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Evaluating Performance of Telecommunication Branch : Application of DEA with Non-Discretionary Factor

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통신지사의 성과평가 : 비재량 요인을 포함한 DEA 적용

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Improving efficiency of the telecommunication is crucial to the development and growth of Korean economy. Recently, it has become important with the huge development of information technology and its greater potential for extensive impact on the rest of the economy. Hence, it is useful to determine the factors that help enhance efficiency in telecommunication and consider them in improving the evaluation model. This study applies DEA (data envelopment analysis) to evaluate the relative efficiency of 51 branches of a Korean telecommunication company. Using the super-efficiency approach, we tested outliers which may affect the results and ranked the efficient branches. A method of deriving key variables applied to business operation is proposed to identify the key performance indicators for evaluation that takes environmental (non-discretionary) factors into account. We used the extended CCR model proposed by Banker and Morey to investigate the influence of non-discretionary factor. The information provided by the model (slacks, weights) and the sensitivity analysis shows that the most important indicator that affects the branch performance is operating cost. The results of sensitivity analysis show that average efficient score decreases from 0.972 (base case) to 0.863 for CASE2-COST. The average score of the data proves the priority of operating cost over other indicators. The effect of environmental (non-discretionary) variable was found to be significant. The population effect was positive and improved overall efficiency by 0.91% on average. Non-discretionary factor plays a meaningful role explaining the performance of branches. The performance optimization report can help a manager of an inefficient branch to develop branch strategies. Managers can identify the top-performing units, study best practices and adopt the strategy to the organization.

Keywords : Telecommunications, DEA, Super-efficiency, Non-discretionary, Performance

1. Introduction

The telecommunication in Korea has shown rapid growth under the fierce competition among the big 3 operators during the last decade. It is important to note that study on performance evaluation of the telecommunication branches has been a neglected issue.

The objectives of this work are threefold. First, we evaluate the efficiency of the telecommunication in Korea, specifically in the branch level, taking the environmental factor

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into account. Second, we examine the priority of key performance indicators to enable a suitable performance evaluation. Lastly, we provide individualized operating benchmark targets for performance improvement. This is a necessary guide to optimize operation with limited resources.

We use the data envelopment analysis to evaluate the performance of the telecommunication branch. The methodology was implemented in four steps. First, DEA super-efficiency was analyzed. With the analysis, outliers were identified and the efficient units were ranked in order [1]; second, using the extended CCR model developed by Banker and Morey [3], we consider the environmental (non-discretionary) factor that affects the performance; and finally, a sensitivity analysis was carried out by deleting variables from the base model to determine the contribution of each variable on the efficiency.

This is one of the few studies that evaluate the performance of telecommunication branches. We propose the method in which the key variables were selected on branch efficiency using DEA in conjunction with the information provided by non-discretionary factor, super-efficiency model, and the sensitivity analysis.

2. Literature Review

Assessing the efficiency of the organization has been studied in many ways. Although efficiency in the organization has also been analyzed using an econometric approach, the most widely used method has been frontier methods such as Data Envelopment Analysis [11, 21, 22].

In order to evaluate performance in the telecom branches, input and output indicators should be selected carefully because DEA results are sensitive to the selection of variables [4]. Hence, we reviewed all of the available studies to determine the input/output variables to be used in our analysis. The empirical works in telecom industry using DEA are shown in <Table 1>.

<Table 1> Review of the Methodology and Indicators Analyzing Efficiency in Telecom Industry.

Author(s)	*Methodology*	*DMUs*	*INPUT indicators*	*OUTPUT indicators*
Sueyoshi [22]	DEA for production and cost analyses, Scale Economies	Nippon Telegraph & Telephone (1953~1992)	1 : total asset 2 : total access line 3 : total No. of employee	1 : Variable revenue 2 : Fixed revenue 3 : Other revenue
Tsai et al. [23]	DEA, Input-Oriented CRS, Super-efficiency	Global Telecom (39)	1 : Total Assets 2 : CAPEX 3 : Employee No.	1 : Revenue 2 : EBITDA 3 : Operating Profit
Nigam et al. [16]	DEA, Input-Oriented CRS, VRS, Sensitivity analysis	Indian Telecom (126)	1 : Expenditure 2 : Call success rate 3 : Voice quality	1 : Service access delay 2 : Complaints 3 : No.of subscribers 4 : Gross revenue
Lam and Shiu [12]	DEA, Input-oriented VRS, Cross-sectional	Provinces in China (31; 2003~2005)	1 : Capital 2 : Labor	1 : Reveune
				1 : Total No. of subscribers
Cooper et al. [7]	Imprecise DEA, Input-oriented	Mobile Telecom Branch (8)	1 : Man-power 2 : Operating cost 3 : Management level	1 : Revenue 2 : Facility success 3 : Rate of call completion
Giokas and Pentzaropoulos [10]	Analytic Hierarchy Process(AHP) Output-oriented, VRS, DEA-P	Countries in OECD (30)	1 : Access Lines 2 : telecom staff 3 : No. of internet host	1 : Total No. of subscribers
	VRS, DEA-R		4 : Total No. of subscribers	1 : Revenue
Uri [24]	DEA, VRS, Cost Minimization Technical/allocative efficiency	Local Exchange Carriers (LEC) (1985~1998)	1 : No. of employees 2 : capital stock 3 : material expense/price index	1 : Local service 2 : Intrastate toll service 3 : Interstate service
Yang and Chang [25]	DEA, Input-oriented, CRS, VRS, Window analysis	Telecom firms in Taiwan (3; 2001~2005)	1 : assets 2 : operating costs 3 : operating expenses	1 : operating revenues 2 : phone subscribers 3 : phone calls
Masson et al. [14]	Two-stage DEA (CRS) : Service Operation/Delivery	Indian telecom (11)	1 : No. of Base Transceiver Station towers 2 : Network operation cost	1 : Network availability 2 : Connection 3 : %of call answered
			1 : Network availability 2 : Connection 3 : %of call answered	1 : Average Revenue Per User (ARPU) 2 : Active subscriber

DMU : Decision Making Unit, CRS : Constant Returns to Scale, VRS : Variable Returns to Scale.

These studies consider the efficiency of telecom operators from a broad perspective, yet only Cooper et al. [7] has studied the efficiency of branch level in a Korean mobile telecommunication company. Our study has a more specific purpose than previous studies, as it attempts to evaluate branch performance in conjunction with KPIs (key performance indicators) considering non-discretionary factor. We can claim the importance of including the environmental variables in performance analysis, as factors like population and competition status have a clear impact on the performance of branches [5, 13].

3. Method and Data

3.1 Method

This work adopts the input-oriented DEA model. Since the telecom branches are homogeneous groups, no differential factor could cause any of them to have an advantage over the others. We assumed constant returns to scale existed. The linear program used to obtain the level of efficiency of each DMU was :

$$\text{Min } \theta_k - \epsilon(\Sigma S_i^- + \Sigma S_r^+)$$

s.t.

$$\theta_k X_{ik} = \Sigma X_{ij}\lambda_j + S_i^- \quad (i = 1, 2, \cdots, m)$$
$$Y_{rk} = \Sigma Y_{rj}\lambda_j - S_r^+ \quad (r = 1, 2, \cdots, s)$$
$$\lambda j,\ S_i^-,\ S_r^+ \geq \epsilon > 0 \quad (j = 1, 2, \cdots, n)$$

Where θ_k is the parameter that measures the efficiency of the unit k (k = 1, ⋯, n); n is the total number of DMU. Y_{rj} is the amount of output r generated by unit j; X_{ij} is the amount of input i used by unit j; λj is weight. S_i^- is slack variable for input; S_r^+ is slack variable for output; ϵ is a small positive number. It is possible to improve efficiency by the total slack values for each input and output.

Second, we use the extended CCR model [6] to investigate the influence of non-discretionary (ND) factor. The original DEA assumed that all variables are discretionary, that is, can be managed at the discretion of managers. However, the variables that are beyond the control of management may influence the level of efficiency. The modification to incorporate ND factors is given by Banker and Morey [3]

$$\text{Min } \theta_k - \epsilon(\Sigma S_i^- + \Sigma S_r^+)$$

s.t.

$$\theta_k X_{ik} = \Sigma X_{ij}\lambda_j + S_i^- \quad (i \in I_D)$$
$$X_{ik} = \Sigma X_{ij}\lambda_j + S_i^- \quad (i \in I_{ND})$$
$$Y_{rk} = \Sigma Y_{rj}\lambda_j - S_r^+ \quad (r = 1, 2, \cdots, s)$$
$$\lambda j \geq 0 \quad (j = 1, 2, \cdots, n)$$

Where I_D, I_{ND} refer to discretionary (D) and non-discretionary (ND) input I.

$I = \{1, 2, \cdots, m\} = I_D \cup I_{ND}$ with $I_D \cap I_{ND} = \phi$; ϕ is the empty set. The θ is minimized in the constraints for which $i \in I_D$, whereas the constraints for which $i \in I_{ND}$ operate indirectly.

Third, we applied the super-efficiency procedure for outlier identification and ranking of efficient units. Outliers which may introduce bias must be dealt with [1, 2].

Lastly, the sensitivity analysis was performed to define the priority of the KPIs. It allows the analyst to perform "what-if" scenarios on the DEA [17].

3.2 Data

Learned from the literature reviews, the input indicators are usually set labors, capital and facility, and the output indicators are set revenue, the number of subscribers. We also used the population of the telecom branch as a non-discretionary factor. Population variable decides the consumer ability of a region that affects the revenue of a branch. Variables used in this study are as follows :

- *Discretionary input variables* : Labor, Operating cost, Access lines
- *Discretionary output variables* : Revenue, subscribers
- *Non-discretionary input variable* : Population of the regional branch

In <Table 2>, the Pearson correlation showed that the inputs will have a direct relation to the outputs. Test results comply with the principle of "isotonicity."

Meanwhile, larger business units may form a cluster, showing that efficiency of scale is a major factor [19]. To test the effect of size, we divided our sample into quartiles by population, revenues and subscribers respectively. Then we compared the relative efficiencies of DMUs in the lowest quartile with the ones in the highest quartile. We found that the differences in relative efficiencies insignificant for each of the quartiles.

<Table 2> Pearson Correlation Coefficients between Indicators

	Employee	*Operating cost*	*Access line*	*Population*
Revenue	0.770**	0.968**	0.943**	0.771**
Subscribers	0.793**	0.947**	0.774**	0.930**

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

<Table 3> Descriptive Statistics for the Data

Variable	*Mean*	*Median*	*SD*	*Min*	*Max*
Revenue (million won)	35,980	35,908	9,186	21,429	67,332
No.of subscribers (thousand)	3,428	3,352	794	2,205	5,478
Labor (No. of Employees)	153	148	35	90	276
Operating cost (million won)	13,781	13,585	3,598	8,122	23,130
No. of access lines (thousand)	368	359	95	220	607
Population (thousand person)	1,007	982	306	436	1,696

The case is a sample of 51 branches of a telecommunication operator in Korea (after this simply "the Telecom"). The telecom branch names were deleted and were named F1 to F51 DMU. The descriptive statistics for the data are as shown in <Table 3>.

4. Results

All DEA results were obtained by using the Efficiency Measurement System (EMS) developed by Holger Scheel [18]. Branches with super-efficiency scores higher than 200% are regarded as an outlier. There is no branch with super-efficiency score higher than 200%.

4.1 Influence of the Non-Discretionary Indicator

The final column of <Table 4> shows the influence of the non-discretionary (ND) indicator on the efficiency level.

<Table 4> Efficiency Score, Potential for Improvement, Virtual Input/Output and ND Influence

DMU	score	% potential for improvement					virtual inputs/outputs					with ND efficiency	% influence of ND
		I1	I2	I3	O1	O2	I1	I2	I3	O1	O2		
F1	1.098	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	50.4%	49.6%	93.5%	16.2%	big	
F2	0.946	0.0%	0.0%	0.0%	0.0%	0.0%	27.8%	55.2%	17.0%	67.5%	27.1%	0.946	0.0%
F3	0.993	0.0%	0.0%	5.8%	0.0%	0.0%	19.4%	80.6%	0.0%	60.7%	38.6%	0.993	0.0%
F4	0.933	0.0%	0.0%	0.0%	0.0%	0.0%	26.8%	55.1%	18.1%	82.9%	10.4%	0.939	0.7%
F5	0.965	0.0%	0.0%	0.0%	0.0%	0.0%	15.5%	48.8%	35.7%	45.9%	50.6%	0.965	0.0%
F6	0.938	0.0%	0.0%	0.0%	0.0%	0.0%	29.3%	53.3%	17.5%	62.1%	31.8%	0.938	0.0%
F7	0.903	0.0%	0.0%	0.0%	0.0%	0.0%	27.6%	53.8%	18.6%	63.8%	26.5%	0.908	0.5%
F8	0.960	0.0%	0.0%	0.0%	0.8%	0.0%	52.9%	23.5%	23.6%	0.0%	96.0%	0.975	1.5%
F9	1.006	0.0%	0.0%	0.0%	0.0%	0.0%	35.8%	49.0%	15.1%	100.6%	0.0%	1.022	1.6%
F10	0.986	0.0%	0.0%	0.0%	0.0%	2.9%	31.7%	53.0%	15.3%	98.6%	0.0%	0.986	0.0%
F11	0.954	0.0%	0.0%	0.0%	0.1%	0.0%	52.0%	28.3%	19.7%	0.0%	95.4%	1.000	4.8%
…	…	…	…	…	…	…	…	…	…	…	…	…	…
F16	0.999	0.0%	0.0%	11.0%	0.0%	0.0%	30.0%	70.0%	0.0%	74.2%	25.7%	0.999	0.0%
F17	1.039	0.0%	0.0%	0.0%	0.0%	0.0%	35.4%	64.6%	0.0%	103.9%	0.0%	1.041	0.2%
F18	0.973	0.0%	0.0%	0.0%	0.0%	0.0%	42.1%	36.1%	21.8%	23.0%	74.3%	0.993	2.1%
F19	0.965	0.0%	0.0%	1.9%	0.0%	0.0%	23.3%	76.7%	0.0%	71.1%	25.4%	0.966	0.1%
F20	0.969	0.0%	0.0%	3.1%	0.0%	0.0%	24.4%	75.6%	0.0%	71.5%	25.4%	0.969	0.0%
F21	0.929	0.0%	0.0%	1.0%	0.0%	0.0%	26.8%	73.2%	0.0%	68.1%	24.8%	0.929	0.0%
F22	0.948	0.0%	0.0%	0.0%	0.0%	0.0%	25.9%	66.3%	7.9%	53.0%	41.8%	0.948	0.0%
F23	0.942	0.0%	0.0%	0.0%	0.0%	0.0%	29.3%	58.3%	12.4%	54.1%	40.2%	0.942	0.0%
F24	1.009	0.0%	0.0%	0.0%	0.0%	0.0%	28.7%	59.0%	12.3%	62.6%	38.2%	1.009	0.0%
F25	0.952	0.0%	0.0%	0.0%	0.0%	0.0%	27.7%	59.6%	12.7%	54.8%	40.4%	0.952	0.0%
F26	1.004	0.0%	0.0%	0.0%	0.0%	0.0%	28.6%	53.1%	18.2%	59.4%	41.1%	1.004	0.0%
F27	0.989	0.0%	0.0%	2.5%	0.0%	0.0%	29.3%	70.7%	0.0%	44.8%	54.1%	0.989	0.0%
F47	0.968	0.0%	0.0%	0.0%	0.0%	0.0%	20.6%	72.6%	6.8%	42.1%	54.7%	1.052	8.7%
F48	0.829	0.0%	0.0%	0.0%	0.0%	0.0%	31.4%	51.0%	17.6%	54.8%	28.1%	0.842	1.5%
F49	0.903	0.0%	0.0%	0.0%	0.0%	0.0%	8.2%	42.5%	49.2%	32.1%	58.2%	0.932	3.2%
F50	0.910	0.0%	0.0%	0.0%	0.0%	0.0%	44.2%	37.0%	18.8%	25.7%	65.4%	0.968	6.3%
F51	1.194	0.0%	0.0%	0.0%	0.0%	0.0%	35.2%	0.0%	64.8%	97.0%	22.4%	1.268	6.2%
Average	0.972	0.08%	0.07%	1.37%	0.02%	0.07%	27.4%	56.1%	16.5%	52.8%	44.3%	0.978	0.91%

I1, Labor; I2, Operating cost; I3, Number of access lines; ND1, population of the regional branch. O1, Revenue; O2, Number of subscribers
The efficiency score of F1 'big' implies that the DMU remains efficient under increased arbitrary inputs, since it is applying the super-efficiency model. This does not give any influence in identifying the presence of outlier.

This result was obtained by comparing the results of efficiency with ND taken into account against the result with ND factor excluded. Therefore, they reveal how the population of the telecom branch influenced the efficiency results. In case of F11 and F47, these effects were 4.8% and 8.7% respectively. ND factor plays a meaningful role explaining the performance of branches.

4.2 Efficiency Analysis of Telecom Branch Performance

In an input-oriented super-efficiency model, all scores may be either greater than the unit (super-efficient), equal to the unit (efficient), or lower than the unit (inefficient). In the case of inefficiency, the gap with the unit indicates the level of inefficiency. For example, the efficiency score of F11 was 0.954, suggesting 4.6% inefficiency. This means that F11 would need to reduce its level of input by 4.6% to become efficient while leaving the output at its present value. However, this would not be the only action to this effect, as other additional measures will be required to achieve efficiency.

The values in the "potential for improvement" column of <Table 4> are obtained from the slack rate against each input and output. Those figures represent the required discretionary input reduction rate to achieve efficiency. Output wise, this explains how much more output should be added to reach efficiency level. That is, with respect to F11, apart from the input reduction of 4.6%, the revenue (O1) needs to be improved (O1 = 0.1%).

We can see the "virtual inputs and outputs", i.e. the weights multiplied by the variables in <Table 4>. The optimal weights provide a measure of the relative contribution of variables to the overall efficiency. If we examine the virtual input and output, then we can see the relative influence of each variable. These values not only show, which variables contribute to the evaluation of DMU, but also to what extent they do so [8].

For example, in case of F11, total subscribers (O2, 95.4%) can explain its overall efficiency, which is influenced by the labor (I1, 52%), operating costs (I2, 28.3%) and access lines (I3, 19.7%).

The aggregated information from the last row "average" helps us to identify the indicators that should be improved and how each indicator contributes to the efficiency value. This implies that, generally speaking, the branches should focus more on reducing the level of access lines (I3 = 1.37%). Similarly, the results from the virtual values of the last row show that operating costs (I2 = 56.1%) and revenue (O1 = 52.8%) were key indicators. According to this analysis, efforts should be made to reduce the level of operating costs, meanwhile paying attention to the level of revenue.

4.3 Sensitivity Study of Evaluated Indicators

<Table 5> shows the overall efficiency based on different combination of indicators. The rates of change are negative or zero; the negative value means that the absence of the indicator will reduce DMU's efficiency value. The average efficiency is decreased from 0.972 of the base case down to 0.863 in CASE2-COST (deleting operating cost).

The labor gives the greatest influence to F13 (up to -17.3%) and minimum impact to F1, F34, F41, and F43. The sensitivity degree of indicators shows that F51 has always been efficient in all cases except for CASE3-LINE. This confirms that F51 is more sensitive to access lines. On average, almost all DMUs are more sensitive to operating costs. The results suggest the priority as follows: operating costs > labor > subscribers > revenue > access line.

Using the sensitivity analysis, the branches could be categorized into 5 groups.

(1) RE : the DEA stays efficient or efficiency decreases very slightly. For example, F51 was robustly efficient.
(2) ME : the DEA is efficient in the base model and remains efficient in some situations, but efficiency decreases significantly in other situations. F1, F34 and F43 fall into this category.
(3) MI : the efficiency is above 0.9 but below 1 in the base model and stays in that range. F27 is a marginally inefficient branch.
(4) SI : the DEA efficiency is above 0.9 but below 1 in the base and drops to lower values. When labor is removed from the analysis, F11's score changes to 0.822 (-13.8%) which suggests that labor is the strength of F11.
(5) DI : the efficiency is significantly low (below 0.9) in all conditions. F48 can be considered as a distinctly inefficient.

Such distinction is useful for selecting branches for performance improvement. DI and SI branches clearly have problems and require attention. Since ME branches are very sensitive to changes in a few indicators, they need more attention than MI branches to prevent them from becoming inefficient. The efficiency of MI branches can be improved only based on a long-tern plan because of their low sensitivity to changes in the indicators [17].

<Table 5> Comparison of CCR Super-Efficiency (Sensitivity Analysis)

DMU	Base	CASE1-LABOR		CASE2-COST		CASE3-LINE		CASE4-REV		CASE5-SUB		CAT.
	Score	Score	Δ CCR	Score	Δ CCR	Score	Δ CCR	Score	Δ CCR	Score	Δ CCR	
F1	1.098	1.098	0.0%	0.918	-16.4%	1.054	-3.9%	0.899	-18.1%	1.097	0.0%	ME
F2	0.946	0.891	-5.9%	0.827	-12.6%	0.922	-2.6%	0.874	-7.6%	0.936	-1.0%	SI
F3	0.993	0.977	-1.6%	0.769	-22.6%	0.993	0.0%	0.906	-8.7%	0.977	-1.6%	SI
F4	0.933	0.806	-13.6%	0.904	-3.1%	0.926	-0.7%	0.905	-3.0%	0.933	0.0%	SI
F5	0.965	0.953	-1.3%	0.878	-9.1%	0.932	-3.4%	0.928	-3.9%	0.946	-2.0%	SI
F6	0.938	0.897	-4.5%	0.826	-12.0%	0.920	-2.0%	0.892	-5.0%	0.910	-3.0%	SI
F7	0.903	0.828	-8.3%	0.799	-11.5%	0.898	-0.6%	0.849	-6.0%	0.887	-1.9%	SI
F8	0.960	0.855	-11.0%	0.948	-1.3%	0.935	-2.6%	0.960	0.0%	0.930	-3.2%	SI
F9	1.006	0.924	-8.1%	0.827	-17.8%	1.003	-0.3%	0.837	-16.7%	1.006	0.0%	ME
F10	0.986	0.874	-11.4%	0.925	-6.2%	0.963	-2.3%	0.899	-8.8%	0.986	0.0%	SI
F11	0.954	0.822	-13.8%	0.952	-0.2%	0.940	-1.5%	0.954	0.0%	0.943	-1.1%	SI
F12	0.970	0.848	-12.5%	0.938	-3.2%	0.963	-0.7%	0.959	-1.1%	0.961	-0.9%	SI
F13	0.951	0.786	-17.3%	0.951	0.0%	0.951	0.0%	0.944	-0.7%	0.951	0.0%	SI
F14	0.974	0.898	-7.8%	0.836	-14.1%	0.962	-1.3%	0.890	-8.6%	0.962	-1.2%	SI
F15	1.007	0.873	-13.3%	1.007	0.0%	0.979	-2.8%	1.007	0.0%	0.988	-1.9%	ME
…	…	…	…	…	…	…	…	…	…	…	…	…
F27	0.989	0.911	-7.9%	0.929	-6.0%	0.989	0.0%	0.987	-0.1%	0.935	-5.4%	MI
…	…	…	…	…	…	…	…	…	…	…	…	…
F34	1.062	1.062	0.0%	0.965	-9.1%	0.963	-9.4%	1.062	0.0%	0.829	-21.9%	ME
F35	0.938	0.917	-2.3%	0.737	-21.5%	0.938	0.0%	0.933	-0.6%	0.869	-7.4%	SI
F36	0.904	0.869	-4.0%	0.748	-17.3%	0.902	-0.2%	0.843	-6.8%	0.882	-2.4%	SI
F37	0.951	0.925	-2.7%	0.787	-17.3%	0.951	0.0%	0.945	-0.6%	0.881	-7.3%	SI
F38	0.909	0.904	-0.5%	0.749	-17.5%	0.909	0.0%	0.874	-3.8%	0.856	-5.8%	SI
F39	0.956	0.949	-0.8%	0.886	-7.3%	0.899	-6.0%	0.934	-2.3%	0.839	-12.3%	SI
F40	0.941	0.933	-0.8%	0.872	-7.3%	0.884	-6.1%	0.920	-2.2%	0.833	-11.5%	SI
F41	0.973	0.973	0.0%	0.859	-11.7%	0.955	-1.8%	0.967	-0.7%	0.865	-11.1%	SI
F42	0.940	0.907	-3.5%	0.724	-22.9%	0.940	0.0%	0.878	-6.6%	0.919	-2.3%	SI
F43	1.041	1.041	0.0%	0.859	-17.5%	1.041	0.0%	1.040	-0.1%	0.912	-12.4%	ME
F44	0.913	0.850	-6.9%	0.739	-19.1%	0.913	0.0%	0.842	-7.8%	0.898	-1.6%	SI
F45	0.987	0.976	-1.1%	0.768	-22.2%	0.987	0.0%	0.955	-3.3%	0.931	-5.7%	SI
F46	0.978	0.910	-7.0%	0.859	-12.2%	0.976	-0.2%	0.939	-4.0%	0.945	-3.4%	SI
F47	0.968	0.938	-3.1%	0.864	-10.7%	0.966	-0.2%	0.957	-1.1%	0.904	-6.5%	SI
F48	0.829	0.809	-2.5%	0.716	-13.7%	0.823	-0.8%	0.792	-4.6%	0.800	-3.6%	DI
F49	0.903	0.883	-2.2%	0.807	-10.7%	0.878	-2.8%	0.878	-2.8%	0.851	-5.8%	SI
F50	0.910	0.869	-4.5%	0.867	-4.8%	0.890	-2.2%	0.909	-0.2%	0.870	-4.5%	SI
F51	1.194	1.142	-4.3%	1.194	0.0%	0.946	-20.8%	1.108	-7.2%	1.193	0.0%	RE
Average	0.972	0.916	-5.8%	0.863	-11.3%	0.954	-1.7%	0.933	-3.9%	0.931	-4.2%	

Note : Δ CCR means the variation percentage of case's CCR super-efficient score compared with that of the base score. CASE1-LABOR (deleting I1), CASE2-COST (deleting I2), CASE1-LINE (deleting I3), CASE4-REV (deleting O1), CASE5-SUB (deleting O2).

4.4 Case Study : Performance Optimization Report

Performance optimization report can be provided for each branch. <Table 6> shows an example. F48's relative efficiency score is 0.829 (0.842 with non-discretionary) and is classified as distinctively inefficient.

(1) Reference sets : if F48 hopes to improve its relative efficiency, it is suggested for F48 to refer to benchmarks (reference sets). That is, F48 is suggested to refer to F24, F51, F26 and F17 at 73.8%, 4.8%, 1.3%, and 1.0% respectively in setting the benchmark target for its input and output.

(2) Improvement : all indicators of F48 should be reduced to 17.05%to reach benchmark target. All of its outputs can be maintained at the same level. It has zero slack in outputs.

(3) Contribution : the input and output items contribute to F48's relative efficiency. I2 (operating costs 51.0%) is the major input indicator and O1 (revenue 54.8%) is the major output indicator.

(4) Sensitivity degree : this shows the I2 (operating costs) has the most important impact on F48's relative efficiency; deleting I2 can reduce F48's relative efficiency down to -13.7%.

As a result, we conclude that the indicators' priority for F48 is operating costs > revenue > subscribers > labor > access line. Even though labor (I1) comes fourth in priority, deleting I1 helps F48 to raise 2 steps in its ranking among all DMUs.

<Table 6> Performance Optimization Report

	input			*output*		*intensity (lambdas)*
	I1	I2	I3	O1	O2	
F48	122	10,098	262	23,551	2,256	
Reference sets						
F17	124	15,203	429	39,510	3,653	0.010
F24	126	10,029	267	28,640	2,755	0.738
F26	136	13,335	333	34,743	3,517	0.013
F51	110	13,716	247	33,145	2,971	0.048
Benchmark Target	101	8,376	217	23,551	2,256	
slack				-	-	
GAP(DMU-Target)	21	1,722	45			
Improvement (%)	17.05%	17.05%	17.05%	0.0%	0.0%	
Contribution (%)	31.4%	51.0%	17.6%	54.8%	28.1%	
Sensitivity degree	-2.5%	-13.7%	-0.8%	-4.6%	-3.6%	
Ranking variation	2	0	0	0	0	
Year of analysis	2016.5					
Classification	DI (Distinctly Inefficient)					
DEA efficiency	0.829~0.716					
% Influence of ND	1.5% (0.842 with Non-discretionary efficiency)					
Strengths	Operating costs (I2)					

5. Conclusion

This paper examines the efficiency in the telecom branches by considering non-discretionary factor and identifies which KPIs (key performance indicators) are important to the organization. Inefficient branches can improve their performance by checking the room for potential improvement (slack); they can also get ideas for performance improvement by benchmarking efficient branch from their reference set. In addition, sensitivity analysis helps the branch to learn the influence its inputs and outputs give to the performance. The results show that average efficient score decreases from 0.972 (base case) to 0.863 for CASE2-COST. The average score of the data proves the priority of operating cost over other indicators.

This paper offers significant contributions compared to past studies. First, it included the effect of non-discretionary indicator when developing the performance evaluation of the branch. The population effect was positive and improved overall efficiency by 0.91% on average. Second, using super-efficiency approach, we tested the outliers and ranked the efficient DMUs. Third, the influence of each indicator was examined using information provided by the model (slacks, virtual input/output) and the sensitivity analysis of the KPIs. In addition, the example of the performance optimization report is presented as a guide for the managers to develop branch strategies. Managers can identify the top-performing units (reference sets), study best practices and adopt the strategy to the organization.

Despite the contributions, this paper has a few shortcomings and therefore further studies should be carried out. First, we use the Banker and Morey approach that includes non-discretionary factors, but it is only applied to an input-oriented model. However, there are theoretical alternatives that may be considered for future studies [9, 15]. Second, a dynamic model such as DEA-windows analysis was not used. Thus, this study cannot be generalized. Lastly, we did not consider the managerial difference. All other things being equal, management level is likely to influence the organization's overall performance [20].

The organization's performance may be evaluated with multiple tools. This paper addresses an issue for managers interested in evaluating the organization and improving efficiency. This study provides a valuable reference for application to future studies, exploring an analysis of KPIs. It will be interesting to examine the results of DEA in conjunction with the results of other measurement models.

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