0.637	5	0.637	6	↓	0.737	4	↑	0.522	6	↓	0.637	5	→
D020	Chunghwa Telecom	Taiwan	0.512	6	0.512	7	↓	0.620	7	↓	0.512	7	↓	0.512	7	↓

5. Conclusion

The contribution of this paper is rather practical. By applying stepwise DEA in terms of analyzing particular input/out variable addition effect, the regionally distinguishing telco management variables are revealed. We applied DEA to extract distinctive regional characteristics for telco management. The computational testing was conducted with 37 telcos across the 12 countries.

The analysis results revealed that one of the major cause of ASEAN telco inefficiency is due to operating at IRS (Increasing Returns to Scale) status, which indicates consolidation opportunity to achieve efficiency. On the other hand, some telcos of Korea, Japan and Taiwan are found to be less efficient due to operating status at DRS (Decreasing Returns to Scale) stage. Also, ARPU and number of subscribers are shown to play a different role across the region in achieving the telco efficiency. Although the regional distinction is not strong, the impact of input variables of marketing and operating expenses, capital expenditure, and number of employees, on the telco efficiency were shown to be significant.

Theoretically, this paper could be added upon the literatures of stepwise DEA applications, and international management studies. On the basis of this paper, more elaborate comparative telco management research could be extendible.

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