CHAPTER - 1

INTRODUCTION

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1.1 Introduction

Energy serves as an input for all economic activity sectors. Even while energy input was acknowledged as being important in every manufacturing process, the energy industry did not fully grasp the finite nature of natural resources and the importance of energy until the late 1960s. The Club of Rome Study at the time highlighted the diminishing supply of non-conventional energy sources and the depletion of natural resources. Research from the 1970s anticipated that the world's coal reserves would endure for 100 years, while the reserves of petroleum and natural gas would remain for 20 and 50 years, respectively. In terms of overall energy usage, India is sixth in the world. The need for energy has significantly increased as general economic activity including industrialization, electrification, rapid infrastructure construction, and human development take shape. Despite having an abundance of coal and other renewable energy sources, the nation cannot meet its energy needs fully. To meet its energy needs, India must still import more than 25%. India's industries are one of the top energy consumers in the world, contributing 29% of the nation's GDP. When we examine the Micro, Small, and Medium Enterprises (MSME), we can find that they make up 80% of the sector (in terms of units), with a few significant and energy-intensive small-scale enterprises alone accounting for more than 60% of the sector's total energy consumption. As a result, it is crucial to increase efficiency levels as fuel and GHG (CO_2) prices grow. Efficiency can only be increased by reducing energy intensity. The energy intensity measures how much energy is consumed per unit of GDP, such as toe/USD 1000 of GDP or energy per rupee of earned GDP. Efficiency and energy intensity are inversely correlated; the more efficiently a product or service is produced, the less energy is used in its production.

The term "energy intensity" refers to how effectively energy is utilized in the economy. India's energy intensity is more than double that of developed economies (OECD). In addition, India's energy intensity is substantially higher than that of other growing economies. However, India's energy intensity has been declining since 1999 and is anticipated to continue to do so (GOI, 2001). The energy–GDP (gross domestic product) elasticity indicator is the ratio of the energy growth rate to the GDP growth rate. GDP is a measure of both the economy's structure and its efficiency (Sarbapriya Ray, 2011). Reduced energy inputs at a given level of consumption could explain the gain in energy efficiency, very specifically superior services for a given quantity of energy inputs, such as superior technology imports or ongoing R & D by industry, or industrial size and age, etc.

Since the second five-year plan, increased industrialization has resulted in high demand for energy, as India's industrial sector becomes increasingly competitive in the global economy, its energy consumption accounts for roughly 43.6 percent of total energy availability (Energy balance Statistics, 2020). This is largely due to a steady increase in investment in basic and energy-intensive industries, as a result of previous development plans' emphasis on achieving self-sufficiency, TERI (The Energy Research Institute, 2018). One of the greatest consequences of GHG, especially CO2, was the constant increase in energy usage. Heavy industries in India use more energy, such as iron and steel, aluminum, cement, fertiliser, refining, and pulp and paper (Bhattacharya and Copper 2010). Food processing, textiles, wood goods, printing and publishing, and metal processing are among the industries with the lowest final energy usage. At current prices, the first and second-mentioned industries contribute 29 percent of the GDP. Energy consumption per rupee of GDP earned is believed to have risen significantly, owing to more energy-intensive businesses. Simultaneously, there is a need to enhance efficiency to achieve much lower intensities. India pledged to cut its GDP's energy intensity by 20-25 percent by 2020, compared to 2005 levels (planning commission, 2011). In this environment, the situation posits to detect issues related to industry and energy use. It’s even more important to examine the industrial sector's energy consumption trends and the impact they have on industrial output. A couple of issues can be unlocked to anchor the research focus.

1.2 Issues

Over the decades of industrialization, energy thirst has aggravated several energy-related issues.

1. Quality coal production and supply stand key to fuel mix.
2. Abundant low-quality coal and growing import for quality coal.
3. Rapid urbanization, expanding middle class, rising income, improvement in the standard of living &high dependence on imports for its petroleum needs.
4. Increasing demand for gas, and geopolitical issues hampering gas supply, are the most urgent challenge.
5. India’s major demand for energy primarily comes from non-renewables.
6. Electricity shortages lead to a fall in industrial output leading to a fall in the profit.
7. Growing vehicle ownership and demand for steel & cement led to an increase in energy demand.

Such grave issues bring to light some concrete questions such as:

1. Which industries heavily depend on energy use?
2. What is the major source of energy for the industrial sector?
3. How much energy has been consumed by industries?
4. How energy shortages are met by the industrial sector?
5. What is the level of energy intensity among the industries?
6. How to mitigate the energy intensities?
7. What should be the role of industries to reduce energy intensities?
8. How energy efficiency has been achieved by agents of concern?

These challenging questions are answered by framing the below objectives

1.3 Objectives of the study

The core objectives of this research undertaking are to quantitatively analyze the influence of energy on industrial value added for various manufacturing industries in India for the period from 2001 to 2021 using appropriate econometric models and statistical tools. With the reason to identify the functional relationship between energy input and industrial output as well as energy efficiency and industrial output.

1. To understand the link between industrial output and energy efficiency.
2. To study the energy intensity of manufacturing industries (Such as Aluminum, cement, Iron- Steel, textiles, fertilizer, pulp and Paper, oil-refineries, Sugar, and Pharmaceuticals) in India.
3. To analyze the impact of the use of energy and its intensity on industrial output.
4. To fathom out industrial energy efficiency.

Based on the above objectives following are the hypotheses formulated.

1.4 Hypotheses:

1. There is a positive relationship between industrial gross value added and fuel consumption.
2. The higher the real energy price the lower the energy demand
3. The industrial gross value added and fuel consumption are related with each other both at aggregate and disaggregate level.
4. Industries with optimal utilization of energy have higher productivity

The above stated hypothesis is taken for testing in the subsequent chapters. The source of data and methodology are detailed in depth in the following sections to quantify the objectives outlined above and test the stated objectives.

1.5 Study outline

The current study is an empirical investigation. The study dealt with four perspectives. These are either descriptive or inferential. Firstly, the energy scenario of India is pictured. Such a blueprint unravels the status of fuel generation by various sources, the dependency of various sectors on fuel, imports, fuel intensity, and fuel efficiency. Moreover, descriptive statistical information among variables of relations is studied. Secondly, the causal relationship between gross industrial value added and fuel consumption is analyzed. Thirdly the functional interaction of fuel and industrial gross value added is worked out both in an aggregate and disaggregate manner. Lastly, the issue of energy intensity and level of fuel efficiency in each industry is dealt with.

1.6 Data Sources

The study's primary data source is the Annual Survey of Industries of India database, which spans the years 2001 to 2021. Data on the consumption of energy inputs such as coal, natural gas, petroleum products, and electricity in physical units, as well as labor employed, fixed capital, and gross value added in value terms have been compiled from a variety of official sources:

i. Petroleum and Natural gas statistics, published by the ministry of petroleum and Natural Gas, Government of India,
ii. Energy Statistics of various years, published by the Ministry of Statistics and Program Implementation, Government of India.
iii. Annual Survey of Industries, Government of India.
iv. Indian Economy survey
v. World Energy Outlook
vi. KLEMS-database (Reserve Bank of India)

1.7 Methodology

Methodology envelopes listing the choice of several industries, selecting the appropriate variables, measuring central tendency, testing correlation, applying test statistics, conducting functional relationships through regression, and measuring efficiency.

a) List of the industries:

Manufacturing of Basic Metal, Beverages, Chemical and Chemical Products, Coke and Refined Petroleum Products, Computer and Electronic Optical products, Electrical Equipment, Fabricated Metal Products except for Machinery and Equipment, Manufacturing of Food Products, Manufacturing of furniture, Manufacturing of leather related products, Manufacturing of machinery and equipment, Other Non-Metallic Mineral products, Manufacturing of paper and paper products, Pharmaceutical medical, chemical & botanical products, Rubber plastic product, Manufacturing of textiles, Manufacturing of tobacco products, Manufacturing of wearing apparels, Manufacturing of wood and wood products, Other manufacturing, printing and reproduction of media, Publishing Activities, and Crop animal production and Hunting related.

Various distinct statistical and mathematical techniques have been used to the filtered data to achieve the study's aims.

b) Selection of variables

The selection of variables includes energy consumption, labor employed, fixed capital, number of factories, profit, fuel price index, and industrial gross value added

c) Model Specification

Methods like fixed and random effect models, Trans-log production function, and Allen elasticity of factor substitution, are applied to statistically explore the relationship between industry and energy and to know the energy elasticity to industrial output and industrial output elasticity to energy use.

An application of cross-section time-series data analysis modeling with the use of unit root, optimum lag selection, Akaike Information Criterion (A.I.C.), Johansen Co-integration Test, unit root test of Levin Lin, Chu and Im, Pesaran and Shin, Fisher-augmented Dickey-Fuller and Phillips Perron Test and Maximum Eigenvalue Test has been undertaken. The direction of the Granger Causality among indicated variables through the Vector Error Correction Model has also been attempted. The detailed modeling has been constructed in the respective chapters.

Further, the measurement of energy efficiency in Indian manufacturing sectors is undertaken through the DEA-based Malmquist Productivity Index (MPI). Malmquist Productivity Index is a distance function that analyzes multi-input and multi-output systems without any prior assumptions. The distance function can be worked out either input-based or

output based. The present analysis focuses on the input-based distance function to measure the MPIs for calculating the energy consumption performance of different Manufacturing sectors in India.

1.8 Chapterisation

Chapter I: *Introduction*

The introductory chapter posits important issues on energy-driven economic activities and states the quest for energy importance, energy generation, consumption, energy deficiency, and energy dependence. The energy sector and its relation to industrial activity pointed out issues related to them and problems to be dealt with. On this account, some of the concrete research objectives, hypotheses, and methodologies, along with model specifications have been formulated. The chapter also outlines the entire development of the study. The data sources have been specified. The thesis outline has been drawn with a brief sketch of each chapter.

Chapter II: *Review of Literature*

In this chapter comprehensive review of earlier studies has been conducted in three main sections, namely (1) Energy studies in the context of world economies, (2) Energy-related studies in the Indian context, and (3) Energy Intensity and Energy Efficiency Studies in India. The review of literature from the above studies provided a knowledge base for the current research. Moreover, such an exercise enabled unearthing the research gap subsequently directing the construction of the present study's objectives. Further, the literature review provided an idea of the choice of variables, the unit of measurement, and appropriate methodologies for the study.

Chapter III: *India's Energy Scenario*

In order to comprehend energy demand and supply, energy insufficiency, energy and trade, and energy and industrial progress, the third chapter examines the energy situation in India. Then, a descriptive data analysis was performed on variables such as fixed capital, labour input, fuel consumption, and gross value added. Their normalcy has been examined throughout. The summary statistics for these variables provide important details on the empirical probability distribution of the research's chosen samples. Additionally, the variables' rates of increase as well as the proportion

of energy used by each industry are looked into.

Chapter IV: *An Analysis of Industrial Gross Value Added and Energy Consumption of Indian Manufacturing Industries: A Fixed and Random Effect Approach*

The prime objective of this chapter is to test the relationship between industrial output production and energy input at aggregate levels statistically. This relationship is analyzed as a function of the industrial fuel consumption from basic energy sources such as coal, electricity, petroleum & other miscellaneous fuels, capital, and labor through a series of empirical frameworks such as the Panel Unit-Root Test, Johensen's Co-integration Test, Fixed and Random Effect Models.

Chapter V: *Energy Consumption and Gross Industrial Value-Added Linkages in the Indian Manufacturing sector*

This chapter examines the relationship between industrial output production and energy input, at aggregate and disaggregates levels as a function of total fuel consumption, coal, electricity, petroleum, and other fuels. It also applies a series of techniques such as the Panel Unit Root Test, Johensen's Co-integration Test, Vector Error Correction Model (VECM), and Granger Causality Test. This is to capture short-run and long-run causalities and to find out the presence of unidirectional, bi-directional relationships.

Chapter VI: Measuring the Efficiency of Energy Consumption of Indian Manufacturing Sector: A DEA-Based Malmquist Productivity Analysis

This chapter examines and assesses the fuel efficiency of each industry. For the measurement of fuel efficiency in Indian manufacturing sectors, the DEA-based Malmquist Productivity Index (MPI) has been used. The MPI is a distance function that enables the analysis of multi-input and multi-output systems without any assumption of the production behavior, here four inputs and one output is worked out. It is to be noted that the distance function can be defined as either input-based or output based. In this chapter, we focus on the input-based distance function to measure the MPIs for calculating the energy consumption performance of different manufacturing sectors in India and the distance to the efficient production frontier (EPF) for the inefficient Decision-Making Units

Chapter VII: *Summary and Conclusion*

The last chapter summarizes the findings and concludes the study, intending to provide policy recommendations for industries to focus on while using fuel without compromising the output.

1.9 References

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