CHAPTER 6. PERFORMANCE MATRIX AND POLICY IMPLICATIONS

As well as those already mentioned, railway transport has played an important role in the economic development of a country, and the rail transport has lost its market share in the recent decades. Why did the railways lose business? Based on the results of current research, the reason for decline situation is that, in general, the railways operate inefficiently and ineffectively. The problem now remained is that how to improve the performance, or in other words, how to restore the competitiveness of the railways? Although from performance measurement to performance improvement, there is still a long way to go, but at least, one can easily find some information to guide the right way. Therefore, based on the measurement results described in chapter four and five, the current research finally constructs some performance matrixes where each firm's performance can be properly allocated, as a result more appropriate strategies for enhancing the rail performance in different sub-matrixes can be proposed. The remaining of this chapter is organized as follows. 6.1 portray the performance matrix, including efficiency vs. effectiveness (6.1.1) and productivity vs. sales force (6.1.2). 6.2 describe some strategies for improvement, including for rail firms in general (6.2.1) and for Taiwan Railway Administration, TRA (6.2.2). Some conclusions follows.

6.1 Performance Matrix

6.1.1 Efficiency vs. effectiveness

Figure 6-1 demonstrates a performance matrix established by the BCC models, in which each firm's efficiency and effectiveness score are indicated, the relative efficiency scores are plotted on the horizontal axis and the relative effectiveness scores are plotted on the vertical axis. Since the average efficiency and effectiveness scores for all of 44 railways over 7 years are 0.639 and 0.497, respectively, therefore one can divide the matrix into four sub-matrices based on average scores as shown in Figure 6-1. Hereinafter, upper-right, upper-left, lower-left and lower-right sub-matrices are defined as first, second, third and fourth quadrant, respectively. Those firms located at the first quadrant represent that both efficiency and effectiveness scores are higher than average, and the firms located at the other quadrants can be explained in the analogous way. The optimal rail operator is located at the point where both the efficiency and effectiveness scores are unity. From Table 6-1, ten DMUs are located at the first quadrant. Most DMUs rated better in one criterion than the other, for instance, DMU 14 is, relative to other DMUs, quite efficient but not effective, on the other hand, for DMU 41, it is effective but not efficient. On the other hand, some DMUs located at the third quadrant have a potential for greater efficiency and effectiveness. Hence, this research confirms that, efficiency is different criterion from effectiveness, and both measurements are relevant to the decision making process for the firms. Estimating efficiency or effectiveness only may be insufficient to reflect true performance of the transport firms or may be biased.

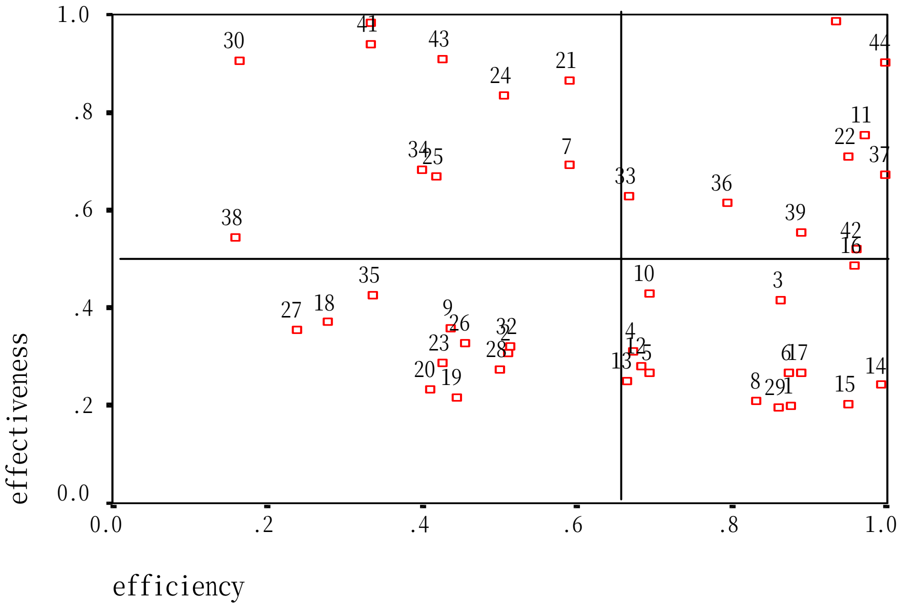

Fig. 6-1 Efficiency vs. Effectiveness (BCC model)

Similar to Figure 6-1, Figure 6-2 portrays the relation between efficiency and effectiveness based on the 3-stage DEA measurement. As one can see from Table 6-2, most DMUs are located at the area where both efficiency and effectiveness scores are higher than 0.9. On average, both efficiency and effectiveness scores are considerably higher than those estimated from BCC model. Especially in effectiveness measurement, the average score is raised from 0.497 to 0.923. Since 3-stage DEA measures efficiency and effectiveness by considering environmental factors, therefore, the results reveal that most ineffective DMUs may simply be experiencing unfavorable environmental factors. Comparing Figure 6-2 with 6-1, it should be noted that, a lot of DMUs exhibited higher efficiency and effectiveness than average values.

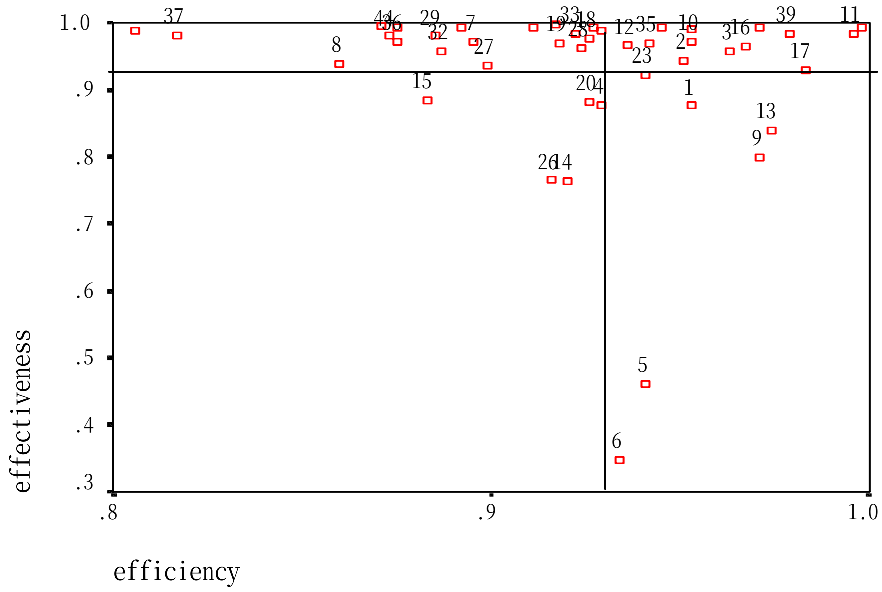

Fig. 6-2 Efficiency vs. Effectiveness (3-stage method)

Similarly, based on the results estimated from 4-stage DEA, a performance matrix can be constructed as shown in Figure 6-3. Looking at Figure 6-3, it shows that, both efficiency and effectiveness scores are slightly decreased in comparison with the results based on 3-stage DEA or Figure 6-2, since 4-stage DEA measures efficiency and effectiveness by considering environmental affects, statistical noises, as well as residual slacks. It should be noted that most of DMUs are located at the first and the second quadrants. In other words, in general, most of DMUs are explored high efficiency and/or high effectiveness based on 4-stage DEA procedure. It should also be noted that, only three DMUs (1, 15, and 41) are located at the third quadrant, which means that the three DMUs need to enhance both efficiency and effectiveness so as to improve their performance.

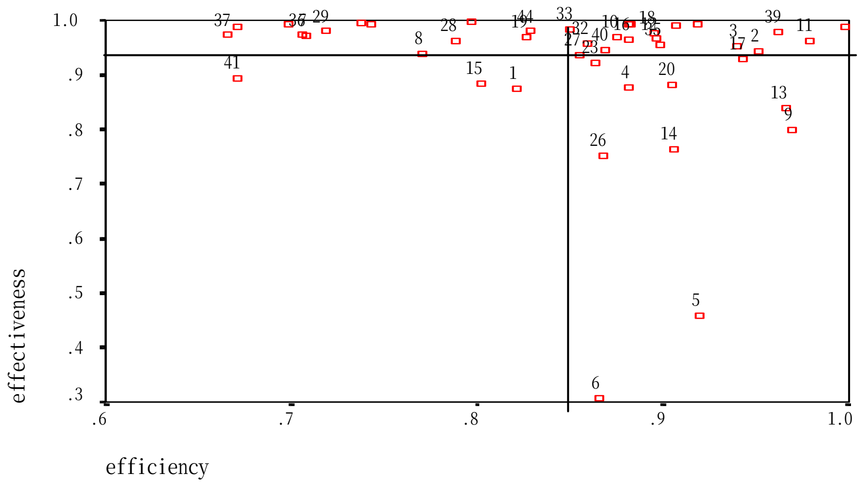

Fig. 6-3 efficiency vs. effectiveness (4-stage DEA)

6.1.2 Productivity vs. sales force

Similar to the matrix of efficiency relative effectiveness, based on the empirical results described in the chapter five, this research constructs a performance matrix, where each firm's productivity and sales force are properly allocated. Figure 6-4 portrays the productive relative to sales force based on the FGNZ measurement method. Let the point (1, 1) as an origin, then the matrix can be divide into four quadrant, as shown in Figure 6-4; which can be explained in the following way. The DMUs located at the first quadrant, experience a cumulative growth rate over the sampling years both in productivity and sales force. Those DMUs located at the second quadrant grow in sales force but regress in productivity. Meanwhile, the DMUs located the fourth quadrant, the converse is true. Finally, the DMUs located at the third quadrant, both productivity and sales force are decline. As one can see from Table 6-4, most of DMU experience a cumulative growth rate over the sampling years both in productivity and sales force.

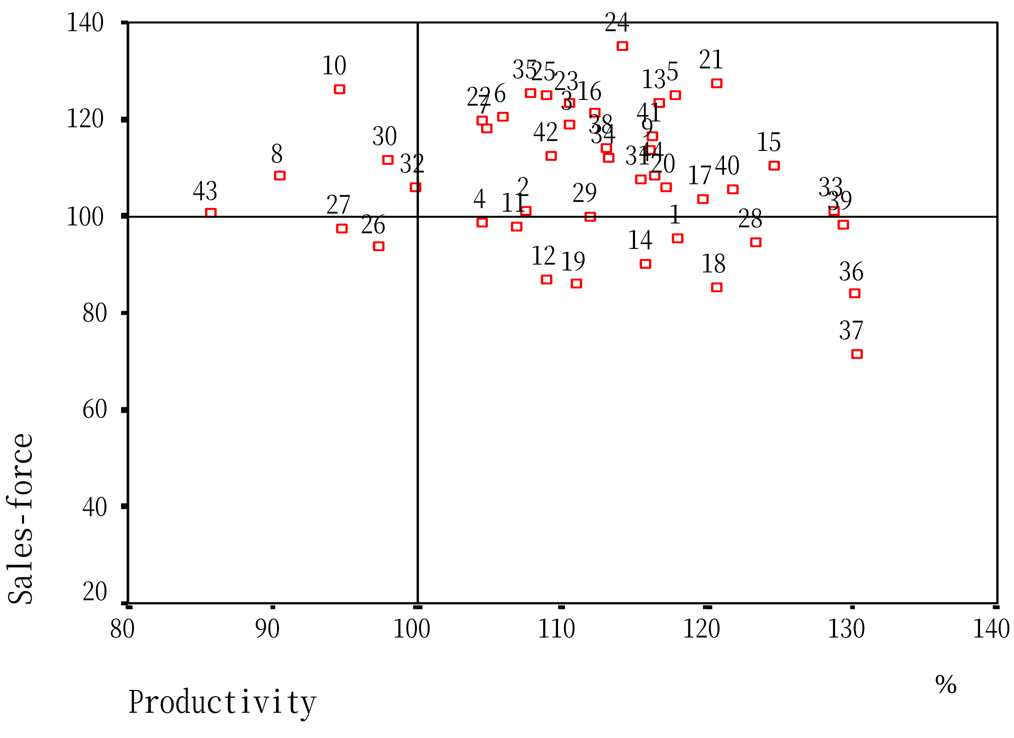

Fig. 6-4 Productivity vs. Sales force (based on FGNZ method)

Similar to Figure 6-4, the current research also constructs a matrix based on proposed four-stage measurement method; which relate the productivity and sales force. As shown in Figure 6-5, the matrix is divided into four quadrants in the same manner as in the Figure 6-4. One can see from Figure 6-5, the number of DMUs located at the first quadrant is decreased in comparison with Figure 6-4, since the method has taken environmental factors, statistical noises, as well as residual slacks into account in the proposed measurement. Meanwhile, the numbers of DMUs in the second and third quadrants are increased significantly.

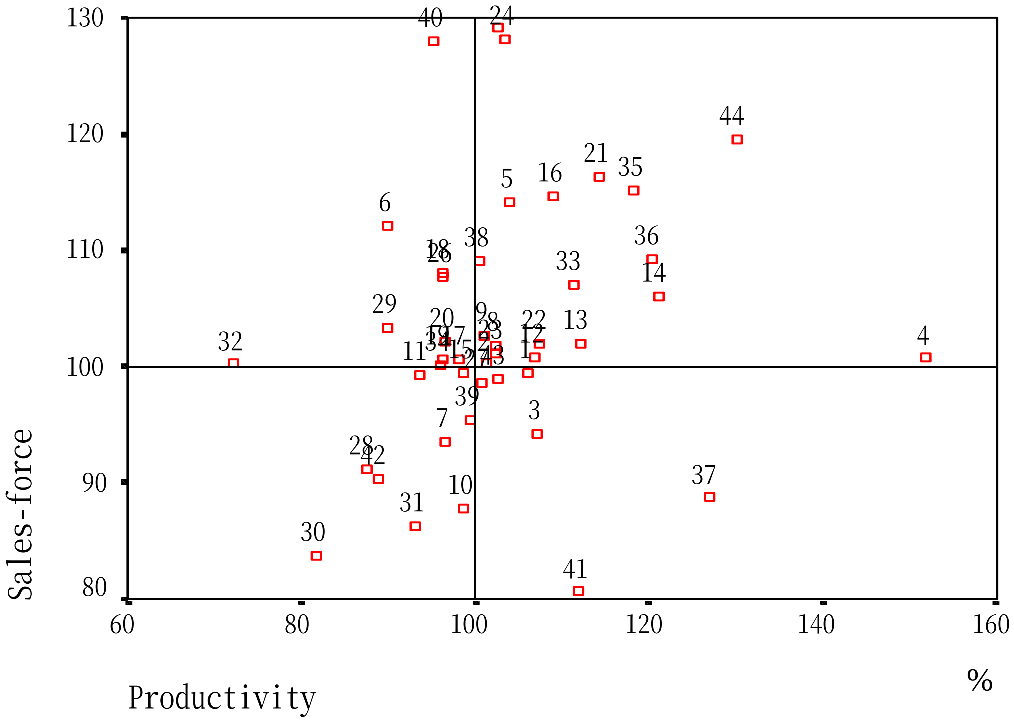

Fig. 6-5 Productivity vs. Sales force (based on four-stage method)

6.2 Policy Implications for Rail Industry

From the empirical results described in chapter four, it can be observed that some DMUs experience high efficiency but low effectiveness, while the other some DMUs exhibit high effectiveness but low efficiency. Thus, some policy implication for improving performance would be implied. Firstly, the strategies for improving efficiency and effectiveness are discussed. Since the DEA method also yields the values of inputs or outputs (depends on input-oriented or output-oriented been used), which the DMU should be able to achieve. From a management science perspective, the decision makers can easily get some information for performance improvements. Therefore, based on the analysis results, some strategies for improving performance could be proposed; which can be classified into four parts, that are strategies for improving efficiency, effectiveness, productivity and for sales force. The strategies proposed by the current research are discussed in turn as follows.

6.2.1 Strategies for improving efficiency

Firstly, since the current research adopts input-oriented DEA model to measure the efficiency of firms, as a consequence, those firms in the second quadrant with relative low efficiency but high effectiveness may curtail the input factors (keeping outputs unchanged) to increase their technical efficiency. The analytical results described in chapter four (see Table 4-10) show that, the total slack of employee is 1344 persons per kilometer of route, which is the most important issue in comparison with the other inputs. This means that overstaffing could be a critical problem, and thus gives an instrument for improving technical efficiency in the railway industry. In other words, reducing the number of employees is crucial for the railways to be efficient.

Furthermore, the results of the current research indicate that, percentage of electrified lines is an internal factor that affects the amount of input slacks as well as technical efficiency. In general, those firms evaluated as efficient are those with high percentage of electrified lines. For example, the percentage of electrified lines of NS (Netherlands), SJ (Sweden) and BLS (Switzerland) are 0.727, 0.748, and 1.000 and their average efficiency scores over sampling period are 0.972, 0.991 and 0.958, respectively, based on BCC model. All are greater than those DMUs with low percentage of electrified lines, for instance, the average efficiency scores of Moldova (CFM(E)), Morocco (ONCFM) and Syria (CFS) are 0.164, 0.400, and 0.337, and their percentage of electrified lines are all zero. Its policy implications suggest that a railway company should enhance electrified routes to improve its technical efficiency.

Finally, since a higher ratio of passenger train-kilometers to total train-kilometers will generally lead to lower slacks thus higher technical efficiency. The results of this research indicate that, in the sample, some DMUs such as NS (Netherlands), DSB (Denmark) and JR (Japan) orient their service toward passenger transport clearly (with average ROP of values 0.925, 0.874 and 0.899, for NS, DSB and JR, respectively) and from empirical result; they experience significantly higher efficiency than those DMUs with lower ROP. This can be partly explained by the fact that the speed of freight trains is generally slower than the speed of passenger trains. Consequently, the policy implication is that a railway company should increase the portion of passenger service rather than freight service. Since freight service is labor intensive and time cost, hence, for those firms have to maintain freight services, of course, reducing total loading and unloading time at stations would be a good strategy.

6.2.2 Strategies for improving effectiveness

The strategies for improving effectiveness can be quite different from those strategies for raising efficiency. Since the current research adopts output-oriented DEA models to measure the effectiveness of firms, therefore, for those firms in the fourth quadrant with relative high efficiency but low effectiveness, increasing the consumption both in passenger and freight services is a crucial issue. Based on the results of slack analysis, the total slack (radial and non-radial) of passenger-km is greater than slack of ton-km (see Table 4-19). This implies that increasing consumption of passenger services is prior to freight services; which is consistent with the policy implication in the efficiency analysis.

The empirical results show that gross national income per capita (GNI) and population density (PD) are two critical factors; which affect the effectiveness of DMU. Based on the underlying theory of transportation, the travel volume is depends on population and gross national income per capita. On one hand, the higher population leads higher traffic demand thus higher effectiveness of a firm. On the other hand, higher gross income per capita generally leads higher private car ownership thus lower dependency of public transport modes. Therefore, the results of the research are consistent with underlying theory of transportation. However, the manager of DMU cannot controls these two factors. Consequently, to improve effectiveness, a marketing promotion to attract more passengers and freight demands could be a good strategy. To do so, rail companies need to shake off their poor image firstly and then to promote their business more widely. As well known, the rail transport industry provides a tangible action for customers and is a long-recognized service industry. Therefore, in order to compete with other modes so as to attract more customers, raising level of service, including raising punctual rate, replacing over aged assets (tracks and rolling stocks) by new ones, could also be a good strategy. In addition, because the demand of transport is derived and transport services are perishable, hence, rescheduling the dispatching plan so as to meet the requirements of the market demand could also be a good strategy. Certainly, improving booking system, developing prepaid cards system, and providing discounts for commuters and group travelers, are good strategies to attract customers so as to raise effectiveness.

6.2.3 Strategies for improving productivity

As it was mentioned in the previous chapter, productivity index can be decomposed into changes in efficiency (catching up) and changes in technologies (innovation). In other words, TFP does not depend only on EC; TC may also be the source of productivity growth. Therefore, for those railway companies explored productivity regression, it is necessary to find out the determinants. If the source comes from efficiency deterioration, the strategies for improving efficiency described above are then applicable. On the other hand, if the determinant of productivity regression is due to technical deterioration, then introducing innovative production technologies could be a good strategy for improvement.

In the current research, the results presented in chapter five show that, of the two factors, in general, technical change was the more important, causing a cumulative increase of only 0.3 percent compared to 19.7 percent due to efficiency change based on

FGNZ method, or alternatively, cumulative decrease of 0.53 percent compared to 12.6 percent due to efficiency change based on four-stage method. That is, the results indicate the importance of technical change as a direction for improving productivity levels no matter which method is adopted. In other words, the source of productivity growth is due to improvements in efficiency rather than productive technology change, which also implies the improvement of productive technology as a critical direction for raising the productivity. Therefore, such strategies as improving the line geometry or introducing tilting trains so as to increase the train operating speed should be considered. Construction of high speed rails, application of new technologies in signaling and traffic control managements, upgrading the infrastructures (such as tracks) and facilities (such as loading and unloading equipment) can also be good strategies for raising the rail productivity.

6.2.4 Strategies for improving sales force

Similar to productivity index, sales force index can be decomposed into effectiveness change and sales technological change. That is, MSI does not depend only on effectiveness; technical change may also be the source of sales force growth or regression. Therefore, for those railway companies explored sales force deterioration, it is need to find out the determinants of regression. If the effectiveness recession was the source of sales force index deterioration, then the strategies described above may be useful for improving. On the other hand, if the deterioration was due to technical regression, then improving effectiveness could be a wrong way. In such case, introducing innovative marketing or sales technologies, such as introducing new dispatching management information system, replacing ticket counter by vending machine, booking ticket by Internet, cooperation with convenience stores firms and tourist agencies etc. could be the good strategies for improvement.

In the current research, the results documented in chapter five indicate that, in general, the cumulative changes in effectiveness, changes in technologies, and sales force change are 0.983, 1.092 and 1.073, respectively, based on the conventional method, or alternatively, 0.994, 1.067, and 1.061, respectively, based on the proposed method. These results indicate the importance of effectiveness change as a direction for improving sales force levels no matter which method is adopted. In other words, the source of sales force growth is due to technical change, rather than effectiveness change. As a consequence, improving effectiveness becomes a crucial issue for raising the sales force index in the railway industry. Thus we conclude that, the strategies for improving effectiveness described above can also be applied for raising sales force level.

6.3 Implications to TRA

6.3.1 Backgrounds

Taiwan Railway was originally the main transportation line of Taiwan. It played an important role both on long distance and short distance transportation for quite a long period of time. But after the first freeway began its operation from 1978, Taiwan Railway Administration (TRA) has to face a great competition pressure from highway transportation mode. Unfortunately, a deregulation policy on airline industries adopted by the government in the succeeding years made the situation even worse. The airlines taking advantage of time saving and fares discount claim the main long distance market share. Gradually TRA lost her operation revenue. In addition, due to large amount of pension and interest expenditure, up to 2001, TRA's negative accumulative revenue reached above NT$100 billion. Many economists in Taiwan argued that, in many ways, TRA is still living in the past. Since it is still public-owned and subsidized by government, many people consider that TRA still exhibit an apparent indifference to the competitive pressure from other modes. As a consequence, TRA lost money in the past several years and its financial situation become worse. To improve the performance of TRA, some actions should be taken immediately. Although the strategies described in 6.2.1 are proposed for general railway companies, they are all valid for TRA. In addition, the current research attempts to propose some specific strategies for improving performance of TRA, including technical efficiency, service effectiveness, productivity, and sales force. To do so, we need to observe the operating data of TRA in the sampling period; which is indicated in Table 6-1. As shown in Table 6-1, the passenger service criterions, including passenger-train-kilometer, passenger carried, and passenger-kilometer, all are in increasing trend, while all of the freight service criterions are in decreasing trend. In addition, the numbers of employees are decreasing from 16,981 by the year of 1995, to 15,280 in 2001, total reduction of 1700 persons or a 10 percent of reduction.

Table 6-1 Some operating data of TRA in the period of 1995 to 2001

	P-tr-km	F-tr-km	Lines	Labors	Pcars	Fcars	Paxs	Pax-km	Ton	Ton-km
1995	59244 (100.0)	7309 (100.0)	1108 (100.0)	16981 (100.0)	1581 (100.0)	4372 (100.0)	159.98 (100.0)	9489 (100.0)	19.21 (100.0)	1845 (100.0)
1996	58508 (98.8)	6812 (93.2)	1108 (100.0)	16566 (97.6)	1657 (104.8)	3813 (87.2)	159.44 (99.7)	8969 (94.5)	16.48 (85.8)	1541 (83.5)
1997	61094 (103.1)	6629 (90.7)	1108 (100.0)	16667 (98.2)	1929 (122.0)	3638 (83.2)	165.23 (103.3)	9254 (97.5)	16.95 (88.2)	1467 (79.5)
1998	62886 (106.1)	6520 (89.2)	1104 (99.6)	16286 (95.9)	2128 (134.6)	3506 (80.2)	171.87 (107.4)	9784 (103.1)	17.08 (88.9)	1367 (74.1)
1999	63235 (106.7)	6250 (85.5)	1104 (99.6)	16419 (96.7)	2147 (135.8)	3197 (73.1)	182.18 (113.9)	9978 (105.2)	16.66 (86.7)	1279 (69.3)
2000	65210 (110.1)	6410 (87.7)	1104 (99.6)	15980 (94.1)	2111 (133.5)	3098 (70.9)	191.48 (119.7)	10577 (111.5)	14.48 (75.4)	1150 (62.3)
2001	66471 (112.2)	6054 (82.8)	1097 (99.0)	15280 (90.0)	2077 (131.3)	2865 (65.5)	186.08 (116.3)	10037 (105.8)	12.37 (64.4)	984 (53.3)

Note: units for paxs, pax-km, ton, ton-km are all in million, units in ( ) are in %.

6.3.2 Policy implications

Strategies for improving efficiency

As mentioned earlier, DEA efficiency measurement has its implication. Technical inefficiency means the firm is failing to minimize the inputs used, given the amount of outputs produced. The current study adopts input-oriented DEA method, which gives TRA average efficiency score of 0.959 based on BCC model, and finds out NS (Netherlands) and CFF (Switzerland) as benchmarks of TRA. Looking at the labors per kilometer of lines used, Table 6-2 indicates the comparison results of TRA, NS, and CFF, as well as the average value of the sample. As one can see from the table, although the labor used by TRA decreased from 15.33 persons per km route by the year of 1995 to 13.93 persons per km route in 2001, it still higher than its peers (NS and CFF) and sample mean. In other words, TRA is a labor-intensive firm in comparison with its benchmarks. This suggests that overstaffing could be a critical problem so reducing the number of employees is crucial for TRA. In addition, based on the results, the percentage of electrified lines and the ratio of passenger service are two factors that affect the efficiency of the firms, as a consequence, enhancing the electrification and passenger service could also be the useful strategies. By the end of 2001, TRA has 592 kilometers or 54 percent of electrified lines; which shows that there is space to improvement.

Table 6-2 Comparison of labor used per km. between TRA and its peer firms

	Sample	NS	CFF	TRA
1995	8.95	9.70	11.22	15.33
1996	8.33	9.44	10.90	14.95
1997	8.27	8.36	10.74	15.04
1998	8.03	8.47	10.61	14.75
1999	7.67	9.25	10.06	14.87
2000	7.50	8.83	9.50	14.48
2001	7.43	7.93	9.26	13.93
Mean	8.03	8.85	10.33	14.76

Strategies for improving effectiveness

Similarly, the current study adopts output-oriented DEA method to measure relative effectiveness. The results show that the average effectiveness score of TRA is 0.519 based on BCC model; which is slightly higher than average value of industry. The result also indicates that NS and JR are benchmarks of TRA. Thus, enhancing service effectiveness becomes a crucial issue for TRA. To do so, the strategies proposed for general railway companies can also be applied to improve the effectiveness of TRA. In addition, some specific strategies are helpful for TRA. For example, Because of the rapid development of the economy, the old organization no longer suits the needs of the market. For instance, since there is no marketing division in TRA, it seems necessary to reform the internal organization. Establishment of some business or sales divisions, such as advertising, marketing research, promotion, and customer relation division, and hiring sales persons could be a good strategy for improving effectiveness. Hiring more employees when establishing a new division seems in conflict with strategy proposed in previous (cutting down overstaffing), however, transforming some employees from the transport division to the marketing division will be one of the possible solutions.

Strategies for raising productivity

The results of the current research indicate that, the cumulative efficiency change, technical change, and productivity change of TRA are 1.000, 0.888, 0.888, respectively, based on the proposed method. This means that its efficiency remains the same and the source of its productivity deterioration was due to technical regression. Thus the policies for improving productivity levels are closely linked to technological advances. In such case, introducing innovative technologies, such as new automatic train control (ATC) system, elimination of cross level, introducing new modern train to raise operating speed, increasing horsepower of locomotives and then hitching up more cars to a train, the application of new technology in signaling, and improvements in maintenance of train and tracks could be good strategies. In addition, privatization is a major trend in railway transport industry, however, TRA is still a public-owned authority, it has to serve the social welfare and cannot eliminate unprofitable branch nor close small station freely. Therefore, the government needs to give TRA greater autonomy so as to make decision more flexibly and thus improve its performance.

Strategies for raising sales force

On the other hand, the empirical results also show that, the cumulative effectiveness change, technical change, and sales force change of TRA are 0.88, 1.026, 0.903, respectively, based on the proposed method. This means that the determinant of sales force regression of TRA is effectiveness deterioration. This suggests that improving effectiveness is crucial for TRA. The strategies for improving effectiveness described above are available. As mentioned before, TRA is a service sector in the economy of the country; the most important is to improve service quality. However, because of TRA is a public-owned authority, there was lack of incentive mechanism to encourage employees' working attitude. Hence, the first step of raising sales force was to improve the work responsibility and attitude of employees. In addition, since the prices for railway transport services are set and controlled by the central government, the prices of railway service are relatively fixed in comparison with economic development. As a consequence, railway transport cannot follow the demands of the market. In order to improve its sales force, TRA need to enjoy a high level of independence in its management, including pricing policy, marketing strategies, etc.

6.4 Concluding Remarks

Based on the analytical results in previous two chapters, this chapter constructs some matrixes where each firm's performance can be properly allocated. As a result more appropriate strategies for enhancing the rail performance in different situations can be proposed; which include improving efficiency, effectiveness, productivity, and sales force. The strategies for improving technical efficiency are curtailing inputs utilized, especially in staffs, enhancing electrification and passenger service. The proposed strategies for improving service effectiveness are improving service quality, rescheduling the dispatching plan, and marketing promotion to attract more passengers and freight demands. The results of productivity measurement indicate the importance of technical change as a direction for improving productivity levels, consequently, to improve productivity, it is need to introduce innovative production technologies. Meanwhile, the results also show that effectiveness deterioration was the determinant of sales force regression, therefore, the strategies for raising sales force are same as those strategies for improving service effectiveness.

Furthermore, the results of this research show that TRA is inefficient and ineffective, and both of its productivity and sales force are deteriorated. The research thus proposed some strategies for improving the performance of TRA. Basically, the strategies for improving performance of general railway companies are valid for TRA. In addition, with respect to the TRA, some specific strategies are also proposed. For example, since TRA is still a state-owned authority, there was lack of incentive mechanism to encourage working attitude of employees. Hence, improving the work responsibility and attitude of employees is the most important thing for raising sales force. In general, the performance improvements may be achieved through learning processes. Thus, the inefficient and/or ineffective firms should try to learn from those are efficient (effective). The current research has identified that NS, CFF, and JR are benchmarks of TRA; therefore, the performance improvements may be achieved if TRA is able to learn better production and sales routines from its benchmarks.