

**EFFICIENCY AND PRODUCTIVITY GROWTH
IN
THE INDIAN IRON AND STEEL INDUSTRY:
A STOCHASTIC FRONTIER ANALYSIS**

By

SATARUPA RAY BHATTACHARYA

HUMANITIES AND SOCIAL SCIENCES DEPARTMENT

Submitted

In fulfillment of the requirements of the degree of Doctor of Philosophy

to the



INDIAN INSTITUTE OF TECHNOLOGY, DELHI

JUNE, 2009

CERTIFICATE

Certified that Ms. Satarupa Ray Bhattacharya was permitted to work for her Ph.D. Degree in Economics at the IIT Delhi, on the problem entitled "EFFICIENCY AND PRODUCTIVITY GROWTH IN THE INDIAN IRON AND STEEL INDUSTRY: A STOCHASTIC FRONTIER ANALYSIS". She has faithfully carried out her study under our guidance and supervision and the accompanying thesis is her genuine and original work.

The results contained in the thesis has not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

Ms. Satarupa Ray Bhattacharya has completed necessary course work and put in the required attendance in this Department.

.....
Dr. Kaustuva Barik
Reader
School of Social Sciences
and
Indira Gandhi National Open University
New Delhi, India

.....
Prof. Vrajindra Upadhyay
Professor of Economics
Department of Humanities
Social Sciences, I.I.T. Delhi,
New Delhi, India

ACKNOWLEDGEMENT

I would like to express my sincere regards and gratitude to my supervisor, Dr. V. Upadhyay, and co-supervisor Dr. K. Barik for their expert guidance, valuable suggestions, and continuous encouragement throughout the research work. Their valuable analysis and constructive criticisms have helped to enrich my research work significantly. I am indebted to both of them for their care and support at a personal level.

I gladly acknowledge Dr. S. Chakrovorty (JNU), Dr. R. Chowdhuri (IITD), Prof. D. Chakrovorty (Jadavpur University), Ms. A. Dhar (Jadavpur University), Dr. R. L. Chowdhuri, for their beneficial comments, and assistance in the early stages of the study. I am also grateful to Prof. A. Khurana, Prof. A. Sharma, Prof. R. Nair and all the staff of the of Humanities and Social Sciences Department, IIT Delhi, for providing encouragement and support necessary for carrying the research work.

I am also thankful to Prof. Subal Kumbhakar for his valuable comments on the thesis design.

I would like to express my heart-felt gratitude and respect to my father late Mr. G. K. Roy and my mother Mrs. Samita Roy for their love, support and encouragement to do my best in all matters of life. I dedicate this thesis to them.

I want to extend my appreciation to my brother Shwetketu for his unconditional support and encouragement and Ms. A. Chakrovorty, Dr B. N. Chakrovorty, Ms. I. Bhattacharya, and Mona, for the informal support and co-operation which has been indispensable for the study.

Finally, I take this opportunity to thank my husband, Jayanta, for his encouragement, patience, and mental support. His thoughtful advice often served to give me a sense of direction during my Ph.D studies. Special acknowledgement is also due to my cute little daughter, Anoushka, whom I failed to give enough time in her formative years.

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

Satarupa Ray Bhattacharya

ABSTRACT

The iron and steel industry in India was under strict government regulation up to 1990 since independence. It was only after 1991 the industry was opened up for free competition which brought sea changes in the industry. Thus it is highly expected that these changes have a considerable effect on efficiency and productivity in the iron and steel industry. With this background the present study aims to investigate the efficiency and productivity performance of the Indian iron and steel industry in terms of its three sub-sectors, viz., finished steel, special steel, pig and sponge iron.

The specific research issues addressed in the thesis are: estimation of the level of technical efficiency, investigation of the sources of inefficiency and decomposition of TFP change in the three sub-sectors mentioned above. Towards these objectives the study adopts an output oriented stochastic production frontier approach and uses firm level panel data for the period 1993-94 to 2005-06.

The results show that evaluated at sample mean, there exists almost constant returns to scale in the finished steel sub-sector whereas decreasing returns exist in the other two sub-sectors covered in the study. The finding also reveals that on an average mean technical efficiency in finished steel, special steel and pig and sponge iron sub-sector are 91 percent, 68 percent and 84 percent respectively. These results indicate that the Indian iron and steel industry have the potential to increase its output by 20 percent on an average without any increase in its resources. The results also bring out the fact that the mean technical efficiency in the finished and special steel sub-sectors experience a negative trend whereas pig and sponge iron sector experiences a positive trend. Firm level analysis reveals that Tata Steel, Shah Alloy and Tata Sponge Iron hold the first position in the finished steel, special steel and pig and sponge iron sub-sectors respectively.

An investigation into the sources of inefficiency reveals that age, liquidity, price cost margin, disembodied technology import intensity, and raw material import intensity help to improve technical efficiency of the finished steel sub-sector; age, liquidity, price cost margin, export intensity, helps to improve efficiency of the special steel sub-sector; and liquidity, price cost margin, indirect tax intensity and export intensity help to improve efficiency of the pig and sponge iron sub-sector. Research and development intensity fails to exert any significant effect on any of the three sub-sectors of the industry. Consistency of the efficiency ranking by the different stochastic frontier models used in the analysis is also verified.

The decomposition of total factor productivity change shows that for finished steel and special steel sub-sectors productivity growth is positive (1.54 percent per annum and 1.57 percent per annum respectively) on an average whereas it is negative (-2.05 percent per annum) in pig and sponge iron sub-sector. The result also shows that for finished steel sub-sector total factor productivity growth came mostly from technical progress. Technical efficiency change remained negative throughout the study period and contribution of scale change component was very little. In the case of the special steel, technical progress together with scale change component pushed up total factor productivity growth. Negative technical efficiency change component, however, continuously reduces their joint effects. Pig and sponge iron sub-sector is little different in the sense that the major contributing factor for negative total factor productivity change rate is negative technical change and occasionally scale change. This is the only sub-sector where technical efficiency change component contribute positively in total factor productivity change.

The research study suggests that as far as improvement measures are concerned, each sub-sector requires different policy initiative. In both the steel sectors emphasis should be on reducing technical inefficiency whereas in the pig and sponge iron sector stress should be on the rapid technological up-gradation.

CONTENTS

CERTIFICATE	
ACKNOWLEDGEMENT	
ABSTRACT	
LIST OF FIGURES	v
LIST OF TABLES	vi
ABBREVIATIONS	ix
CHAPTER 1 INTRODUCTION	1
1.1 Background	1
1.2 Major Policy Developments in the Indian Iron and Steel Industry	3
1.3 Rationale of the Study	7
1.4 Objectives of the Study	10
1.5 Methodology and Database	11
1.6 Period and Coverage of the Study	14
1.7 Organization of the Study	14
CHAPTER 2 IRON AND STEEL INDUSTRY IN INDIA	17
2.1 Introduction	17
2.2 Structure of the Industry	18
2.3 The Beginning of the Early Phase (1907 -1979)	19
2.4 The Pre Liberalization Decade 1980s	26
2.5 Period of Liberalization and Post-liberalization (1990 – 2006)	28
2.6 Some Key Characteristics of the Industry	35
2.6.1 Production	35
2.6.2 Consumption	37
2.6.3 Ownership	38
2.6.4 Research and Development	39
2.6.5 Input Price Indices	40
2.6.6 Profitability	43
2.6.7 Cyclical Phases Witnessed by the Industry	43
2.7 Conclusion	44

CHAPTER 3 REVIEW OF LITERATURE	45
3.1 Introduction	45
3.2 Productivity and Efficiency	46
3.2.1 Productivity	47
3.2.2 Efficiency	48
3.3 Approaches to Performance Measurement	50
3.4 Evolution of Stochastic Frontier Approach	52
3.5 Benchmark Studies in the Stochastic Frontier Literature	54
3.5.1 Time-invariant Technical Inefficiency Model	56
3.5.2 Time-variant Technical Inefficiency Model	61
3.5.3 Determinants of Inefficiency	65
3.6 Application of Stochastic Frontier Analysis in Iron and Steel Industry	67
3.7 Frontier Approach Based Studies Pertaining to India	69
3.7.1 Studies Based on Deterministic Frontier	69
3.7.2 Studies Based on Deterministic and Stochastic Frontier	71
3.7.3 Studies Based on Stochastic Production Frontier	72
3.7.4 Studies Based on Data Envelopment Analysis	77
3.8 Review of Studies on Indian Iron and Steel Industry	77
3.9 Conclusion	83
CHAPTER 4 METHODOLOGY AND DATABASE	85
4.1 Introduction	85
4.2 The Basic Stochastic Frontier Model	86
4.3 Battese and Coelli (1992) Model	88
4.4 Battese and Coelli (1995) Model	92
4.5 Specification of the Production Structure	94
4.6 Decomposition of Total Factor Productivity Change	96
4.6.1 Technical Change	96
4.6.2 Change in Technical Efficiency	97
4.6.3 Scale Change Component	98
4.7 Database of the Study	99
4.8 Construction of the Variables	101
4.8.1 Output	105
4.8.2 Labor Input	105

4.8.3 Material	107
4.8.4 Energy	108
4.8.5 Capital	108
4.8.5.1 Revaluation Factor	109
4.8.5.2 Replacement Cost	110
4.8.5.3 Capital Stock Series	111
4.9 Limitations of the Data	111

Chapter 5 TECHNICAL EFFICIENCY IN THE SUB-SECTORS OF THE INDIAN IRON AND STEEL INDUSTRY

5.1 Introduction	113
5.2 Hypothesis Testing and Model Selection	114
5.3 Maximum Likelihood Estimates of the Selected Models	119
5.4 Average Technical Efficiency of the three Sub-sectors	124
5.5 Firm-Wise Technical Efficiency Estimates	130
5.5.1 Frequency Distribution of Technical Efficiency	130
5.5.2 Efficiency Ranking	136
5.6 Summary	138

Chapter 6 DETERMINANTS OF TECHNICAL EFFICIENCY IN THE INDIAN IRON AND STEEL INDUSTRY

6.1 Introduction	141
6.2 Variables Considered for Explaining Inter-Firm Differences in Technical Efficiency	142
6.2.1 Variables Related to Liberalization	143
6.2.2 Variables Related to General Characteristics	146
6.2.3 Variables Considered in the Inefficiency Equation	148
6.3 Specification of the Stochastic Frontier and Inefficiency Equation	151
6.4 Interpretation of the Results	155
6.5 Sensitivity of Model Selection	163
6.6 Summary	167

CHAPTER 7 DECOMPOSITION OF TOTAL FACTOR PRODUCTIVITY	
CHANGE IN STOCHASTIC FRONTIER MODEL	170
7.1 Introduction	170
7.2 Evaluation of Productivity Decomposition using Stochastic Frontier Approach	171
7.3 Productivity Literature in the Indian Context	174
7.4 Year-wise Average Decomposition Results	176
7.4.1 Change in Total Factor Productivity	176
7.4.2 Components of Total Factor Productivity Change	181
7.4.2.1 Finished Steel Sub-sector	181
7.4.2.2 Special Steel Sub-sector	184
7.4.2.3 Pig and Sponge Iron Sub-sector	186
7.5 Firm-wise Average Decomposition Results	188
7.5.1 Finished Steel Sub-sector	188
7.5.2 Special Steel Sub-sector	193
7.5.3 Pig and Sponge Iron Sub-sector	194
7.6 Summary	200
CHAPTER 8 SUMMARY AND CONCLUSION	201
REFERENCES	214