Chapter 5

The Empirical Results

This chapter presents the results of estimated technical efficiency of Bangkok Mass Transit Authority (BMTA) during 1989 – 2007 and the estimated technical efficiency between BMTA and four selected private operators; minibuses, Union Bus Service Group; Rangsit zone, Wangsakarnkij Company, and Sahakonsong Thonburi Company in 2007 by employing Data Envelopment Analysis (DEA).

This chapter will be organized as follows;

5.1 Data summaries

5.2 The technical efficiency under VRS Model

5.3 The technical efficiency under CRS and VRS Model

The study will be divided into two measurements which are technical efficiency measurement using number of trips as output and using number of passengers as output, respectively.

5.1 Data Summaries

The data summaries of variables that are employed in this study to measure the technical efficiency are shown in Tables 5.1 and 5.2. Tables 5.1 shows the mean, minimum, maximum, and standard deviation of both inputs and output of BMTA during 1989 – 2007 and Table 5.2 shows those values of BMTA and selected private operators in 2007, respectively. As reported in Table 5.1, the average inputs of BMTA, which are number of buses, number of officers and amount of fuel used, were 4,210 buses, 21,255 persons and 151,069,111 litres, respectively. The BMTA average outputs, in term of number of trips and number of passengers, are 23,034,198 trips and 1,116,336,857 persons, respectively.

As reported in Table 5.2, the average inputs of BMTA, which are number of buses, number of officers and amount of fuel used, are 3,535 buses, 18,206 persons and 135,060,739 litres, respectively. The average outputs of private operators, which are number of trips and number of passengers, are 11,102,981 trips and

613,201,577 persons, respectively. Whereas the average inputs of private operators, which are number of buses, number of officers and amount of fuel used, are 3,135 buses, 1,066 persons and 8,334,184 litres, respectively. The average outputs of private operators, which are number of trips and number of passengers, are 744,870 trips and 252,168,463 persons, respectively.

Table 5.1

Summary Statistics of Sample Data of BMTA during 1989 – 2007

Variable	Mean	S.D.	Min	Max
Input				
Number of buses (buses)	4,210	577	3,535	5,287
Number of officers (persons)	21,255	1,887	18,206	23,628
Amount of fuel used (litres)	151,069,111	7,968,663	135,060,739	161,614,854
Output				
Number of trips(trips)	23,034,198	1,422,126	10,953,606	14,867,281
Number of passengers (persons)	1,116,336,857	319,919,764	613,201,577	1,646,171,457

Source: Calculated by author.

Table 5.2

Summary Statistics of Sample Data of BMTA comparing with Private Operators in 2007

Variable	Mean	S.D.	Min	Max
BMTA				
Input				
Number of buses (buses)	3,535	-	3,535	3,535
Number of officers (persons)	18,206	-	18,206	18,206
Amount of fuel used (litres)	135,060,739	-	135,060,739	135,060,739
Output				
Number of trips (trips)	11,102,981	-	11,102,981	11,102,981
Number of passengers (persons)	613,201,577	-	613,201,577	613,201,577
Private Operators				
Input				
Number of buses (buses)	3,135	2,971	100	5,725
Number of officers (persons)	1,066	768	311	2,138
Amount of fuel used (litres)	8,334,184	8,166,654	257,010	19,509,250
Output				
Number of trips (trips)	744,870	1,053,918	12,188	2,309,040
Number of passengers (persons)	252,168,463	456,413,287	4,307,000	936,444,252

Source: Calculated by author.

Note: Data of BMTA is only year 2007.

5.2 The Technical Efficiency under VRS Model

Firstly, the empirical results under VRS model will be discussed with two measurements which are the number of trips and that of passengers as proxies for outputs. The results comparing between CRS and VRS models will be discussed in the next step.

The discussion starts with the correlation testing by Pearson correlation method. Pearson correlation method is the method of testing the degree of correlation between input and output variables (Kao et al., 2003). It not only shows the relative direction of inputs and outputs but also suggests that variables should be employed in this study to avoid multicolinearity problem. As shown in Tables 5.3 – 5.6, the correlation between input and output variables is relatively high. Tables 5.3 and 5.4 show the degree of correlation in case of the number of trips as proxy for output. Pearson correlation of input and output variables of Table 5.3 is significant at the level of confidence at 99% and Table 5.2 is significant at the levels of confidence at 99% and 98%, respectively.

Tables 5.5 and 5.6 represent the correlation between input and output variables in case of the number of passengers as proxy for output. Table 5.5 is significant at the level of confidence at 99% and Table 5.6 is significant at the levels of confidence at 99% and 95%, respectively. According to the test results, these chosen input and output variables, can be applied to analyze technical efficiency using DEA. Therefore, this study employs three inputs and two outputs (in separate measurement) for input-oriented DEA model.

Table 5.3

Pearson Correlations for Input and Output Variables of BMTA during 1989 -2007 (Number of Trips)

		BUS	OFFICER	FUEL	TRIP
BUS	Pearson Correlation	1	.866(**)	.665(**)	.865(**)
	Sig. (2-tailed)	.	.000	.001	.000
OFFICER	Pearson Correlation	.866(**)	.1	.824(**)	.994(**)
	Sig. (2-tailed)	.000	.	.001	.000
FUEL	Pearson Correlation	.665(**)	.824(**)	1	.808
	Sig. (2-tailed)	.001	.001	.	.001
TRIP	Pearson Correlation	.865 (**)	.994(**)	.808(**)	1
	Sig. (2-tailed)	.000	.000	.001	.

Source: Calculated by author.

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

Table 5.4

Pearson Correlations for Input and Output Variables of BMTA and Private operators in 2007 (Number of Trips)

		BUS	OFFICER	FUEL	TRIP
BUS	Pearson Correlation	1	.876(*)	.745(*)	.732(*)
	Sig. (2-tailed)	.	.001	.012	.015
OFFICER	Pearson Correlation	.876(*)	1	.999(**)	.993(**)
	Sig. (2-tailed)	.001	.	.000	.001
FUEL	Pearson Correlation	.745(*)	.999(**)	1	.996(**)
	Sig. (2-tailed)	.012	.000	.	.000
TRIP	Pearson Correlation	.732(*)	.993(**)	.996(**)	1
	Sig. (2-tailed)	.015	.001	.000	.

Source: Calculated by author.

Note * Correlation is significant at the 0.02 level (2-tailed).

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

Table 5.5

Pearson Correlations for Input and Output Variables of BMTA during 1989 -2007 (Number of Passengers)

		BUS	OFFICE	FUEL	PASS
BUS	Pearson Correlation	1	.873(**)	.606(**)	.903(**)
	Sig. (1-tailed)	.	.000	.006	.000
OFFICER	Pearson Correlation	.873(**)	1	.691(**)	.897 (**)
	Sig. (1-tailed)	.000	.	.001	.000
FUEL	Pearson Correlation	.606(**)	.691(**)	1	.805(**)
	Sig. (1-tailed)	.006	.001	.	.000
PASS	Pearson Correlation	.903(**)	.897(**)	.805(**)	1
	Sig. (1-tailed)	.000	.000	.000	.

Source: Calculated by author

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

Table 5.6

Pearson Correlations for Input and Output Variables of BMTA and Private operators in 2007 (Number of Passengers)

		BUS	OFFICER	FUEL	PASS
BUS	Pearson Correlation	1	.767(*)	.877 (*)	.904(**)
	Sig. (1-tailed)	.	.027	.017	.001
OFFICER	Pearson Correlation	.767(*)	1	.999(**)	.800(**)
	Sig. (1-tailed)	.027	.	.000	.002
FUEL	Pearson Correlation	.877(*)	.999(**)	1	.800(**)
	Sig. (1-tailed)	.017	.000	.	.002
PASS	Pearson Correlation	.904(**)	.800 (**)	.800(**)	1
	Sig. (1-tailed)	.001	.002	.002	.

Source: Calculated by author.

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

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

The correlation results show the high correlation of variables. Therefore, the variables can use to measure the technical efficiency in both cases. In order to measure the technical efficiency (TE) of BMTA and private operators, the analysis is divided into TE estimation of time series data of BMTA during 1989 – 2007 and estimation of technical efficiency between BMTA and selected private operators; Wangsakarnkij Company, Sahakhonsong Thonburi, Union Bus Service Group Company and minibuses by employing annual data in 2007. These two sources of data were substituted into the CRS and VRS model respectively in order to compute the efficiency by employing a DEA approach. Since bus service does not operate in the competitive market then CRS model is not suitable to explain the bus service industry. Therefore, results of VRS case will be more appropriate to estimate the situation of bus service industry that does not operate in the competitive market (CRS assumption is servicer under competitive market). Therefore, the results of VRS will be discussed first. Subsequently, the results of both CRS and VRS cases will be compared and discussed. The results of VRS model are indicated in Tables 5.7 and 5.10.

5.2.1 The Results under VRS Model of BMTA during 1989 - 2007

The results of technical efficiency of the bus providers that employ the data of the multiple inputs and single output by using DEA under VRS model is explained in this section. This section starts with the results of VRS model because bus service industry in Bangkok does not operate in the competitive market. This industry provides service under government regulation (price control) then VRS model is more suitable to measure the results than CRS model.

Table 5.7 interprets the results of two outputs under VRS model. Model 1 stands for results of number of trips and model 2 stands for results of number of passengers. As reported in Table 5.7, the efficiency scores of model 1 have range between 0.965 – 1 and model 2 have range between 0.903 – 1. TE scores under model 1 show that in 1989, 1990, 1992, 2000, 2001 and 2007, BMTA are technical efficient. For the other model, BMTA is technically efficient in1989, 1991, 1992, 2000, 2001, 2003, 2004, 2005 and 2007.

The average TE scores of these two models are 0.991 and 0.974, respectively. This means that at the same efficiency level, BMTA could possibly reduce the sum of all amount of input by 0.9% and 2.6% without reducing the number of trip and number of passengers, respectively. In other words, BMTA could use the input level at 99.1% and 97.4% of primary level to provide services on the efficiency frontier. Alternatively, it can have score at 1 (100%) without reducing the number of trip and the number of passengers, respectively.

The scores of both models are high. The result of BMTA during 1989 – 2007 using the number of passengers as a proxy for output under VRS model are similar to the results using the number of trips as a proxy for output.

Tables 5.8 and 5.9 show the peer of technical inefficiency score in each year and suggests λs and slacks to improve the efficiency. λ_a will be the representative of peer 1, λ_b stands for peer 2, and so on. The inefficient firms can calculate the proper inputs and outputs from the combinations of multiplication between lambda values of its peer and values of inputs or outputs. The slacks suggest that the further reduction of those inputs or outputs depend on types of slack.

For example, as reported in Table 5.8, λ in 1994 has λ_a for 1993 and λ_b for 2007 as its peers which in λ_a is 0.773 and λ_b is 0.227 and IS_1 is 0.039 and IS_2 is 0.01. It could be seen that in year 1994 input usage is radically inefficient by a factor of 2% plus it has (non-radial) input slack of 0.039 and 0.01 units (per unit of number of trips) of number of buses and number of officers, respectively. The target of 1994 would therefore be to reduce usage of three inputs by 2% and also to reduce the use of number of buses and number of officers by a further 0.039 and 0.01 units. And as shown in Table 5.13, in 1993, this year has years 1989, 2003, and 2005 as its peers. interprets that λ_a to λ_c 0.692, 0.156 and 0.152, respectively and IS_3 is 0.025, which means that in year 1993, input usage is radically inefficient by a factor of 8% and it has (non-radial) input slack of 0.025 units of amount of fuel used (per unit of number of passengers). The target of year 1993 would therefore be to reduce usage of three inputs by 8% and also to reduce the use of amount of fuel by a further 0.025 units.

The empirical results of BMTA during 1989 – 2007 employing number of trips as outputs review that BMTA is technically efficient operators but apparently from financial record, BMTA experience loss during that time. Moreover, the result

of BMTA comparing with private operators in 2007 also shows BMTA is technically efficient. The number of trips of each route is controlled by Department of Land Transport. And all operators including of BMTA and private operators will try to provide at least 80% of maximum level of trips. Hence the number of trips may not be appropriate as proxy of output to measure the technical efficiency. The next section will explain the results between BMTA and private operators in 2007 with the same two outputs. Each of the two outputs, the number of trips and that of passengers, would be selected separately to estimate with the same set of inputs.

Table 5.7

Score of VRS Technical Efficiency of BMTA during 1989 – 2007

Years	Model 1	Model 2
1989	1	1
1990	0.996	0.999
1991	0.986	1
1992	1	1
1993	1	0.92
1994	0.98	0.92
1995	0.99	0.91
1996	0.965	0.903
1997	0.981	0.959
1998	1	0.973
1999	0.992	0.936
2000	1	1
2001	1	1
2002	0.989	0.988
2003	0.997	1
2004	0.988	1
2005	0.99	1
2006	0.988	0.994
2007	1	1
Average	0.991	0.974

Source: Calculated by author

Note: Model 1 stands for VRS model employed the number of trips as a proxy for output.

Model 2 stands for VRS model employed the number of passengers as a proxy for output.

Table 5.8

Peer, Slacks and Lambda of Inefficiency Years of BMTA during 1989 – 2007

(Number of Trips)

Year	Peers	IS_1	IS_2	IS_3	OS_1	λ_a	λ_b	λ_c
1990	1989, 1993, 2007	0.008	-	-	-	0.935	0.03	0.035
1991	1990, 1993, 2007	0.121	-	-	-	0.648	0.164	0.188
1994	1993, 2007	0.039	0.01	-	-	0.773	0.227	-
1995	1993, 2007	0.065	0.05	-	-	0.639	0.361	-
1996	1993, 2007	0.02	0.055	-	-	0.635	0.365	-
1997	1993, 1998, 2007	-	0.034	-	-	0.19	0.665	0.145
1999	1989, 1998, 2000	-	-	0.009	-	0.381	0.167	0.451
2002	2001, 2007	-	0.015	0.021	-	0.586	0.414	-
2003	2001, 2007	-	0.009	0.029	-	0.437	0.563	-
2004	2001, 2007	-	0.025	0.023	-	0.011	0.089	-
2005	2001, 2007	-	0.004	0.019	-	0.067	0.933	-
2006	2007	-	0.001	0.002	0.01	1	-	-

Source: Calculated by author.

Note: IS_i is input slack of year i.

OS_j is output slack of year i.

λ_i is the weight of each year i adjustment comparing with the efficiency year i that lies on the frontier.

According to Table 5.8, the calculation of λ_i is

Inefficient score x $x_{ni} = \sum\lambda_{ni} + IS_{ni}$ where n is the type of variables, n = 1, 2, 3.

Inefficient score x $y_{mi} = \sum\lambda_{mi} + OS_{mj}$, where m is the type of variables, m = 1, 2.

Table 5.9

Peer, Slacks and Lambda of Inefficiency Years of BMTA during 1989 – 2007

(Number of Passengers)

Year	Peers	IS_1	IS_2	IS_3	λ_a	λ_b	λ_c	λ_d
1990	1989, 1992, 2007	-	0.01	-	0.787	0.165	0.004	-
1993	1989, 2003, 2005	-	-	0.025	0.692	0.156	0.152	-
1994	1989, 2007	0.022	-	0.022	0.607	0.393	-	-
1995	1990, 2005, 2007	0.006	-	-	0.585	0.160	0.255	-
1996	1990, 1992, 2004, 2007	-	-	-	0.271	0.317	0.32	0.009
1997	1992, 2000, 2001	-	-	0.01	0.482	0.209	0.309	-
1998	1989, 1992, 2000, 2003	-	-	-	0.004	0.252	0.62	0.008
1999	1989, 2003, 2005	-	0.08	0.066	0.329	0.32	0.351	-
2002	2003, 2005	-	0.011	0.002	0.122	0.878	-	-
2006	1989, 2005, 2007	-	-	-	0.001	0.212	0.778	-

Source: Calculated by author.

Note: IS_i is input slack of year i.

OS_j is output slack of year i.

λ_i is the weight of each year i adjustment comparing with the efficiency year i that lies on the frontier.

5.2.2 The Results under VRS Model of BMTA and Private Operators

This section discusses the results of two outputs under VRS model of BMTA and private operators in 2007. As reported in Table 5.10, model 1 stands for results of number of trips and model 2 stands for results of number of passengers. The efficiency scores of model 1 have range between 0.593 – 1 and model 2 have range between 0.204 – 1. Efficiency firms that are located in the production efficiency frontier under VRS for model 1 are BMTA, Union Bus Service Group Company, and Minibuses while Wangsakarnkij Company and Sahakhonsong Thonburi Company are

technically inefficient. For the other model, Union Bus Service Group Company and Minibuses are technically efficient while BMTA, Wangsakarnkij Company and Sahakhonsong Thonburi Company are technically inefficient.

The average TE scores of these two models are 0.838 and 0.58, respectively. It means the efficient firms could possibly reduce sum of all the number of buses, the number of officers and the amount of fuel by 16.2% and 42%, respectively without reducing the number of trips. In other words, BMTA and these selected private operators in year 2007 could use the input level at 83.8% and 58% of primary level, and then they could produce at the efficiency frontier. Alternatively, they can have score at 1 (100%) without reducing the number of trips and the number of passengers, respectively.

Table 5.11 shows the result of partial productivity of BMTA and private operators in 2007 in case of model 1. It can be referred that why BMTA, Union Bus Service Group Company and minibuses are efficient. The partial productivity of inputs namely, number of buses and fuel of BMTA, Union Bus Service Group Company and minibuses are high comparing with the rest. The partial productivity of number of officer of BMTA, Sahakhonsong Thonburi Company and minibuses are not different, while Union Bus Service Group Company is quite high. Meanwhile, all partial productivities of Wangsakarnkij Company are low.

The results of both models show Wangsakarnkij Company and Sahakhonsong Thonburi Company are technically inefficient. In the other hands, the result of BMTA in model 2 is inverse with model 1. The result of BMTA in model 1 is technical efficiency but in model 2 shows BMTA is technically inefficient. The results of model 2 mark that BMTA is the worst in terms of technical inefficiency. This result is aligned with the real situation that BMTA's operations produce losses while the operations of private bus operators generate profits.

Tables 5.12 and 5.13 show the peer of each inefficiency company and suggests λs and slacks to improve the efficiency. For example, as shown in Table 5.12, Wangsakarnkij Company has Union Bus Service Group Company as its peers and its λ_a is 0.15 and IS_1 is 0.271 and IS_3 is 0.018. According to the results, Wangsakarnkij Company is radially inefficient in input usage by a factor of 40.4% plus it has (non-radial) input slack of 0.271 units of number of buses and input slack of 0.018 units of

amount of fuel used (per unit of number of trips). The target of Wangsakarnkij Company is to reduce usage of three inputs by 40.4% and also to reduce the use of number of buses and amount of fuel used and by a further 0.271 and 0.018 units, respectively.

Table 5.13 shows the peer of each inefficiency company and suggests λs and slacks to improve the efficiency. For example, BMTA has Union Bus Service Group Company and Minibus as its peers and λ_1 is 0.347 and λ_2 is 0.653 and IS_2 is 0.127 and IS_3 is 0.112. BMTA is radially inefficient in input usage by a factor of 79.6% plus it has (non-radial) input slack of 0.127 units of number of officers and input slack of 0.112 units of amount of fuel used (per unit of number of passengers). The target of BMTA is to reduce usage of three inputs by 79.4% and also to reduce the use of number of officers and amount of fuel used and by further 0.127 and 0.112 units, respectively.

Table 5.10

VRS Technical Efficiency Scores of BMTA and Private Operators in 2007

Company	Model 1	Model 2
BMTA	1	0.204
Wangsakarnkij	0.596	0.317
Sahakhonsong Thonburi	0.593	0.346
Union Bus Service Group	1	1
Minibuses	1	1
Average	0.838	0.58

Source: Calculated by author.

Note: Model 1 stands for VRS model employed the number of trips as a proxy for output.

Model 2 stands for VRS model employed the number of passengers as a proxy for output.

Table 5.11

Partial Productivity of BMTA and Selected Private Operators in 2007

Company	Trip/Bus	Trip/Fuel	Trip/Office
BMTA	3140.87	609.85	0.08
Wangsakarnkij	2.09	12.66	0.001
Sahakhonsong Thonburi	51.31	333.84	0.06
Union Bus Service Group	3684.78	1,184.82	1.43
Minibuses	2160	1,080	0.11

Source: Calculated by author.

Table 5.12

Peer, Slacks and Lambda of Inefficiency Companies of BMTA and Private Operators in 2007 (Number of Trips)

Company	Peers	IS_1	IS_2	IS_3	OS_1	λ_a
Wangsakarnkij	Union	0.271	-	0.018	-	0.15
Sahakhonsong Thonburi	Union	0.009	-	0.012	-	0.41

Source: Calculated by author.

Note: IS_i is input slack of year i.

OS_j is output slack of year i.

λ_i is the weight of each firm i adjustment comparing with the efficiency firm i that lies on the frontier.

Table 5.13

Peer, Slacks and Lambda of Inefficiency Companies of BMTA and Private Operators in 2007 (Number of Passengers)

Company	Peers	IS_1	IS_2	IS_3	OS_1	λ_a
BMTA	Union, Mini	-	0.127	0.112	0.347	0.653
Wangsakarnkij	Union	0.271	-	0.018	-	0.15
Sahakhonsong Thonburi	Union	0.009	-	0.012	-	0.41

Source: Calculated by author.

Note: IS_i is input slack of year i.

OS_j is output slack of year i.

λ_i is the weight of each firm i adjustment comparing with the efficiency firm i that lies on the frontier.

The results of technical efficiency between BMTA and private operators employed the number of passengers as a proxy of output show BMTA is technical inefficient that conflicts with the result that using number of trips. It may indicate that the number of passengers may be more suitable than the number of trips to measure the technical efficiency and to explain the current situation in bus service.

5.3 The Technical Efficiency under CRS and VRS Model

5.3.1 The Results under CRS and VRS Model: Number of Trips

CRS model are under competitive market. But bus service presently does not operate at the optima level. The empirical results under CRS model can show the efficiency of BMTA and private companies if they operate at the optimal level. CRS technical efficiency is the technical overall efficiency while VRS technical efficiency is pure technical efficiency. Moreover, CRS and VRS TE scores can calculate the scale efficiency (SE). If there is difference in the CRS and VRS TE scores for a particular firm, then it indicates that the firm has scale inefficiency. In this section, technical efficiency scores can be calculated by DEA under CRS and VRS model.

BMTA during 1989 – 2007

As reported in Table 5.14, the efficiency scores of CRS and VRS model range between 0.915 – 1 and 0.965 – 1, respectively. TE scores under CRS model show that in 1989, 1992, 1993 and 1998, BMTA are technically efficient and under VRS model show that in 1989, 1992, 1993, 1998, 2000, 2001, and 2007, BMTA are technically efficient. The averages of these two models are 0.963 and 0.991 respectively. It means that BMTA could use input level at 3.7% and 0.9% of primary level; BMTA will provide services on the efficiency frontier.

According to Figure 4.4, the scale efficiency (SE) is interpreted as the ratio of the average product of a firm operating at the point P to the average product of the point operating at the point of (technically) optimal scale (point R). If the SE scores increases, bus service of BMTA and these selected companies in case of VRS are close to the competition market (CRS case). As shown in Table 5.14, the average SE is 0.971 that means on average technical efficiency score is close to the competition market case (the optimal scale), it is far from the optimal scale 2.9%.

Table 5.14 shows that both the CRS and VRS scores of BMTA during 1989 – 2007 are high. But the SE scores during 2001 – 2007 are quite low. These SE scores show that BMTA uses partly of its available input factors. Therefore, its production process is not at full capacity.

Moreover, the returns to scale during year 2002 – 2006 are increasing returns to scale that mean BMTA should increase the number of trips (output) instead of decreasing the amount of inputs because if BMTA increase amount of inputs (numbers of buses, amount of fuel and numbers of officers) 1%, the number of trips can increase more than 1% in those years.

Tables 5.14 and 5.15 show the returns to scale of BMTA during 1989 - 2007 and returns to scale of BMTA comparing with private operators in 2007, respectively. Table 5.14 shows that BMTA are operating at increasing returns to scale (IRS) in 12 years. In other words, if BMTA increase inputs (numbers of buses, amount of fuel and numbers of officers) 1%, the number of passengers can increase more than 1% in that year. For example, if increase number of buses by 10%, the number of passengers will increase more than 10%. While BMTA are operating at constant returns to scale (CRS) in 9 years, it means that if all inputs of BMTA increase by 1%, the output can rise at the rate of 1%.

Table 5.14

Scores of CRS and VRS Technical Efficiency of BMTA during 1989 – 2007

(Number of Trips)

Years	VRS TE	CRS TE	SE	RTS
1989	1	1	1	CRS
1990	0.996	0.993	0.997	IRS
1991	0.986	0.972	0.986	IRS
1992	1	1	1	CRS
1993	1	1	1	CRS
1994	0.98	0.957	0.977	IRS
1995	0.99	0.938	0.947	IRS
1996	0.965	0.927	0.961	IRS
1997	0.981	0.967	0.986	IRS
1998	1	1	1	CRS
1999	0.992	0.988	0.996	IRS
2000	1	0.995	0.995	CRS
2001	1	0.968	0.968	CRS
2002	0.989	0.94	0.95	IRS
2003	0.997	0.942	0.945	IRS
2004	0.988	0.915	0.926	IRS
2005	0.99	0.933	0.942	IRS
2006	0.988	0.922	0.933	IRS
2007	1	0.947	0.947	CRS
Average	0.991	0.963	0.971	NA

Source: Calculated by author.

Note: VRS is variable returns to scale.

CRS is constant returns to scale.

RST is returns to scale.

IRS is increasing returns to scale.

DRS is decreasing returns to scale.

BMTA and Private Operators

As shown in Table 5.15, in 2007, the efficiency scores of BMTA and private operators under CRS and VRS model have range between 0.366 – 1 and 0.593 – 1, respectively. BMTA, Union Bus Service Group Company and minibuses are technically efficient firms that located in the production frontier under both CRS and VRS model while Wangsakarnkij Company and Sahakhonsong Thonburi Company are technically inefficient in both models. The average scores of these two models are 0.766 and 0.838, respectively. This could be interpreted that the inefficient firms could possibly reduce sum of all of the number of buses, the amount of fuel and the number of officers by 23.4% and 25.2% without reducing the number of trips.

The CRS and VRS scores of BMTA, Union Bus Service Group Company and minibuses are both technical efficiency. These can imply that BMTA, Union Bus Service Group Company and minibuses use the input factors optimally.

The average SE score of BMTA comparing with private operators is 0.88, which means that the current situation of BMTA and these companies is far from the competition market by 12%. The TE scores of Wangsakarnkij Company and Sahakhonsong Thonburi companies are quite low, whereas the SE scores of these two firms are higher. The high SE scores of these two firms do not show that their technical efficiencies are closely to the optimal but it may imply that these two companies are large companies but low technical efficiency. The VRS scores of Wangsakarnkij Company and Sahakhonsong Thonburi Company are low. These imply that these two firms use not all of their available input factors to produce the output (the number of trips). Consequently, to improve this, the firms may use more of their available input into the production. However, Table 5.15 shows that Wangsakarnkij Company and Sahakhonsong Thonburi companies are increasing returns to scale that mean these two firms should increase the number of trips (output) instead of decreasing the amount of inputs because if they increase amount of inputs (numbers of buses, amount of fuel and numbers of officers) 1%, the number of trips can increase more than 1%.

As presented in Chapter 2, Wangsakarnkij and Sahakhonsong Thonburi companies have many buses. The buses are used for providing services, available for rent and for replacing the repaired buses. The companies do not use all buses for bus

service at the same time. The number of buses of these two companies will affect the actual amount of fuel used and the number of passengers. Moreover, data of the fuel used are collected from the bills that might not reflect the real use of fuel for providing bus service.

Table 5.15

Scores of CRS and VRS Technical Efficiency of BMTA during 1989 – 2007 (Number of Trips)

Companies	VRS TE	CRS TE	SE	RTS
BMTA	1	1	1	CRS
Wangsakarnkij	0.596	0.366	0.614	IRS
Sahakhonsong Thonburi	0.593	0.466	0.786	IRS
Union Bus Service Group	1	1	1	CRS
Minibuses	1	1	1	CRS
Average	0.838	0.766	0.88	NA

Source: Calculated by author.

The empirical results of BMTA during 1989 – 2007 employing number of trips as outputs review that BMTA is technically efficient operators that imply that BMTA is efficient to use inputs factors to produce the number of trips. But the empirical results are in conflict with the financial record of BMTA that experience loss during that time. Moreover, the result of BMTA comparing with private operators in 2007 also shows BMTA is technically efficient. The number of trips of each route is controlled by Department of Land Transport. BMTA and private operators will try to provide at least 80% of maximum level of trips. Therefore, the number of trips may not be a proper proxy of output to measure the technical efficiency. The next section will use the number of passengers as proxy for output instead. It will reflect the true demand rather than the number of trips.

5.3.2 The Results under CRS and VRS Model: Number of Passengers

BMTA during 1989 – 2007

The technical efficiency can be calculated by DEA under CRS model and VRS model. This section will discuss the results calculated by both CRS and VRS models. As reported in Table 5.16, the efficiency scores of CRS and VRS model have range between 0.507 – 1 and 0.903 – 1, respectively. TE scores under CRS model show that only in 1989, BMTA is technically efficient and under VRS model show that in 1989, 1991, 1992, 2000, 2001, 2003, 2004, 2005 and 2007, BMTA is technically efficient. The averages of these two models are 0.769 and 0.974 respectively. It means that BMTA could use input level at 76.9% and 97.4% of primary level. BMTA will provide services on the efficiency frontier.

The VRS TE scores of two outputs show the high score. However, the CRS TE scores of BMTA during 1989 – 2007 when using the number of trips as proxy for output are high while this section interprets that BMTA's technical efficiency change for the worse.

Table 5.16 shows that VRS scores of BMTA during 1989 – 2007 are high. But VRS scores are low that leads to SE scores are low. The SE scores during 1993 – 2007 are low and tend to decrease. These SE scores show that BMTA uses partly of its available input factors. Therefore, its production process is not at full capacity Moreover, the returns to scale during year 1993 – 1999, 2002 and 2006 are increasing returns to scale that mean BMTA should increase the number of passengers instead of decreasing the amount of inputs (numbers of buses, amount of fuel and numbers of officers) because if BMTA increase amount of inputs 1%, the number of trips can increase more than 1% in those years.

According to the interview with the Deputy Directors (Department of Bus Operation) on June 11, 2009, the problem of excess labor is likely to be the major cause of the technical inefficiency. The average number of officers per bus of BMTA is 4.5, while the standard ratio should be only 2 persons per bus. Furthermore, the actual amount of annual fuel usage is normally higher than the targeted amount. The cause of this extra fuel usage is from the inefficiency of using old buses. These two variables may be the main reasons of the technical inefficiency of BMTA in each year. Moreover, the number of passengers tends to decrease over year because recently

there are more private operators providing bus services according to the public-private partnership policy.

As shown in Table 5.16, the average SE is 0.790 that means the average technical efficiency is close to the competition market case (the optimal scale), it is far from the optimal scale by 21%.

The trends of SE scores employed the number of trips as a proxy for output is high because VRS and CRS TE score are high. On the contrary, the VRS TE scores of this section are high while the CRS TE scores tend to decrease then the SE scores is lower and lower as the same direction of CRS TE scores. The different outputs lead to the different SE scores. This may be from the number of passengers reflects the real demand while the number of trips does not (controlled by Department of Land Transport).

Table 5.16

Scores of CRS and VRS Technical Efficiency of BMTA during 1989 – 2007

(Number of Passengers)

Years	VRS TE	CRS TE	SE	RTS
1989	1	1	1	CRS
1990	0.999	0.959	0.96	IRS
1991	1	0.943	0.943	CRS
1992	1	0.985	0.985	CRS
1993	0.92	0.838	0.911	IRS
1994	0.92	0.774	0.841	IRS
1995	0.91	0.759	0.834	IRS
1996	0.903	0.77	0.853	IRS
1997	0.959	0.845	0.881	IRS
1998	0.973	0.828	0.851	IRS
1999	0.936	0.733	0.783	IRS
2000	1	0.793	0.793	CRS
2001	1	0.748	0.748	CRS
2002	0.988	0.699	0.707	IRS
2003	1	0.702	0.702	CRS
2004	1	0.618	0.618	CRS
2005	1	0.583	0.583	CRS
2006	0.994	0.527	0.53	IRS
2007	1	0.507	0.507	CRS
Average	0.974	0.769	0.79	NA

Source: Calculated by author.

Note: VRS is variable returns to scale.

CRS is constant returns to scale.

RST is returns to scale.

IRS is increasing returns to scale.

DRS is decreasing returns to scale.

BMTA and Private Operators

As shown in Table 5.17, the efficiency values of BMTA and private operators in year 2007 under CRS and VRS model have range between 0.198 – 1 and 0.237 – 1, respectively. Union Bus Service Group Company and Minibuses are efficient firms that are located on the production frontier under both CRS and VRS model while BMTA, Wangsakarnkij Company and Sahakhonsong Thonburi Company are technically inefficient. The average values of these two models are 0.548 and 0.58, respectively. This could be interpreted that the inefficient firms could possibly reduce sum of all of the number of buses, the amount of fuel and the number of officers by 45.2% and 42% without reducing the number of passengers.

The average SE score of BMTA comparing with private operators is 0.946, which means that the current situation of BMTA and these companies is far from the competition market by 5.4%. If the SE scores increases, the service of BMTA and these selected companies move toward to the competition market (CRS case).

The TE scores of both models of BMTA are low even though the SE score is quite high at 0.835. This SE score does not mean that technical efficiency of BMTA is far from the optimal scale by 22.5%. The average SE score is quite high because the high SE scores of private operators that are technical efficiency are high. It can imply that BMTA is a large organization but low efficiency.

The CRS and VRS scores of Union Bus Service Group Company and minibuses are both technical efficiency. These can imply that Union Bus Service Group Company and minibuses use the input factors optimally to produce output (the number of passengers). The low CRS scores of BMTA can imply that BMTA does not use the amount of input factors optimally to produce the output (the number of passengers).

The CRS and VRS scores of BMTA, Wangsakarnkij Company and Sahakhonsong Thonburi Company are low especially BMTA is the lowest TE score. The low VRS score of BMTA can imply that these three firms use not all of their available input factors to produce the output (the number of passengers). Consequently, to improve this, the firms may use more of their available input into the production.

Furthermore, the low CRS score of BMTA can imply that BMTA does not use input factors properly. For example, old buses and improper types of fuel are adopted. This may bring inefficiency.

The average SE score of BMTA comparing with private operators is 0.88, which means that the current situation of BMTA and these companies is far from the competition market. The TE scores of BMTA, Wangsakarnkij Company and Sahakhonsong Thonburi companies are quite low, whereas the SE scores of them are higher. The high SE scores of them do not show that their technical efficiencies are closely to the optimal but it may imply that these two companies are large companies but low technical efficiency. However, Table 5.17 shows that BMTA, Wangsakarnkij Company and Sahakhonsong Thonburi companies are increasing returns to scale that mean these two firms should increase the number of trips (output) instead of decreasing the amount of inputs because if they increase amount of inputs (numbers of buses, amount of fuel and numbers of officers) 1%, the number of trips can increase more than 1%.

As presented in Chapter 2, Wangsakarnkij and Sahakhonsong Thonburi companies have many buses. The buses are used for providing services, available for rent and for replacing the repaired buses. The companies do not use all buses for bus service at the same time. The number of buses of these two companies will affect the actual amount of fuel used and the number of passengers. Moreover, data of the fuel used are collected from the bills that might not all use for provide bus service. However, the efficiency scores are still higher than the scores of BMTA.

Tables 5.16 and 5.17 show BMTA's return to scale during 1989 – 2007 and return to scale of BMTA comparing with private operators in 2007, respectively.

Table 5.16 shows that BMTA are operating at increasing returns to scale (IRS) in 10 years. In other words, the years are IRS; if BMTA increase inputs (numbers of buses, amount of fuel and numbers of officers) by 1%, the number of passengers can increase by more than 1%. For example, if BMTA increases number of buses by 10%, the number of passengers will increase by more than 10%. While BMTA are operating at constant returns to scale (CRS) in 9 years, it means that if all inputs employed by BMTA increase by 1%, the output can rise by 1%.

Table 5.17

Scores of CRS and VRS Technical Efficiency of BMTA during 1989 – 2007

(Number of Trips)

Company	VRS TE	CRS TE	SE	RST
BMTA 2007	0.237	0.198	0.835	IRS
Wangsakarnkij	0.317	0.266	0.78	IRS
Sahakhonsong Thonburi	0.346	0.278	0.803	IRS
Union Bus Service Group	1	1	1	CRS
Minibuses	1	1	1	CRS
Average	0.58	0.548	0.946	NA

Source: Calculated by author.

Note: VRS is variable returns to scale.

CRS is constant returns to scale.

RST is returns to scale.

IRS is increasing returns to scale.

DRS is decreasing returns to scale.

5.4 Summary of the Empirical Results

The results employing the number of trips as output show that BMTA's technical efficiency under both CRS and VRS models are high whereas the results under CRS model turn to be opposite when number of passengers as output. The number of trips may not be the appropriate output to measure the technical efficiency because they are controlled by Deputy of Land Transport. All operators, including of BMTA and private operators, will try to provide at least 80% of maximum level of number of trips.

The empirical results employing the number of passengers as proxy for output show high technical efficiency like in the case of employed number of trips under VRS model. However, the result under CRS model does not. It follows the real situation of BMTA that have losses from inefficient operation. The results of BMTA

also indicate that BMTA is inefficient relative to the private operators even though Wangsakarnkij Company and Sahakhonsong Thonburi Company are also inefficient. The case of BMTA yields the lowest technical efficiency scores comparing with those two inefficient firms.

In case of the number of passengers as proxy of output, TE scores of BMTA in 2007 are 0.507 and 1 but the scores in case of BMTA comparing with private operators is 0.198 and 0.237 under CRS and VRS model, respectively. It shows that BMTA‘s operation itself is well-performed. On the contrary, the results of BMTA comparing with private operators reveal very poor performance in both measurements.

Actually, the scores could suggest that the capability to locate years and firms which have inefficiency as well as improve them toward the frontier. For example, BMTA during 1989 – 2007, TE score in 2007 is 0.507 under CRS model. This means that BMTA could decrease the level of input factors by 49.3% in given output level. With this, BMTA’s technical efficiency would be on the frontier. The results of BMTA comparing private operators in 2007 suggest that BMTA has a large capability to improve its organization. BMTA could decrease a large proportion of number of buses, number of officers and amount of fuel used by 81.2% in given output level. With this, BMTA’s technical efficiency will be on the frontier.

The empirical results in section 5.3 also suggest that BMTA and inefficient companies can increase the number of trips. It can increase not only the number of passengers but also fare revenue.