

**PRODUCTIVITY AND EFFICIENCY ANALYSIS OF
INDIAN AVIATION INDUSTRY**

BALRAM TYAGI



**DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCES
INDIAN INSTITUTE OF TECHNOLOGY DELHI
SEPTEMBER 2015**

© Indian Institute of Technology Delhi (IITD), New Delhi, 2015

**PRODUCTIVITY AND EFFICIENCY ANALYSIS OF
INDIAN AVIATION INDUSTRY**

by

BALRAM TYAGI

Department of Humanities and Social Sciences

Submitted

in fulfilment of the requirements of the degree of

Doctor of Philosophy

to the



Indian Institute of Technology Delhi

September 2015

CERTIFICATE

This is to certify that the thesis titled “**Productivity and Efficiency Analysis of Indian Aviation Industry**” submitted by **Mr. Balram Tyagi** to the **Indian Institute of Technology Delhi** for the award of the degree of **Doctor of Philosophy**, is a record of original bona-fide research carried out by him under our supervision. We are satisfied that the thesis is worthy of consideration for award of the degree.

The results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

(Dr. Seema Sharma)

Associate Professor

Department of Management Studies
Indian Institute of Technology Delhi

(Dr. V. Upadhyay)

Professor

Department of Humanities & Social Sciences
Indian Institute of Technology Delhi

Date:

New Delhi

ACKNOWLEDGEMENTS

I take immense pleasure in expressing my deep sense of gratitude to my Supervisor Prof. V. Upadhyay and co-supervisor Dr. Seema Sharma whose sagacity, constant encouragement and support steered me through every step during the course of this research work. Their valuable guidance helped me find solution and instill immense confidence whenever the going got tough.

I would like to thank profusely to Mr. Chhatar Singh, Dy. Director, DGCA, New Delhi, for providing access to data without whom active support this work would not have been possible. I gratefully acknowledge the help rendered by Late Mr. Madan Lal (ISS) for getting access to data.

I am grateful to my friend Neha Gupta for her support and valuable suggestions at every step of this journey. My sincere thanks are due to my colleague Bhawna Soni for her constant support and encouragement during the course of this work.

I sincerely thank my friends and relatives, Preeti Tyagi, Sandeep Tyagi, Sumita Goel, Jyoti Tyagi, Apratul Chandra Shukla, Sitakanta Panda, Sanjeev Gupta, Jyoti Tikoria and Rahul Devgun and for helping me and keeping me motivated during challenging times.

I am ever indebted to my parents particularly to my father who has been the greatest source of inspiration and constant motivation behind this work.

It is difficult to put in words the motivation and constant moral support provided by my wife Renu, daughters Arushi and Himani, son Vatsal and all other family members. My heart-felt thanks to all of them for showing all the understanding and patience for all these years.

I am solely responsible for errors, if any, in this study.

(Balram Tyagi)

ABSTRACT

Aviation industry is a vital segment of the fast growing Indian economy because of its catalytic role in stimulating growth across all other sectors of the economy. In tandem with fast growth of Indian economy and its continuing liberalization, the industry has witnessed rapid growth and expansion in the past decade. Against this backdrop, the present study endeavours to analyse TFP, labour productivity and unit cost of Indian aviation industry for the period 1999-00 to 2011-12. To that end, Caves, Christensen and Diewert (CCD) multilateral index procedure has been used. The latter half of the study period is marked with intense competition and turbulence which is subjected to a deeper investigation by estimating technical and scale efficiency of Indian airlines by using data envelopment analysis (DEA). Furthermore, Malmquist productivity index has been used for estimating productivity change and its components. The global competitiveness of Indian airlines has been assessed by comparing their efficiency and productivity with select US airlines for the period 2006-07 to 2011-12.

The findings suggest that the industry has witnessed significant growth in TFP, labour productivity and decline in unit cost for the period 1999-00 to 2011-12 which clearly shows the positive effect of liberalization and deregulation. The industry TFP has grown at about 3% per annum during the period. In line with TFP growth, industry unit costs also witnessed an annual decline of 2.7%. Due to decline in productivity of public airlines, the rate of TFP growth was moderate in the latter half of the study period. In contrast, most of the fall in unit cost is noted during the second half only. Despite productivity growth and continuously declining unit costs, the industry profitability declined due to decline in yield.

After 2006-07, despite rise in VRS technical efficiency, technical efficiency growth of the industry has remained stagnant due to decline in scale efficiency. Nonetheless, private airlines show significant improvement in technical efficiency as against substantial decline witnessed by public airlines which is noted entirely on account of inappropriate choice of scale rather than poor managerial performance. All categories of airlines show improvement in VRS technical efficiency (managerial efficiency) suggesting competition has positively contributed towards improvement in

managerial performance. However, decline in scale efficiency indicates that the airlines did not manage their scale properly. Malmquist productivity analysis suggests that industry TFP growth after 2006-07 was almost entirely driven by technological progress. Furthermore, our analysis shows evidence of technological catching-up in the industry.

After 2005-06, in the face of stiff competition public airlines have seen steady decline in their productivity and technical efficiency, and rise in unit cost. Nonetheless, TFP and efficiency levels of those are still found comparable to majority of the private airlines. The low cost carriers are noticed to have higher productivity, lower unit costs and better managerial efficiency than all other categories. However, TFP, labour productivity, unit costs and yields of all categories of airlines have sharply converged towards the end of study period.

The study does not indicate any significant difference in technical efficiency of Indian and US airlines for the period 2006-07 to 2011-12. However, Indian airlines are found to enjoy higher scale efficiency but relatively lower managerial efficiency than US airlines. TFP growth rate of Indian airlines is noted to be nearly 30% higher than US airlines. Furthermore, while TFP growth of Indian airlines was mainly driven by technical progress that of US airlines was largely on account of improvement in technical efficiency.

The findings suggest load factor and stage-length to be the main drivers of industry productivity in India while scale is noticed to have only moderate influence on productivity. Furthermore, aircraft size, traffic density and proportion of international traffic are noted to have significant positive influence on efficiency of airlines. The dominance of increasing return-to-scale and low industry-wide load factor points towards the need of consolidation in the industry.

CONTENTS

	Page No.
Certificate	i
Acknowledgements	ii
Abstract	iii
List of Contents	v
List of Figures	xiii
List of Tables	xvii
Chapter 1 Introduction	
1.1 Introduction	1
1.2 Aviation Industry and Economy	2
1.3 Structure of Indian Aviation Industry	3
1.3.1 Director General of Civil Aviation	4
1.3.2 Bureau of Civil Aviation Security (BCAS)	4
1.3.3 Airports Authority of India (AAI)	4
1.3.4 Indira Gandhi Rashtriya Uran Akademi (IGRUA)	5
1.3.5 Scheduled Airlines in India	5
1.4 Indian Aviation Industry: Genesis, Growth and Evolution of Regulatory Framework	7
1.4.1 The Origin and Historical Phase (1932-1986)	7
1.4.2 The Early Liberalization Period (1986-2003)	8
1.4.3 Growth and Expansion Phase (2003 onwards)	10
1.5 Growth, Expansion and Change in Market Structure (1999-00 to 2011-12)	13
1.6 Current Challenges and Future Opportunities	18
1.6.1 Policy Environment	18
1.6.2 Aviation Fuel Tax Structure	19
1.6.3 Overcapacity in Market	20
1.6.4 Infrastructure Deficit	20

1.7	Rationale of the Study	22
1.8	Objectives of the Study	26
1.9	Methodological Framework and Database	27
1.10	Period and Coverage of Study	28
1.11	Organization of the Study	29

Chapter 2 Productivity and Efficiency: Concepts and Measurement

2.1	Introduction	31
2.2	Concepts of Productivity and Efficiency	32
2.3	Productivity: Definition and Evolution of Concept	34
2.3.1	Importance of Productivity Growth	36
2.4	Measurement of Productivity and Productivity Growth	37
2.5	Growth Accounting/Index Number Approach of TFP Measurement	39
2.5.1	Kendrick Index	41
2.5.2	Solow Index	42
2.5.3	Fisher Index	44
2.5.4	Törnqvist-Theil index	45
2.5.5	Limitations of Index Number Approach	47
2.5.6	Temporal and Cross-sectional Measurement of Productivity	47
2.6	Frontier Approach of TFP Measurement	49
2.6.1	Malmquist TFP index	50
2.7	Econometric Approach of TFP Measurement	51
2.8	Productivity Measurement Approaches: A Comparison	52
2.9	Efficiency: Definition and Evolution of Concept	54
2.10	Measurement of Technical Efficiency: Frontier Approach	56
2.11	Parametric Approach: Stochastic Frontier Analysis (SFA)	57
2.12	Nonparametric Approach: Data Envelopment Analysis	58
2.12.1	CCR Model	60
2.12.3	BCC Model	61
2.12.3	Return to Scale in DEA	61
2.12.4	Slack Analysis in DEA	62
2.12.5	DEA Extensions and Advancement	63
2.12.6	Statistical Inferences in DEA	65

2.12.7	Sensitivity Analysis in DEA	66
2.12.8	Panel Data Analysis with DEA	67
2.13	Parametric and Nonparametric Frontier Methods: A Comparison	68
2.14	Conclusion	69

Chapter 3 Review of Literature

3.1	Introduction	73
3.2	Airlines Performance Measurement	73
3.3	Comparative Productivity and Efficiency Studies across Markets	77
3.4	Deregulation and Performance of Airlines	80
3.5	Economies of Scale and Density	83
3.6	Productivity and Profitability	85
3.7	Literature on Indian Aviation Industry	86
3.8	Gaps in Literature	88
3.9	Conclusion	91

Chapter 4 Methodology and Database

4.1	Introduction	93
4.2	Framework for Performance Measurement	94
4.3	Operating Model of Airlines	95
4.4	Measurement of Total Factor Productivity: Choice of Method	95
4.5	Measurement of Productivity: Index Number Approach	98
4.5.1	Caves, Christensen and Diewert (CCD) Index	98
4.5.2	Aggregate Industry Productivity	101
4.5.3	Unit Cost Estimation	102
4.6	Measurement of Technical Efficiency	102
4.6.1	Charnes, Cooper and Rhodes (CCR) Model	103
4.6.2	Banker, Charnes and Cooper (BCC) Model	106
4.6.3	Input and Output Orientation	107
4.6.4	Measurement of Scale Efficiency	108
4.6.5	Sensitivity Analysis of Technical Efficiency Estimates	111
4.6.6	Measurement of Aggregate Industry Efficiency	111

4.7	Measurement of Productivity: Frontier Approach	112
4.7.1	Malmquist Productivity Index	113
4.7.2	Decomposition of Malmquist Productivity Index	114
4.8	Database, Coverage and Period of Study	117
4.8.1	Data Source and Analysis Tools	117
4.8.2	Airlines Sample for Measurement of TFP	119
4.8.3	DEA Panel	121
4.8.4	Scope of the Study	121
4.8.5	Study Period	122
4.9	Construction of TFP Variables	123
4.9.1	TFP Outputs	123
4.9.2	TFP Inputs	124
	Labour Quantity Index	124
	Capital Service Flow	125
	Material Quantity Index	130
	Fuel Quantity Index	131
4.10	Inputs and Outputs for DEA	131
4.11	Sources of Productivity and Technical Efficiency	134
4.11.1	Sources of Total Factor Productivity	134
4.11.2	Structural Drivers of Technical Efficiency	136
4.12	Conclusion	138

Chapter 5 Measurement of Productivity

5.1	Introduction	139
5.2	Total Factor Productivity Results	140
5.2.1	Firm-level TFP	141
5.2.2	Aggregate Industry TFP	148
5.2.3	Category-wise TFP	152
5.3	Unit Cost Comparison	156
5.3.1	Firm-level Unit Cost	156
5.3.2	Industry Unit Cost	158
5.3.3	Category-wise Unit Cost	160
5.3.4	Estimation of Cost Savings to Industry	163

5.4	Labour Productivity	163
5.5	Industry Yield	169
5.6	Airline Industry Growth and Profitability	173
5.7	Productivity and Profitability	177
5.8	Sources of Productivity Change	179
5.8.1	Scale of Operations	186
5.8.2	Composition of Outputs	186
5.8.3	Stage Length	187
5.8.4	Load Factor	189
5.8.5	Individual Effects of Airlines	190
5.9	Conclusion	190

Chapter 6 Measurement of Technical Efficiency

6.1	Introduction	193
6.2	Technical Efficiency Results	194
6.2.1	Firm Level Technical Efficiency	195
6.2.2	Sensitivity Analysis of Technical Efficiency Results	199
6.3	Scale Efficiency	201
6.4	Category-wise Productive Efficiency	204
6.5	Ownership and Productive Efficiency	208
6.6	Aggregate Technical Efficiency of Industry	211
6.7	Total Factor Productivity Growth	215
6.8	Components of Productivity Growth	218
6.8.1	Technical Change	218
6.8.2	Technical Efficiency Change	221
6.9	Structural Drivers of Technical Efficiency	223
6.9.1	Aircraft size	229
6.9.2	Number of Flights	229
6.9.3	Traffic Density	230
6.9.4	International Traffic	230
6.9.5	Ownership	231
6.10	Conclusion	231

Chapter 7 Comparison of Indian and US Airlines Performance

7.1	Introduction	237
7.2	US Airlines as Benchmark	237
7.3	Technical Efficiency Results	240
7.3.1	Robustness of Technical Efficiency Results	245
7.3.2	Statistical Significance of Efficiency Differentials	247
7.4	Aggregate Technical Efficiency	248
7.5	Scale Efficiency and Returns-to-scale	252
7.6	Measurement of Input Slacks	255
7.7	Total Factor Productivity Growth	257
7.8	Decomposition of Productivity Growth	260
7.8.1	Technical Change	262
7.8.2	Technical Efficiency Change	264
7.9	Productivity Growth, Efficiency and Profitability	266
7.10	Effect of Reference Technology on Efficiency of Indian Airlines	268
7.11	Conclusion	272

Chapter 8 Summary and Conclusions

8.1	Introduction	275
8.2	Summary of the Findings	279
8.2.1	Results for Productivity and Efficiency	279
8.2.2	Comparative Performance of Public and Private Airlines	286
8.2.3	Comparative Performance of LCC and FSC	289
8.2.4	Effect of Mergers and Acquisitions on Productive Performance	290
8.3	Conclusions	292
8.4	Suggestions for Airlines' Management	296
8.5	Policy Recommendations	298
8.6	Limitations of the Study	301
8.7	Suggestions for Future Study	301

References		303
Appendix-I	Glossary of Aviation Terms	325
Appendix-II	Malmquist Efficiency Change, Technical Change and TFP Change Indexes for Indian Airlines	329
Appendix-III	CRS Technical Efficiency, VRS Technical Efficiency and Scale Efficiency of Indian and US Airlines	331
Appendix-IV	Percentage Slacks for Indian and US Airlines	333
Appendix-V	Malmquist Efficiency Change, Technical Change and TFP Change Indexes for Indian and US Airlines	335
Brief Bio-data of the Author		339

LIST OF FIGURES

Figure No.	Description	Page No.
1.1	Passengers and Freight Growth in Indian Aviation Industry	14
1.2	Growth of Aircraft Departures and Number of Aircrafts in Indian Aviation Industry	15
1.3	Available Capacity and Load Factor in Indian Aviation Industry	16
1.4	Percentage Market-shares of Various Categories of Airlines	16
1.5	Percentage Market-shares of Airlines in Year 2011-12	17
1.6	Operating Revenues, Expenses and Profits Margins for Indian Aviation Industry	18
4.1	Input-output Transformation Model for Airlines	96
4.2	Measurement of Scale Efficiency in DEA	109
4.3	Components of Malmquist Productivity Index	116
5.1	Total Factor Productivity Index of Indian Airlines (1999-00 to 2011-12)	144
5.2	TFP, Input and Output Index for Indian Aviation Industry (1999-00 to 2011-12)	150
5.3	Total Factor Productivity Growth in Indian Aviation Industry (1999-00 to 2011-12)	151
5.4	Category-wise TFP Trend for Indian Airlines (1999-00 to 2011-12)	154
5.5	Industry and Category-wise Unit Cost Trend for Indian Airlines (1999-00 to 2011-12)	160

5.6	Labour Productivity Trend in Indian Aviation Industry (1999-00 to 2011-12)	167
5.7	TFP and Labour Productivity Growth in Indian Aviation Industry (1999-00 to 2011-12)	169
5.8	Industry and Category-wise Yield Trend in Indian Aviation Industry (1999-00 to 2011-12)	172
5.9	Industry and Category-wise Profitability Trend in Indian Aviation Industry (1999-00 to 2011-12)	173
5.10	Comparative Trend of TFP, Output, Profitability, Unit Cost & Yield for Indian Airline Industry (1999-00 to 2011-12)	177
6.1	CRS Technical Efficiency of Indian Airlines (2007-08 to 2011-12)	197
6.2	Category-wise CRS Technical Efficiency of Indian Airlines (2007-08 to 2011-12)	205
6.3	Category-wise VRS Technical Efficiency of Indian Airlines (2007-08 to 2011-12)	206
6.4	Category-wise Scale Efficiency of Indian Airlines (2007-08 to 2011-12)	207
6.5	CRS Technical Efficiency for Public and Private Airlines (2007-08 to 2011-12)	209
6.6	VRS Technical Efficiency for Public and Private Airlines (2007-08 to 2011-12)	209
6.7	Scale Efficiency for Public and Private Airlines (2007-08 to 2011-12)	210
6.8	Trend of Aggregate Industry Efficiency for Indian Airlines (2006-07 to 2011-12)	212
6.9	Annual Mean of Efficiency Change, Technical Change and TFP Change Indexes for Indian Aviation Industry (2007-08 to 2011-12)	216

6.10	Mean Annual Efficiency Change, Technical Change and TFP Change Indexes for Indian Airlines (2007-08 to 2011-12)	219
6.11	Components of Technical Efficiency Change in Indian Aviation Industry (2007-08 to 2011-12)	222
7.1	Growth in International Passenger Traffic in India (million) (1999-00 to 2011-12)	236
7.2	Percentage of Indian and US Airlines with CRS Technical Efficiency $\geq 85\%$	243
7.3	Aggregate CRS-Technical Efficiency of Indian and US Airlines	250
7.4	Aggregate VRS-Technical Efficiency of Indian and US Airlines	251
7.5	Aggregate Scale Efficiency of Indian and US Airlines	253
7.6	Mean Annual Malmquist TFP Index for Indian and US Airlines (2007-08 to 2011-12)	260
7.7	Mean Annual Efficiency Change, Technical Change and TFP Change Indexes for Indian and US Airlines (2007-08 to 2011-12)	261
7.8	Mean Annual Technical Change Index for Indian and US Airlines (2007-08 to 2011-12)	262
7.9	Mean Annual Technical Efficiency Change for Indian and US airlines (2007-08 to 2011-12)	265
7.10	Operating Profit Margins for Indian and US Airlines (2006-07 to 2011-12)	267
7.11	CRS Technical Efficiency of Indian Airlines under Frontier-I & Frontier-II	271
7.12	VRS Technical Efficiency of Indian Airlines under Frontier-I & Frontier-II	271
7.13	Scale Efficiency of Indian Airlines under Frontier-I & Frontier-II	271

List of Tables

Table No.	Description	Page No.
3.1	Select Studies on Concepts and Methods of Performance Measurement in Aviation Industry	78
3.2	Summary of Select Comparative Studies on Airlines across Regions	79
3.3	Select Studies on Deregulation and Performance of Airlines	82
3.4	Select Studies on Economies of Scale and Traffic Density in Air Transport	84
3.5	Select Studies on Relationship between Productivity and Profitability	85
3.6	An Overview of Studies on Indian Aviation Industry	89
4.1	Details of Specific Tools and Database used for each Objective	118
4.2	Summary Operating Characteristics of Indian Airlines (1999-00 to 2011-12)	120
4.3	Explanatory Variables for TFP Regression	135
5.1	Descriptive Statistics of Indian Airline Industry (1999-00 to 2011-12)	140
5.2	Multilateral Input, Output and TFP Index of Indian Airlines for Select Years	142
5.3	TFP Index of Indian Airlines (1999-00 to 2011-12)	143
5.4	TFP, Input and Output Index for Indian Aviation Industry (1999-0 to 2011-12)	149
5.5	Category-wise TFP of Indian Airlines (1999-00 to 2011-12)	153

5.6	Unit Cost Index of Indian Airlines (1999-00 to 2011-12)	157
5.7	Industry and Category-wise Unit Cost Index of Indian Airlines (1999-00 to 2011-12)	159
5.8	Estimated Cost Savings to Indian Aviation Industry due to Decline in Unit Cost (2006-07 to 2011-12)	163
5.9	Labour Productivity Index of Indian Airlines (1999-0 to 2011-12)	165
5.10	Industry and Category-wise Labour Productivity of Indian Airlines (1999-00 to 2011-12)	166
5.11	Yield Index of Indian Airlines (1999-00 to 2011-12)	171
5.12	Industry and Category-wise Yield Index of Indian Airlines (1999-00 to 2011-12)	172
5.13	Profitability Index of Indian Airlines (1999-00 to 2011-12)	174
5.14	Industry and Category-wise Profitability Index of Indian Airlines (1999-00 to 2011-12)	175
5.15	Industry and Category-wise Unit Cost, Yield & Profitability Changes of Indian Airlines	175
5.16	Descriptive Statistics of Explanatory Variables	179
5.17	Pearson Correlation Coefficients of TFP and Explanatory Variables	180
5.18	Results of MacKinnon, White and Davidson (MWD) Test	181
5.19	Summary of TFP Regression Results for Model-I	182
5.20	Summary of TFP Regression Results for Model-II	184
5.21	Summary of TFP Regression Results for Model-III	185
6.1	Year-wise Descriptive Statistics of CRS Technical Efficiency of Indian Airlines (2006-07 to -2011-12)	195

6.2	CRS Technical Efficiency of Indian Airlines (2007-08 to 2011-12)	196
6.3	VRS Technical Efficiency of Indian Airlines (2007-08 to 2011-12)	196
6.4	Peer Count Summary for Indian Airlines (2007-08 to 2011-12)	200
6.5	Scale Efficiency of Indian Airlines (2007-08 to 2011-12)	202
6.6	Return-to-scale Characteristics of Indian Airlines (2007-08 to 2011-12)	203
6.7	Category-wise Efficiency of Indian Airlines (2006-07 to 2011-12)	205
6.8	Aggregate Efficiency Results for Indian Aviation Industry (2007-08 to 2011-12)	212
6.9	Malmquist Index Summary of Annual Means for Indian Aviation Industry (2007-08 to 2011-12)	215
6.10	Mean Annual Malmquist Index for Indian Airlines (2007-08 to 2011-12)	215
6.11	Explanatory Variables for Technical Efficiency	224
6.12	Descriptive Statistics of Explanatory Variables	225
6.13	Pearson Correlation Coefficients of Efficiency Estimates and Explanatory Variables	226
6.14	Results of Tobit Regression Model-I	227
6.15	Results of Tobit Regression Model-II	228
6.16	Results of Tobit Regression Model-III	228
7.1	Descriptive Statistics of Sample Indian and US Airlines for 2011-12	239

7.2	Year-wise Descriptive Statistics of CRS Technical Efficiency of Indian and US Airlines (2006-07 to 2011-12)	240
7.3	Number of Airlines with CRS Technical Efficiency $\geq 85\%$	242
7.4	CRS Technical Efficiency Ranks of Indian and US Airlines (2006-07 to 2011-12)	244
7.5	Peer Count Summary of Technically Efficient Indian and US Airlines (2006-07 to 2011-12)	246
7.6	Wilcoxon Test Results for Efficiency Scores of Indian and US Airlines	248
7.7	Aggregate Efficiency for Indian and US Airlines (2006-07 to 2011-12)	250
7.8	Return-to-scale Characteristics for Indian and US Airlines (2006-07 to 2011-12)	254
7.9	Year-wise Input Slacks for Indian and US airlines (2006-07 to 2011-12)	256
7.10	Malmquist Index Summary of Annual Means for Indian and US Airlines (2007-08 to 2011-12)	258
7.11	Mean Annual Malmquist Indexes for Indian and US Airlines (2007-08 to 2011-12)	259
7.12	<i>t</i> -test: Paired Two Sample for Efficiency Means for Indian Airlines	269