

# CONTENTS

	<u>PAGE</u>
<u>ABSTRACT (in Chinese)</u>	i
<u>ABSTRACT</u>	ii
<u>ACKNOWLEDGEMENTS</u>	iii
<u>ACKNOWLEDGEMENTS (in Chinese)</u>	iv
<u>LIST OF TABLES</u>	xi
<u>LIST OF FIGURES</u>	xiii
1 <u>INTRODUCTION</u>	1
1.1 The Problem and Its Significance	1
1.2 Motivation and Purposes for the Research	3
1.3 Methodology	5
1.4 Organization of the Research	7
2 <u>REVIEW OF PERFORMANCE EVALUATION RESEARCH</u>	9
2.1 Previous Studies on Efficiency Measurement	9
2.1.1 Data Envelopment Analysis	9
2.1.2 Stochastic Frontier Analysis	17
2.2 Previous Studies on Productivity Measurement	19
2.3 An Overview of the Empirical Studies in Rail Industry	24
2.3.1 Index Numbers	24

	PAGE
2.3.2 Least Squares	25
2.3.3 Data Envelopment Analysis	27
2.3.4 Stochastic Frontier Analysis	29
2.3.5 Malmquist Productivity Index	30
2.4 A Review of Other Relevant Works	35
2.5 Some Comments	38
<b>3 <u>METHODOLOGY AND RESEARCH FRAMEWORK</u></b>	<b>42</b>
3.1 The Methods for Measuring Efficiency and Effectiveness	42
3.1.1 Data Envelopment Analysis	42
3.1.1.1 CCR model	42
3.1.1.2 BCC model	43
3.1.1.3 SZ model	44
3.1.2 Stochastic Frontier Analysis	45
3.1.2.1 Stochastic production frontier	45
3.1.2.2 Stochastic cost frontier	46
3.1.3 The Comparison between DEA and SFA	47
3.2 The Method for Measuring Productivity and Sales Force	49
3.3 The Research Framework	51
3.3.1 The three-stage model	51
3.3.2 The four-stage model	54
3.3.2.1 The efficiency measurement	54
3.3.2.2 The effectiveness measurement	56

	PAGE
3.3.2.3 The productivity measurement	57
3.3.2.4 The sales force measurement	58
4 <u>EFFICIENCY AND EFFECTIVENESS MEASUREMENT FOR RAIL TRANSPORT</u>	60
4.1 The Data	60
4.2 Efficiency Measurement	64
4.2.1 Measured by CCR and BCC models	64
4.2.2 Sensitivity analysis	67
4.2.3 Measured by 3- stage DEA procedure	67
4.2.4 Measured by 4-stage DEA procedure	70
4.2.5 Comparison	70
4.3 Effectiveness Measurement	73
4.3.1 Measured by CCR and BCC models	73
4.3.2 Sensitivity analysis	73
4.3.3 Measured by 3- stage DEA procedure	76
4.3.4 Measured by 4-stage DEA procedure	78
4.3.5 Comparison	80
4.4 Concluding Remarks	81
5 <u>PRODUVTIVITY AND SALES FORCE MEASUREMENT FOR RAIL TRANSPORT</u>	83
5.1 The Data	83
5.2 Productivity Measurement	84
5.2.1 Measured by conventional FGZ method	84

	<u>PAGE</u>
5.2.2 Measured by proposed four-stage method	86
5.3 Sales Force Measurement	89
5.3.1 Measured by conventional FGZ method	89
5.3.2 Measured by proposed four-stage method	91
5.4 Concluding Remarks	93
6 <u>PERFORMANCE MATRIX AND POLICY IMPLICATIONS</u>	95
6.1 Performance Matrix	95
6.1.1 Efficiency vs. effectiveness	95
6.1.2 Productivity vs. sales force	98
6.2 Policy Implications for Rail Industry	99
6.2.1 Strategies for improving efficiency	99
6.2.2 Strategies for improving effectiveness	100
6.2.3 Strategies for improving productivity	101
6.2.4 Strategies for improving sales force	102
6.3 Implications to TRA	102
6.3.1 Backgrounds	102
6.3.2 Policy Implications	104
6.4 Concluding Remarks	106
7 <u>CONCLUSIONS</u>	108
7.1 General Conclusions	108
7.2 Possible Extensions of the Research	113
<u>REFERENCES</u>	116

	<u>PAGE</u>
A. Efficiency Measurement	116
B. Productivity Measurement	120
C. Empirical Studies in Transportation Industries	121
D. General	122
<u>APPENDIX</u>	124
The Data	124
Published Paper List	131
Vita	132



## LIST OF TABLES

<u>NUMBER</u>	<u>PAGE</u>
1-1 Freight European Union Modal Split (% , ton-km) .....	1
2-1 Empirical studies of efficiency and productivity measurement on rail industry .....	31
3-1 The comparison between DEA and SFA .....	48
4-1 The descriptive statistics for the observations (44 railways over 7 years).....	62
4-2 The correlation coefficients between input and output, output and consumption .....	63
4-3 The efficiency measurement for 44 railways (CCR model).....	65
4-4 The efficiency measurement for 44 railways (BCC model).....	66
4-5 The results of sensitivity analysis for BCC efficiency measurement .	67
4-6 Estimated results of SFA model .....	68
4-7 The efficiency measurement for 44 railways (3-stage) .....	69
4-8 The results of input slack analysis.....	70
4-9 The efficiency measurement for 44 railways (4-stage) .....	71
4-10 Distribution frequencies of estimated results based on CCR, BCC, 3-stage, and 4-stage efficiency measurement .....	72
4-11 The results of sensitivity analysis for BCC effectiveness measurement .....	73
4-12 Service effectiveness (CCR model).....	74
4-13 Service effectiveness (BCC model).....	75
4-14 SFA result for output slacks.....	76
4-15 Service effectiveness (3-stage) .....	77
4-16 Slack analysis results .....	78

<u>NUMBER</u>	<u>PAGE</u>
4-17 Service effectiveness (4-stage) .....	79
4-23 Distribution frequencies of estimated results based on CCR, BCC, 3-stage, and 4-stage efficiency measurement .....	80
5-1 The sum and change rate of consumption and outputs over the time .	83
5-2 Cumulative indices of EC, TC and MPI by FGNZ method .....	84
5-3 The result of productivity measured by FGNZ method .....	85
5-4 Cumulative indices of efficiency change, technical change and MPI by using four-stage method .....	87
5-5 The result of productivity measured by proposed four-stage method .....	88
5-6 Cumulative indices of effectiveness change, technical change and MSI change by using FGNZ method .....	89
5-7 The result of sales force measured by FGNZ method .....	90
5-8 Cumulative indices of effectiveness change, technical change and MSI change by using four-stage method .....	91
5-9 The result of sales force measured by four-stage method .....	92
6-1 Some operating data of TRA in the period of 1995 to 2001 ....	103
6-2 Comparison of labor used per km of line between TRA and its peer firms .....	104

## LIST OF FIGURES

<u>NUMBER</u>	<u>PAGE</u>
1-1 Productivity and Technical Efficiency .....	2
2-1 Technical Efficiency and Allocative Efficiency .....	10
2-2 Technical and Scale Efficiencies .....	16
2-3 The Sensitivity of DEA .....	16
2-4 Productivity, Technical Change and Efficiency Change .....	21
2-5 Output-based Malmquist Productivity Index .....	22
2-6 Framework for a Transit Performance Concept Model.....	36
3-1 Radial and Non-radial Input Slacks.....	52
3-2 Radial and Non-radial Output Slacks.....	52
5-1 Time Trend of EC, TC and TFP Change Measured by FGNZ Method	86
5-2 Time Trend of EC, TC and TFP Change Measured by four-stage Method .....	87
5-3 Cumulative Sales Force Index Measured by FGNZ Method.....	91
5-4 Cumulative Sales Force Index Measured by Four-stage Method .....	93
6-1 Efficiency vs. Effectiveness (BCC model).....	96
6-2 Efficiency vs. Effectiveness (3-stage Method).....	97
6-3 Efficiency vs. Effectiveness (4-stage model) .....	97
6-4 Productivity vs. Sales Force (FGNZ Method) .....	98
6-5 Productivity vs. Sales Force (4-stage Method) .....	99