CHAPTER 5. PRODUVTIVITY AND SALES FORCE MEASUREMENT FOR RAIL TRANSPORT

This research measures productivity and sales force for 44 selected railways worldwide over the period of 1995 to 2001 by using the same data set as been used in chapter 4. More specifically, the research measures productivity by adopting input-based Malmquist Productivity Index (hereinafter, MPI) and by selecting number of passenger cars per kilometer of lines, number of freight cars per kilometer of lines, and number of employees per kilometer of lines as input factors, and passenger-train-kilometer per kilometer of lines and freight-train-kilometer per kilometer of lines as output variables. In addition, this research also measures sales force by employing Malmquist Salesforce Index (hereinafter, MSI), and by choosing passenger-kilometers and ton-kilometers as two output variables and passenger train-kilometers and freight train-kilometers as two input factors. The chapter describes MPI and MSI in turn. The remaining of this chapter is organized as follows. The data set is presented in 5.1, and 5.2 describes analytical results of productivity measurement, including measured by conventional method and proposed method. 5.2 presents the empirical results of sales force measurement, also containing measured by conventional method and proposed method. The conclusion follows.

5.1 The Data

The data set used in this chapter is as same as in the previous chapter. The raw data, including two consumptions, two service outputs and four service inputs, are presented in Appendix and the descriptive statistics of the data is indicated in Table 4-1. To see the rate of change in each of the data, Table 5-1 indicates the sum of each item of all DMUs in each year. On average, the statistics show that passenger-km increased 13.26 percent, while passenger-train-km increased only 3.9 percent. Ton-km almost remains the same, while freight-train-km declined for 5.61 percent. In service inputs, this research also observed a decrease in length of line, labor, number of passenger cars and freight cars over the sampling years.

Table 5-1 the sum and change rate of consumptions and outputs over the sampling time.

Year	P-km	Rate	Tonkm	Rate	Ptrkm	Rate	Ftrkm	Rate
1995	999899	100.00%	964019	100.00%	3937783	100.00%	1475081	100.00%
1996	1021978	102.21%	936789	97.18%	3966266	100.72%	1436644	97.39%
1997	1028215	102.83%	930016	96.47%	3985849	101.22%	1440358	97.65%
1998	1032987	103.31%	927132	96.17%	4036813	102.51%	1405432	95.28%
1999	1070362	107.05%	903322	93.70%	4109591	104.36%	1385383	93.92%
2000	1104535	110.46%	964796	100.08%	4141059	105.16%	1433411	97.18%
2001	1132497	113.26%	969496	100.57%	4091500	103.90%	1392323	94.39%

Table 5-1 the sum and change rate of inputs data over the sampling time (continued).

Year	Line	Rate	Staff	Rate	Pcar	Rate	Fcar	Rate
1995	358693	100.00%	4111182	100.00%	206091	100.00%	1518479	100.00%
1996	357081	99.55%	3979384	96.79%	190271	92.32%	1498623	98.69%
1997	356188	99.30%	3861297	93.92%	186235	90.37%	1425979	93.91%
1998	355113	99.00%	3757658	91.40%	178056	86.40%	1431668	94.28%
1999	354389	98.80%	3678715	89.48%	188754	91.59%	1400006	92.20%
2000	350877	97.82%	3619575	88.04%	185788	90.15%	1352011	89.04%
2001	346894	96.71%	3520574	85.63%	185000	89.77%	1183574	77.94%

5.2 Productivity Measurement

5.2.1 Measured by conventional FGNZ method

To measure productivity for 44 railways over the period of 1995 to 2001, this research adopts the input-based Malmquist Productivity Index model as described in chapter three, and then decomposes MPI into efficiency change and technical change. Following Färe Grosskopf, Norris and Zhang (1994) (hereinafter, FGNZ method), four linear programming programs are constructed, and then solved by utilizing GAMS computer program. The measured results are indicated in Table 5-2 and 5-3. Note that Table 5-2 shows the cumulative geometric mean efficiency changes (EC), technical changes (TC), and productivity growth for all railways over seven years, while Table 5-3 indicates cumulative efficiency changes, technical changes, and productivity growth for each of 44 railways over the same period. One can see from these two tables, the productivity growth in the sampling period is 20.1 percent, which is due in most part to efficiency change (19.7 percent), rather than technical change, because technical change in the sampling period is only 0.3 percent. Figure 5-1 shows the time trend of EC, TC and TFP change.

Table 5-2 Cumulative indices of EC, TC and MPI by FGNZ method.

Year	Efficiency change	Technical change	MPI
1995	1.000	1.000	1.000
1996	1.079	0.971	1.047
1997	1.117	0.988	1.104
1998	1.091	1.020	1.112
1999	1.086	1.043	1.131
2000	1.083	1.065	1.155
2001	1.197	1.003	1.201

Table 5-3 the result of productivity measured by FGNZ method

No	Country	Railways	Efficiency change	Technical change	TFP change
1	Austria	*ÖBB*	1.209	0.975	1.179
2	Belgium	*SNCB/NMBS*	1.106	0.969	1.074
3	Denmark	*DSB*	1.098	1.005	1.104
4	Finland	*VR*	1.054	0.989	1.045
5	France	*SNCF*	1.040	1.132	1.177
6	Germany	*DB AG*	1.032	1.027	1.059
7	Greece	*CH*	1.135	0.923	1.048
8	Ireland	*CIE*	0.976	0.929	0.904
9	Italy	*FS SpA*	1.129	1.026	1.160
10	Luxembourg	*CFL*	0.888	1.065	0.946
11	Netherlands	*NS N.V.*	1.000	1.069	1.069
12	Portugal	*CP*	0.979	1.112	1.089
13	Spain	*RENFE*	1.076	1.084	1.166
14	Sweden	*SJ AB*	1.000	1.157	1.157
15	Norway	*NSB BA*	1.077	1.155	1.246
16	Switzerland	*BLS*	1.000	1.121	1.122
17	Switzerland	*CFF/SBB/FFS*	1.103	1.069	1.179
18	Bulgaria	*BDZ*	1.214	0.995	1.207
19	Croatia	*HZ*	1.265	0.878	1.110
20	Czech Rep	*CD*	1.172	1.000	1.172
21	Estonia	*EVR*	1.094	1.102	1.206
22	Hungary	*GYSEV/RÖEE*	1.001	1.044	1.045
23	Hungary	*MÁV Rt.*	1.091	1.013	1.105
24	Latvia	*LDZ*	1.016	1.123	1.141
25	Lithuania	*LG*	1.203	0.906	1.089
26	Poland	*PKP*	0.849	1.003	0.973
27	Romania	*CFR*	1.048	0.905	0.948
28	Slovak	*ZSR*	1.275	0.965	1.233
29	Slovenia	*SZ*	1.110	1.008	1.119
30	Moldova	*CFM (E)*	1.059	0.925	0.980
31	Ukraine	*UZ*	1.229	0.939	1.154
32	Turkey	*TCDD*	0.942	1.060	0.999
33	Israel	*IsR*	1.246	1.033	1.288
34	Morocco	*ONCFM*	1.289	1.002	1.131
35	Syria	*CFS*	0.994	1.084	1.077
36	Mozambique	*CFM*	1.135	1.147	1.302
37	Tanzania	*TRC*	1.150	1.134	1.303
38	Azerbaijan	*AZ*	1.155	0.978	1.130
39	Korea	*KNR*	1.087	1.193	1.294
40	Japan	*JR*	1.117	1.086	1.213
41	India	*IR*	1.079	1.077	1.162
42	Taiwan	*TRA*	1.002	1.089	1.092
43	Turkmenistan	*TRK*	0.955	0.897	0.857
44	Australia	*QR*	1.000	1.164	1.164
	Mean		1.197	1.003	1.201

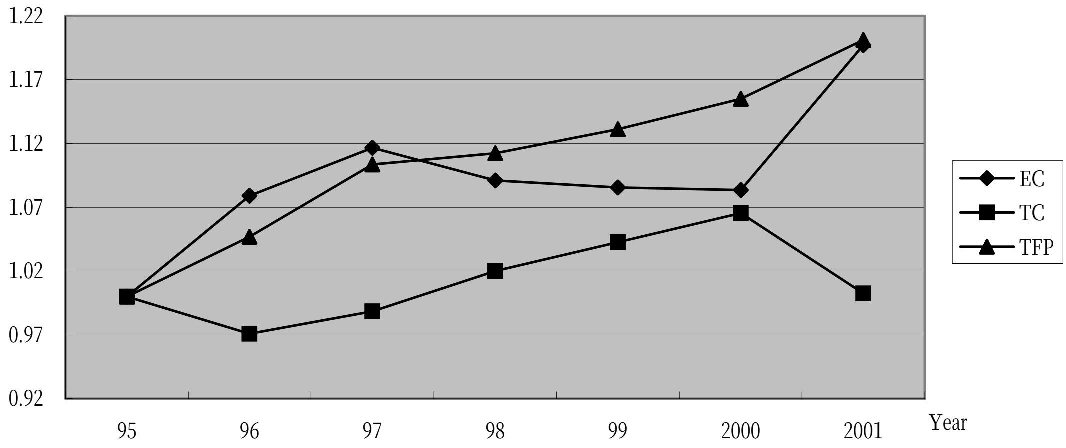

Fig 5-1 Time Trend of EC, TC and TFP Change Measured by FGNZ Method

5.2.2 Measured by proposed four-stage method

In the FGNZ Malmquist productivity measurement, there are two drawbacks. The first one is that the solutions of four linear programs frequently contain slacks, which are typically ignored. When slacks are presented, radial measures may overstate the true efficiency thus affects productivity index in an unknown way. The second one is that FGNZ measurement does not take environmental factors and statistical noises into account. To measure MPI more precisely, this research thus solves four distance functions by substituting adjusted data obtained from third-stage in efficiency measurement procedure and adopting SA-DEA model (3-36) (hereinafter, called four-stage method). The four-stage method thus takes environmental factors and statistical noises, as well as residual slacks into account. Similarly, four linear programs were solved by GAMS computer program. The results are documented in Table 5-4 and 5-5. Again, note that Table 5-4 shows the cumulative geometric mean efficiency changes, technical changes, and productivity growth for all railways over seven years, while Table 5-5 indicates cumulative efficiency changes, technical changes, and productivity growth for each of 44 railways over the same period. From the two tables, we see that the productivity growth in the period is 6.6 percent, which is due to efficiency change (12.6 percent). Figure 5-2 shows the time trend of EC, TC and MPI over the sampling period. Comparing the result with those measured from FGNZ method, the results confirm that radial measures in distance functions may overstate the true efficiencies thus affect productivity index measurement in an unknown way.

Table 5-4 Cumulative indices of efficiency change, technical change and MPI by using four-stage method.

Year	Efficiency change	Technical change	MPI
1995	1.000	1.000	1.000
1996	1.071	0.911	0.976
1997	1.083	0.918	0.994
1998	1.110	0.874	0.970
1999	1.190	0.851	1.013
2000	1.197	0.851	1.019
2001	1.126	0.947	1.066

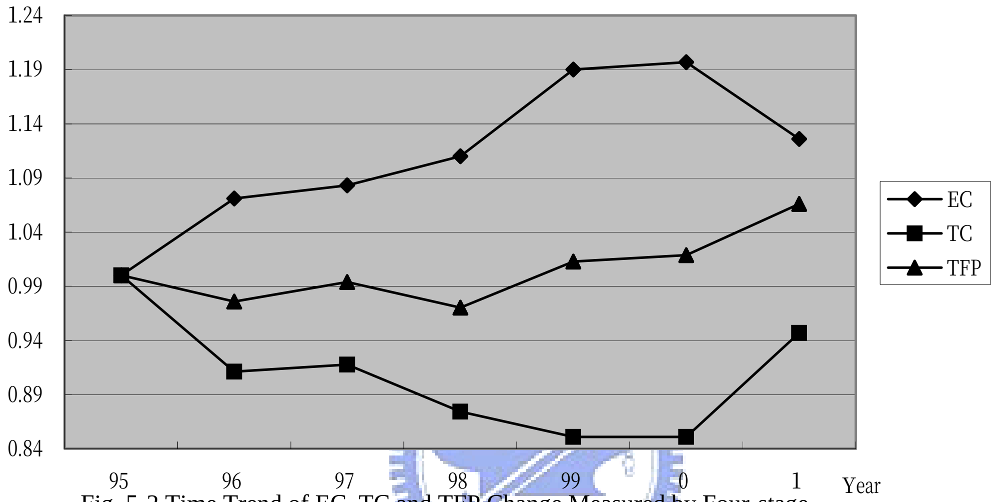

Fig. 5-2 Time Trend of EC, TC and TFP Change Measured by Four-stage Method

Table 5-5 the results of productivity measured by proposed four-stage method.

No	Country	Railways	Efficiency change	Technical change	TFP change
1	Austria	*ÖBB*	1.312	0.809	1.061
2	Belgium	*SNCB/NMBS*	0.948	1.070	1.014
3	Denmark	*DSB*	0.986	1.087	1.071
4	Finland	*VR*	1.208	1.256	1.517
5	France	*SNCF*	1.122	0.927	1.040
6	Germany	*DB AG*	0.934	0.961	0.898
7	Greece	*CH*	0.870	1.110	0.966
8	Ireland	*CIE*	1.182	0.865	1.022
9	Italy	*FS SpA*	0.974	1.039	1.011
10	Luxembourg	*CFL*	0.942	1.048	0.987
11	Netherlands	*NS N.V.*	0.801	0.169	0.935
12	Portugal	*CP*	0.942	1.136	1.069
13	Spain	*RENFE*	1.039	1.079	1.121
14	Sweden	*SJ AB*	1.132	1.069	1.210
15	Norway	*NSB BA*	1.009	0.978	0.987
16	Switzerland	*BLS*	1.044	1.044	1.090
17	Switzerland	*CFF/SBB/FFS*	1.000	0.980	0.980
18	Bulgaria	*BDZ*	1.035	0.929	0.962
19	Croatia	*HZ*	1.013	0.949	0.962
20	Czech Rep	*CD*	1.013	0.954	0.966
21	Estonia	*EVR*	1.439	0.795	1.143
22	Hungary	*GYSEV/RÖEE*	1.683	0.638	1.073
23	Hungary	*MÁV Rt.*	1.035	0.989	1.023
24	Latvia	*LDZ*	1.137	0.909	1.034
25	Lithuania	*LG*	0.946	1.083	1.025
26	Poland	*PKP*	1.187	0.812	0.963
27	Romania	*CFR*	1.212	0.831	1.007
28	Slovak	*ZSR*	1.252	0.698	0.874
29	Slovenia	*SZ*	1.278	0.704	0.899
30	Moldova	*CFM (E)*	1.025	0.798	0.818
31	Ukraine	*UZ*	1.401	0.664	0.931
32	Turkey	*TCDD*	0.857	0.842	0.722
33	Israel	*IsR*	0.997	1.116	1.113
34	Morocco	*ONCFM*	1.015	0.947	0.961
35	Syria	*CFS*	1.288	0.919	1.183
36	Mozambique	*CFM*	1.406	0.855	1.202
37	Tanzania	*TRC*	1.798	0.706	1.269
38	Azerbaijan	*AZ*	1.822	0.552	1.006
39	Korea	*KNR*	0.806	1.235	0.995
40	Japan	*JR*	0.948	1.005	0.953
41	India	*IR*	1.668	0.671	1.119
42	Taiwan	*TRA*	1.000	0.888	0.888
43	Turkmenistan	*TRK*	0.824	1.244	1.025
44	Australia	*QR*	1.539	0.845	1.301
	Mean		1.154	0.924	1.066

5.3 Sales Force Measurement

5.3.1 Measured by conventional FGNZ method

As mentioned in previous chapter, due to non-storable characteristics of transport service, therefore, it is need to measure sales force in addition to productivity. To do so, this research measures sales force for 44 railways over the period of 1995 to 2001 by adopting the output-based Malmquist Salesforce Index model; which can be found in chapter three. Furthermore, to find the determinants of sales force, the MSI then decomposed into effectiveness change and sales technical change. Following Färe, Grosskopf, Norris and Zhang (1994) (hereafter, FGNZ method) four linear programming programs are constructed and solved by GAMS computer program. The measured results are indicated in Table 5-6 and 5-7. Note that Table 5-6 shows the cumulative geometric mean effectiveness changes, technical changes, and sales force growth for all railways over seven years, while Table 5-7 indicates cumulative effectiveness changes, technical changes, and sales force growth for each of 44 railways over the same period. One can see from these two tables, the sales force growth in the sampling period is 7.3 percent, which is due to sales force change (9.2 percent), rather than effectiveness change. Figure 5-3 shows the time trend of EC, TC and MSI change over the sampling period.

Table 5-6 Cumulative indices of effectiveness change, technical change and MSI change by using FGNZ method.

Year	Effectiveness change	Technical change	MSI change
1995	1.000	1.000	1.000
1996	0.969	1.026	0.994
1997	0.985	0.993	0.979
1998	0.954	1.027	0.980
1999	0.972	1.043	1.015
2000	0.963	1.067	1.029
2001	0.983	1.092	1.073

Table 5-7 the result of sales force measured by FGNZ method

No	Country	Railways	Effectiveness change	Technical change	MSI change
1	Austria	*ÖBB*	0.868	1.100	0.953
2	Belgium	*SNCB/NMBS*	0.948	1.069	1.012
3	Denmark	*DSB*	1.110	1.071	1.189
4	Finland	*VR*	0.931	1.061	0.986
5	France	*SNCF*	0.980	1.172	1.149
6	Germany	*DB AG*	1.110	1.085	1.204
7	Greece	*CH*	1.108	1.066	1.181
8	Ireland	*CIE*	0.888	1.217	1.082
9	Italy	*FS SpA*	0.990	1.143	1.135
10	Luxembourg	*CFL*	1.194	1.056	1.262
11	Netherlands	*NS N.V.*	0.946	1.035	0.979
12	Portugal	*CP*	0.776	1.120	0.869
13	Spain	*RENFE*	1.072	1.151	1.234
14	Sweden	*SJ AB*	0.857	1.048	0.900
15	Norway	*NSB BA*	0.978	1.128	1.105
16	Switzerland	*BLS*	1.145	1.059	1.212
17	Switzerland	*CFF/SBB/FFS*	0.917	1.132	1.037
18	Bulgaria	*BDZ*	0.774	1.104	0.854
19	Croatia	*HZ*	0.803	1.069	0.859
20	Czech Rep	*CD*	0.986	1.071	1.058
21	Estonia	*EVR*	1.140	1.118	1.274
22	Hungary	*GYSEV/RÖEE*	0.922	1.085	0.999
23	Hungary	*MÁV Rt.*	1.149	1.070	1.232
24	Latvia	*LDZ*	1.173	1.153	1.353
25	Lithuania	*LG*	1.104	1.134	1.251
26	Poland	*PKP*	0.895	1.046	0.936
27	Romania	*CFR*	0.872	1.119	0.976
28	Slovak	*ZSR*	0.869	1.088	0.945
29	Slovenia	*SZ*	0.907	1.101	0.998
30	Moldova	*CFM (E)*	1.007	1.108	1.117
31	Ukraine	*UZ*	1.000	1.075	1.075
32	Turkey	*TCDD*	0.922	1.147	1.058
33	Israel	*IsR*	1.003	1.007	1.011
34	Morocco	*ONCFM*	1.052	1.069	1.122
35	Syria	*CFS*	1.121	1.093	1.225
36	Mozambique	*CFM*	0.364	0.931	0.339
37	Tanzania	*TRC*	0.996	0.720	0.716
38	Azerbaijan	*AZ*	1.010	1.131	1.142
39	Korea	*KNR*	0.806	1.218	0.981
40	Japan	*JR*	1.000	1.054	1.054
41	India	*IR*	1.000	1.165	1.165
42	Taiwan	*TRA*	1.048	1.074	1.125
43	Turkmenista	*TRK*	0.866	1.160	1.005
44	Australia	*QR*	1.000	1.073	1.073
	Mean		0.983	1.092	1.073

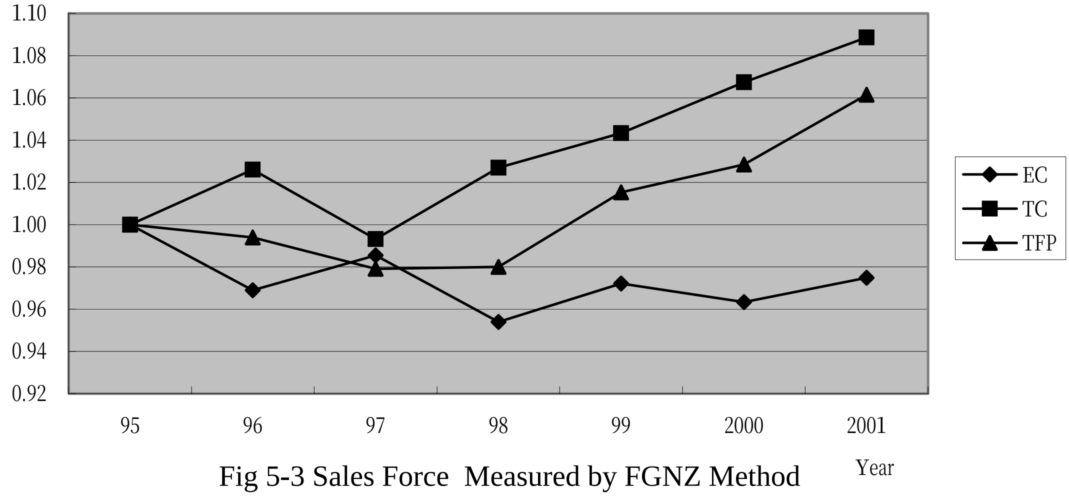

Fig 5-3 Sales Force Measured by FGNZ Method

5.3.2 Measured by proposed four-stage method

Similar to productivity measurement, there are two drawbacks in FGNZ method, which are without taking environmental factors into account, and neglecting slacks. To measure sales force more precisely, this research thus adopts proposed four-stage method; which is described in chapter three. More specifically, the research measures four distance functions by applying four-stage method and by substituting adjusted consumption data. GAMS computer program is utilized as in productivity measurement. The results are presented in Table 5-8 and 5-9. Note that, Table 5-8 shows the cumulative geometric mean effectiveness changes, sales technical changes, and sales force growth for all railways over seven years, while Table 5-9 indicates cumulative effectiveness changes, sales technical changes, and sales force growth for each of 44 railways over the same period. One can see from these two tables, the cumulative sales force growth in the sampling period is 6.1 percent, which is due in large part to sales technical change (6.7 percent), rather than effectiveness change. Figure 5-4 shows the time trend of effectiveness change, technical change and MSI change.

Table 5-8 Cumulative indices of effectiveness change, technical change and MSI change by using four-stage method.

Year	Effectiveness change	Technical change	MSI change
1995	1.000	1.000	1.000
1996	0.978	1.014	0.992
1997	0.992	1.019	1.010
1998	0.990	1.030	1.019
1999	0.988	1.042	1.030
2000	0.998	1.058	1.055
2001	0.994	1.067	1.061

Table 5-9 the result of sales force measured by four-stage method

No	Country	Railways	Effectiveness change	Technical change	MSI change
1	Austria	*ÖBB*	0.967	1.028	0.994
2	Belgium	*SNCB/NMBS*	1.010	1.002	1.012
3	Denmark	*DSB*	1.027	0.917	0.942
4	Finland	*VR*	0.962	1.047	1.007
5	France	*SNCF*	1.100	1.038	1.142
6	Germany	*DB AG*	1.087	1.031	1.121
7	Greece	*CH*	0.984	0.951	0.936
8	Ireland	*CIE*	0.959	1.062	1.018
9	Italy	*FS SpA*	0.995	1.031	1.026
10	Luxembourg	*CFL*	0.788	1.114	0.878
11	Netherlands	*NS N.V.*	0.976	1.016	0.992
12	Portugal	*CP*	0.978	1.031	1.008
13	Spain	*RENFE*	0.986	1.034	1.020
14	Sweden	*SJ AB*	0.948	1.118	1.060
15	Norway	*NSB BA*	0.959	1.037	0.994
16	Switzerland	*BLS*	1.079	1.062	1.146
17	Switzerland	*CFF/SBB/FFS*	0.977	1.030	1.006
18	Bulgaria	*BDZ*	0.948	1.141	1.082
19	Croatia	*HZ*	0.981	1.025	1.006
20	Czech Rep	*CD*	0.973	1.051	1.023
21	Estonia	*EVR*	1.040	1.118	1.163
22	Hungary	*GYSEV/RÖEE*	1.006	1.013	1.019
23	Hungary	*MÁV Rt.*	0.983	1.028	1.011
24	Latvia	*LDZ*	0.994	1.289	1.281
25	Lithuania	*LG*	1.091	1.184	1.292
26	Poland	*PKP*	1.043	1.033	1.077
27	Romania	*CFR*	0.954	1.033	0.985
28	Slovak	*ZSR*	0.793	1.150	0.912
29	Slovenia	*SZ*	0.786	1.314	1.033
30	Moldova	*CFM (E)*	0.654	1.280	0.837
31	Ukraine	*UZ*	1.000	0.863	0.863
32	Turkey	*TCDD*	0.956	1.048	1.002
33	Israel	*IsR*	1.063	1.006	1.069
34	Morocco	*ONCFM*	0.962	1.040	1.000
35	Syria	*CFS*	1.158	0.994	1.151
36	Mozambique	*CFM*	1.105	0.988	1.092
37	Tanzania	*TRC*	1.000	0.887	0.887
38	Azerbaijan	*AZ*	0.983	1.109	1.090
39	Korea	*KNR*	0.833	1.145	0.954
40	Japan	*JR*	1.000	1.280	1.280
41	India	*IR*	1.000	0.806	0.806
42	Taiwan	*TRA*	0.880	1.026	0.903
43	Turkmenistan	*TRK*	0.951	1.040	0.989
44	Australia	*QR*	1.000	1.195	1.195
	Mean		0.994	1.067	1.061

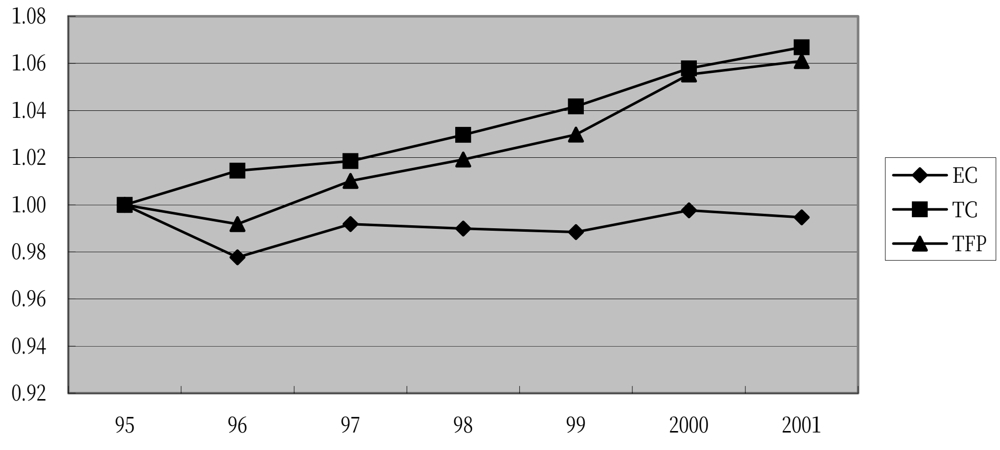

Fig 5-4 Sales Force Measured by Four-stgae Method

5.4 Concluding Remarks

This chapter measures productivity for selected 44 railway companies over the period of 1995-2001 by using the Malmquist Productivity Index model and by applying linear programming technique. In contrast to previous studies, the environmental factors, statistical noise, as well as slacks are taken into account. Firstly, the research measures productivity by using FGNZ method. The result shows that the cumulative productivity growth is 20.2 percent on average. It should be noted that, this growth was due to improvements in efficiency or catching-up, rather than innovation or shift of frontier. Secondly, the research measures productivity by using proposed four-stage method and by substituting adjusted data from chapter four. The result indicates that the productivity increases 6.6 percent for the period of 1995-2001; which is less than those measured from FGNZ method. Thus, this research concludes that, in comparison with four-stage method, the productivity measurement will be overestimated if environmental factors, statistical noises and slacks are neglected in this empirical study.

In addition to productivity measurement, because the outputs produced by transportation industries are non-storable, this research thus measures Malmquist sales force index by the same procedure as in productivity measurement but alternative orientated. Both of FGNZ and proposed four-stage methods are adopted to the measurements. The results indicate that, on average, cumulative sales force grows with rate of 7.3 percent over the period of 1995 to 2001 when FGNZ method was adopted. The determinant of sales force growth can be attributed to innovation, rather than effectiveness change. Meanwhile, if the sales force was measured by considering environmental factors, statistical noises and slacks, in other words, by using proposed four-stage method and substituting adjusted data, the sales force growth becomes 6.1 percent. This result indicates that, in this empirical study, sales force index will be overestimated if one does not take residual slacks into account. The results also reveal that, same as in the measurement by FGNZ method, sales force growth was due to technical change, rather than improvements in effectiveness.