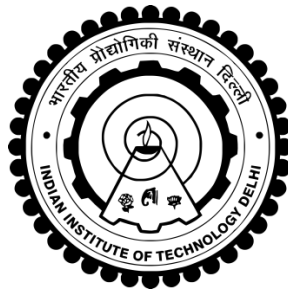


PRODUCTIVITY AND EFFICIENCY ANALYSIS OF ENERGY INTENSIVE INDUSTRIES IN INDIA

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**DEPARTMENT OF MANAGEMENT STUDIES
INDIAN INSTITUTE OF TECHNOLOGY DELHI**

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PRODUCTIVITY AND EFFICIENCY ANALYSIS OF ENERGY INTENSIVE INDUSTRIES IN INDIA

by

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Department of Management Studies

Submitted

in fulfilment of the requirements of the degree of Doctor of Philosophy

to the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

February 2018

Dedicated to

My Parents

&

My Husband

CERTIFICATE

The thesis entitled “**Productivity and Efficiency Analysis of Energy Intensive Industries in India**”, being submitted by **Ms. Mini Kundi** to the Indian Institute of Technology Delhi, for the award of the degree of “**Doctor of Philosophy**” is a record bona fide research work carried out by her. She has worked under my supervision in conformity with rules and regulations of the Indian Institute of Technology Delhi. The results presented in this thesis have not been submitted elsewhere for award of any degree or diploma.

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Mini Kundi

ABSTRACT

Energy intensive industries namely, cement, aluminium and glass, are of vital importance for the development of a country. These industries tend to form the basis of production in many industries, as well as act as ingredient to the growth of different sectors of the economy. Development of these industries serves as an engine of growth for the rest of the economy. But on the negative side, development of these industries put enormous pressure on the already depleting energy resources of the country. Energy intensive industries are a prominent source of greenhouse gas (GHG) emissions. Output expansion of these industries on the basis of increased use of energy resources may be possible, but it is not sustainable. Therefore, productivity of resources becomes a critical factor for the development of these industries. With this background, the present study aims to analyse the productivity and efficiency performance of energy intensive industries in India.

This study applies the methodology of Data Envelopment Analysis (DEA) to estimate efficiency parameters for three most energy intensive industries namely, cement, aluminium and glass. Empirical results show that the average technical efficiency for the cement, aluminium and glass industries are 0.829, 0.897 and 0.806 respectively, which indicates the scope of further reduction in inputs. There are significant differences in the impact of age, size, ownership and location on the efficiency across industries. Sensitivity analysis confirms the stability of efficiency scores obtained during the present study.

A Malmquist index analysis of Total Factor Productivity (TFP) change shows that TFP growth on an average remained positive for aluminium and glass industries in India. In contrast, cement industry reflects sluggish TFP growth over 2000-01 to 2012-13. The dynamics of TFP changes

and its constituent sources varied significantly across the three industries. Study reveals that the efficiency improvement has been the major source of productivity growth in the aluminium and glass industries; whereas efficiency deterioration caused the negative TFP growth in the Indian cement industry.

This study adds to the limited literature on the energy intensive industries. With the growing consciousness about deteriorating energy reserves and climate change, such a study on productivity and efficiency analysis of energy intensive industries may have significant implications for firms and policy makers to stimulate economic growth in an environmentally sustainable way.

सार

एनर्जी गहन उद्योग, सीमेंट, एल्यूमीनियम और ग्लास, एक देश के विकास के लिए महत्वपूर्ण हैं। ये उद्योग कई उद्योगों में उत्पादन का आधार बनाते हैं, साथ ही साथ अर्थव्यवस्था के विभिन्न क्षेत्रों के विकास के घटक के रूप में कार्य करते हैं। इन उद्योगों का विकास शेष अर्थव्यवस्था के विकास के एक इंजन के रूप में कार्य करता है। लेकिन नकारात्मक पक्ष पर, इन उद्योगों के विकास ने देश के पहले ही कमी वाले ऊर्जा संसाधनों पर भारी दबाव डाल दिया। ऊर्जा गहन उद्योग ग्रीनहाउस गैस (जीएचजी) उत्सर्जन का प्रमुख स्रोत हैं। ऊर्जा स्रोतों की बढ़ती उपयोग के आधार पर इन उद्योगों का उत्पादन विस्तार संभव हो सकता है, लेकिन यह टिकाऊ नहीं है। इसलिए, उद्योगों के विकास के लिए संसाधनों की उत्पादकता एक महत्वपूर्ण कारक बन जाती है। इस पृष्ठभूमि के साथ, वर्तमान अध्ययन का उद्देश्य भारत में ऊर्जा गहन उद्योगों की दक्षता और उत्पादकता के प्रदर्शन का विश्लेषण करना है।

सीमेंट, एल्यूमीनियम और कांच जैसे तीन सबसे ऊर्जा गहन उद्योगों के लिए दक्षता और उत्पादकता में बदलाव का अनुमान लगाने के लिए यह अध्ययन डेटा एन्वेलमेंट एनालिसिस (डीईए) की पद्धति पर लागू होता है। अनुभवजन्य परिणाम बताते हैं कि सीमेंट, एल्यूमीनियम और कांच उद्योगों के लिए औसत तकनीकी दक्षता क्रमशः 0.829, 0.897 और 0.806 है, जो इनपुट में और कटौती की संभावना को दर्शाती है।

उद्योगों में दक्षता पर उम्र, आकार, स्वामित्व और स्थान के प्रभाव में महत्वपूर्ण अंतर हैं। संवेदनशीलता विश्लेषण वर्तमान अध्ययन के दौरान प्राप्त दक्षता स्कोर की स्थिरता की पुष्टि करता है।

कुल फैक्टर उत्पादकता (टीएफपी) के माल्मक्विस्ट सूचकांक के विश्लेषण से पता चलता है कि टीएफपी विकास एल्यूमीनियम और कांच उद्योगों के लिए सकारात्मक रहा। इसके विपरीत, सीमेंट उद्योग 2000-01 से 2012-13 तक नकारात्मक टीएफपी विकास को दर्शाता है। टीएफपी परिवर्तन की गतिशीलता और इसके घटकों के स्रोत तीन उद्योगों में काफी भिन्न हैं। अध्ययन से पता चलता है कि दक्षता में सुधार एल्यूमीनियम और कांच उद्योगों में उत्पादकता में वृद्धि का प्रमुख स्रोत रहा है; जबकि दक्षता में गिरावट ने भारतीय सीमेंट उद्योग में नकारात्मक टीएफपी उत्पन्न किया।

यह अध्ययन ऊर्जा से संबंधित उद्योगों पर सीमित साहित्य को बढ़ाता है। बिगड़ती ऊर्जा भंडार और जलवायु परिवर्तन के बारे में बढ़ती चेतना के साथ, ऊर्जा संबंधी उद्योगों के उत्पादकता और दक्षता विश्लेषण के बारे में इस तरह के अध्ययन से, कंपनियां और नीति निर्माताओं के लिए पर्यावरणीय रूप से स्थायी तरीके से आर्थिक विकास को प्रोत्साहित करने के लिए महत्वपूर्ण प्रभाव पड़ सकता है।

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LIST OF ABBREVIATIONS

AIGMF	All India Glass Manufacturers Association
CMA	Cement Manufacturers Association
CMIE	Centre for Monitoring Indian Economy
CPI	Consumer Price Index
CRS	Constant Returns to Scale
CRSSE	Constant Returns to Scale Super-Efficiency
CRSTE	Constant Returns to Scale Technical Efficiency
CSO	Central Statistical Organisation
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Program
DIPP	Department of Industrial Policy and Promotion
DMU	Decision Making Unit
DRS	Decreasing Returns to Scale
EMS	Efficiency Measurement System
GHG	Green House Gas
GOI	Government of India
IEA	International Energy Agency
IRS	Increasing Returns to Scale
MPI	Malmquist Productivity Index
OTE	Overall Technical Efficiency
PTE	Pure Technical Efficiency
PECH	Pure Efficiency Change
R & D	Research and Development
SECH	Scale Efficiency Change
SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
TECHCH	Technical Change
TFP	Total Factor Productivity
TFPCH	Total Factor Productivity Change
TFPG	Total Factor Productivity Growth
US	United States
VRS	Variable Returns to Scale
VRSE	Variable Returns to Scale Super-Efficiency
VRSTE	Variable Returns to Scale Technical Efficiency
WPI	Wholesale Price Index
FDI	Foreign Direct Investment