Energy Intensity and Firm Performance: Do Energy Clusters Matter?

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Abstract

According to the basic law of supply and demand, as the cost of energy input rises, ceteris paribus, producer prefers to employ smaller quantity of energy input and substitute cheaper inputs for more expensive energy during the production process (Schurr, 1982; Jorgenson, 1984). Hence, the question arises whether determinants of profitability of firms differ based on different types of energy consumption. In analyzing this phenomenon for Indian manufacturing industries, this study tries to find out the determinants of profitability of firms based on three energy clusters (natural gas, petroleum and coal) of Indian manufacturing industries. This study uses data from the PROWESS database provided by the Center for Monitoring Indian Economy from 2000-2008. The finding of the study suggests that capital intensity, age of the firm and MNE affiliation of firms are the common determinants of profitability for different energy clusters in Indian manufacturing industries. However, the determinants of profitability differ for variables such as energy intensity, size of firm and R&D intensity and based on the choice of primary source of energy consumption. In the debate of CDM, climate change; shifting from traditional fuel sources to recent fuel source might help in reducing CO_2 emissions, specifically for developing country such as India. Fiscal policies support to industries such as value-added tax exemption for new energy conservation products, import duty reduction and exemption for energy conservation technology might help Indian manufacturing industries to increase the profitability as well as energy efficiency.

Key words: Energy, Profitability, Cluster, Indian Manufacturing Industries

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1. Introduction

Energy efficiency and conservation have long been critical elements in the energy policy dialogue, and they have taken on a renewed importance as concerns about global climate change and energy security have intensified. Many advocates and policy makers hold that reducing the demand for energy is essential to meet these challenges, and analyses tend to find that demand reductions can be a cost-effective means of addressing these concerns. With such great policy interest, a significant literature has developed over the past few years, providing an economic framework in addressing energy efficiency, conservation and performance as well as empirical estimates of how consumers/firms respond to policies to reduce the demand for energy.

In this connection, we begin with defining a few terms to put the literature in context. First, it is important to conceptualize energy as input into the production of desired energy services, rather than as an end in itself. In this framework, energy efficiency is typically defined as the energy services provided per unit of energy input. At the individual product level, energy efficiency can be thought of as one of a bundle of product characteristics, alongside product cost and other attributes (Newell et *al*. 1999). At a more aggregate level, the energy efficiency of a sector or of the economy as a whole can be measured as the level of gross domestic product (GDP) per unit of energy consumed in its production (for analyses of the determinants of energy intensity at the state, national levels and industries levels, see, for example, Metcalf 2008, Sue-Wing 2008, Goldar, 2010, Sahu and Narayanan 2009; 2010).

In contrast, energy conservation is typically defined as a reduction in the total amount of energy consumed. Thus, energy conservation may or may not be associated with an increase in energy efficiency, depending on how energy services change. That is, energy consumption may be reduced with or without an increase in energy efficiency, and energy consumption may increase alongside an increase in energy efficiency. These distinctions are important when considering issues such as the "*rebound effect*[3]". The distinction is also important in understanding the short versus long-run price elasticity of energy demand,

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[3] Defined as the demand for energy services may increase in response to energy efficiency-induced decline in the marginal cost of energy services

whereby short-run changes may depend principally on changes in consumption of energy services, whereas longer-run changes include greater alterations of the energy efficiency of the equipment stock.

In the debate of energy and performance of any economy/firm, one must also distinguish between energy efficiency and economic efficiency. Maximizing economic efficiency typically operationalized as maximizing net benefits to society is generally not going to imply maximizing energy efficiency, which is a physical concept and comes at a cost. Market conditions may depart from efficiency if there are market failures, such as environmental externalities or imperfect information. Aside from such market failures, most economic analysis of energy efficiency has taken cost-minimizing (or utility/profit-maximizing) behavior by households and firms as a point of departure in analysis. Some literature, however, has focused more closely on the decision-making behavior of economic actors, identifying potential "*behavioral failures*" that lead to deviations from cost minimization and motivated at least partly by results from the field of behavioral economics. Much of the economic literature on energy efficiency therefore, seeks to conceptualize energy efficiency decision making to identify the degree to which market or behavioral failures may present an opportunity for net-beneficial policy interventions, and to evaluate the realized effectiveness and cost of actual policies.

Energy markets and its prices influence consumer decisions regarding how much energy to consume and whether to invest in more energy-efficient products and equipment. An increase in energy prices will result in some energy conservation in the short run; however, short-run changes in energy efficiency tend to be limited owing to the long lifetimes and slow turnover of energy-using appliances and capital equipment. Nonetheless, if an energy price increase is persistent, it also is more likely to significantly affect energy efficiency adoption, as consumers replace older capital equipment and firms have time to develop new products and processes.

This study tries to differentiate between firms in terms of energy consumption (by primary source of energy), and attempts to identify the energy-intensive clusters by the profitability of such firms. This study is an attempt to compare profitability of firms for different energy clusters. The motivation for such an attempt is majorly because, we want to find out whether technological advancement (proxy as different primary energy consumption) has any difference in profitability of firms. However, as this study uses firms of different size concluding on this research problem can't be generalized. Hence, we have attempted whether firms from similar energy clusters have similarity in the determinants of profitability.

The rest of this study is designed as follows. Section-2 of the study is an attempt to understand why firms form clusters in general and on energy clusters in particular. However, literature on energy cluster in economics science research is limited. This section further focuses on literature on determinants of profitability of firms. Section-3 of the study is based on the data and variable construction. Section-4 describes the econometric framework and narrates the estimation results. Section-5 concludes the findings of the study.

2. Why industries form clusters?

Porter argues that the internationally competitive industries in a country are generally not a number of diverse and unconnected sectors or firms. Rather, competitive and successful industries usually occur in the form of specialized clusters of "*indigenous*" or "*home-base*" industries, which are linked together through vertical relationships (buyers/suppliers) or horizontal relationships (common customers, technology, skills, distribution channels, etc.). Porter states that, this claim is empirically supported in the studies of the ten countries covered in his book, and he found that "the phenomenon of industry clustering is so pervasive that it appears to be a central feature of advanced national economies" (Porter, 1990[4]).

Since Porter's (1990) study, quite a number of similar studies have been undertaken on other countries (see Hernesniemi et *al*. 1996, on Finland; Beije and Nuys, 1995; and Jacobs et *al*., 1990, on the Netherlands). In Ireland, Porter's findings influenced the Culliton review of industrial policy, which recommended that policy should aim to develop clusters of related industries, building on sources of national competitive advantage (Industrial Policy Review Group, 1992[5]). Subsequently, the National Economic and Social Council (NESC) commissioned a substantial study on industrial clusters in Ireland, examining in particular the relevance of clusters for the competitive advantage of three Irish sectors, dairy processing, the music industry and the Irish indigenous software industry. Reports on these three case studies have been published by NESC[6] (O'Connell et *al*., 1997; Clancy and Twomey, 1997),

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[4] Porter, M., (1990), The Competitive Advantage of Nations, London, Macmillan

[5] Industrial Policy Review Group, (1992), A Time for Change: Industrial Policy for the 1990s, Dublin, Stationery Office

[6] National Economic and Social Council, Dublin

and further discussion of their broader implications can be found in NESC (1998)[7], particularly the works by Clancy et *al*. (1998) and by O'Donnell (1998). Clancy et *al*. (1998) concluded that their three case studies sectors cannot be regarded as part of fully-developed industry clusters of the type and scale described by Porter, although they do gain appreciable benefits from the presence of some form of groupings of connected or related companies and industries, and from interactions between them.

To understand Porter's view[8] of why competitive and successful industries generally occur in the form of clusters, we must refer to his "*diamond model*" of competitive advantage. According to Porter's theory, the competitive advantage of an industry derives from the national "*diamond*", i.e., the four different determinants of competitive advantage which are created within the home base of a country. These four determinants are domestic factor conditions, the nature of domestic demand conditions, the presence of related and supporting industries, and firm strategy, structure and rivalry in the industry concerned.

2.1 Industrial clusters and energy use in Indian industries

In India, there are about 138 major clusters which are engaged in specialized industrial sub-sectors such as: locks at Aligarh, leather footwear at Agra and Kanpur; cotton hosiery at Calcutta and Delhi; blankets in Panipat; power looms at Bhiwadi; diesel engines in Rajkot, diamond polishing in Surat. Space bound "*dense clusters*" related to a specialized industry are even more pronounced in the State of Punjab with woolen garments, bicycle and bicycle parts, sewing machine parts and machine tools in Ludhiana; printing and printing goods, water pipes and bathroom fixtures in Jallandhar; foundries in Batala, etc. Of these, the one at Ludhiana is one of the very successful clusters, having a wide range of diverse products building on "mechanical" skills, which include sewing machines parts, bicycle and

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[7] National Economic and Social Council, (1998), Sustaining Competitive Advantage, Proceedings of NESC Seminar, Research Series, Dublin: National Economic and Social Council

[8] Porter also identifies two other influences-government and chance events-which can affect the competitive advantage of an industry through the influence they have on the four principal determinants of competitive advantage. The conditions which bring about successful industry clusters are said to grow out of the operation of the determinants of competitive advantage, in various ways. For example, if one competitive industry is a sophisticated and demanding customer for the products of its suppliers, it creates domestic demand conditions which help to develop and sustain competitive advantage among the supplier industries. At the same time, if the suppliers are competitive, they help to sustain the competitive advantage of the customer industry through their role as supporting industries. As another example, two or more industries may be "related" industries in so far as they require the same type of factor conditions, such as specialized labour skills. If they are based in the same location, they can have the effect of developing and strengthening the common pool of labour skills through training and on the job experience, and hence each of the industries benefits from this general strengthening of factor conditions. By such means, the industries in a cluster are linked to each other in ways that mutually reinforce the competitive advantage of each industry concerned.

bicycle parts, auto parts components and machine tools. Ludhiana is also better known as the Manchester of India, which alone contributes to the production of 95% of the country's woolen knitwear, 85% of country's knitting machines and 60% of the nation's bicycles and bicycle's parts. Agra cluster makes 0.15 million pairs of shoes per day with a production value of 1.3 m US$ and exporting shoes worth US $ 57.14 million per year (Juneja, 1998). Knitwear cluster in Tiruppur, Tamil Nadu is responsible for 85% of Indian Market and its export earnings have expanded from US$ 25 million in 1986 to US$ 636 million in 1997. What is interesting about Tiruppur cluster is that it is organized in a web of small work places through which the entire town works like a living industrial organization (Chari, 2000). Here we p resent three detailed case studies of clusters relating to Diesel Engines in Rajkot, and Gems and Jewelry Cluster in Surat, and Ceramics Cluster near Ahmedabad, all located in the Gujarat region in India.

The industrial energy use reached 150 million tones of oil equivalent (Mtoe) in 2007 accounting for 38% of the country's final energy used. From a global perspective, India is the fourth-largest industrial energy consumer with a 5% share of total industrial energy use, surpassed only by China, the United States and Russia. Globally, industry accounts for one-third of all the energy used and for almost 40% of worldwide carbon dioxide (CO_2) emissions. In 2007, total final energy use in industry amounted to 3019 Mtoe. Direct emissions of CO_2 in industry amounted to 7.6 Gigatonnes of CO_2 (Gt CO_2) and indirect emissions to 3.9 Gt CO_2. Reducing CO_2 emissions from industry must be an essential part of a global action to prevent dangerous climate change. The International Energy Agency (IEA) analysis shows that industry will need to reduce its current direct emissions by about 24% of 2007 levels if it is to halve global emissions from 2005 levels by 2050. The five most energy-intensive industrial sectors (iron and steel, cement, chemicals and petrochemicals, pulp and paper, and aluminium) accounted for 56% of India's industrial energy consumption in 2007. Globally, these five sectors accounted for 66% of industrial energy consumption.

In implementing sector-wise environmental and energy policies, it is crucial not only to clarify the concept and definition of sectors (e.g., firms, industries, or commodities) but also to decide their priority levels based on reliable environmental inventories such as CO_2 intensities and energy intensities. In these respects, the environmental input-output analyses are useful not only for estimating commodity-wise and industry-wise environmental inventories, but also for identifying the environmentally important key sectors using economic statistics that are calculable from the backward and forward inter-industry linkage effects obtained from column and row sums of the direct and indirect intermediate input coefficient matrix (see Lenzen, 2003). A recent interesting discussion is that not only net multipliers developed by Osterhaven and Stelder (2002) can be used to avoid double counting of the total impact of an industry which results from multiplying a certain input-output multiplier by the industrial output. For a recent empirical contribution, Lenzen (2003) identified environmentally important paths, linkages, and key sectors in the Australian economy using weighted and unweighted coefficients of variation derived from backward and forward inter-industry linkage effects. In addition, an alternative key sector approach is to use both in-degrees and out-degrees obtained from column and row sums of the adjacency matrix represented as a (0, 1) matrix, where 1 denotes an influential inter-industry transaction larger than (or greater than) a certain threshold value, otherwise 0 (see Kagawa et *al*., 2009).

In the field of regional studies, many contributions have been put forth in attempts to identify regional and industrial clusters and complexities (Kelton et *al*., 2008). Their studies normally calculated the relevant four correlation coefficients representing the following similarities between two industries:

1. Industries X_1 and X_2 have similar input purchasing patterns,
2. Industries X_1 and X_2 have similar output selling patterns,
3. The buying pattern of industry X_1 is similar to the selling pattern of industry X_2
4. The buying pattern of industry X_2 is similar to the selling pattern of industry X_1 and identified the industrial clusters by application of the similarity matrices to principal component factor analysis

In the literature of Industrial Organization, Research & Development (R&D) is considered as a strategic or entry barrier. Firm can gain comparative advantage by doing R&D as differentiation strategy. This is because R&D activities results new products and processes that can gain the competitive advantages as long as it is successfully imitated. Firms R&D efforts create new technologies, products, and solutions designed to satisfy customer needs that are not easily imitated by competitors and hence, gain competitive advantages. This behavior of a firm enables it to differentiate itself from other firms. In a similar way, few other economists argue that, this behavior creates value for firms by generating some intangible assets. Following this we can also assume that firms do employ different energy sources based on the technology they adopt in production. For example firms consume latest energy sources when they are technological more superior than the other firms. In another argument for achieving cleaner technology or to become environmental friendly firms adopt efficient/clean energy sources.

Hansen and Wernerfelt (1989) integrated two sample models of firm performance, one which used economic factors and one which used organizational factors. The economic factor model is based primarily on economic tradition, emphasizing the importance of external market factors in determining firm success. The other model, organizational, is built on the behavioral and sociological paradigm and sees organizational factors and their fit with the environment as the major determinants of success. Their results confirm the importance and independence of both sets of factors in explaining performance, but they also find that organizational factors explain roughly twice as much variance in firm profit rates as economic factors.

Hirschey and Wichern (1984) analyze the consistency, determinants, and uses of accounting and market-value measures of profitability. They find that differences between accounting and market measures of profitability suggest the validity of cautioning remarks concerning the use of accounting data as it has a primarily historical interpretation unlike market-value measures of profitability which are forward looking. In addition, they find that there exists a significant explanatory role for R&D intensity, TV advertising, leverage, and industry growth as determinants of profitability.

Kessides (1990) estimated a specified model of oligopoly. Kessides finds that the existence of firm effects implies inter-firm differences in internal efficiency, and also that such firm-specific efficiency characteristics persist across industries (i.e. if a firm is relatively efficient in market *A*, it is also likely to be relatively efficient in a randomly selected market *B*). The author also finds that the presence of industry effects signifies cross-industry differences in the height of effective entry barriers, the net advantage of size, and various elasticities. Overall, the study clarifies the relationship between market share and profitability.

Brush et *al*. (1999) find that both corporation and industry influence business unit profitability but corporation has the larger influence. The authors use a continuous variable model, as an alternative to the more conventional ANOVA or VCA. This approach estimates the coefficients of corporation and industry effects on business segment returns while explicitly removing the simultaneous effects that might cause inconsistent estimates. In the end, they find a sizable corporate effect on business segment performance, one which appears to be greater than the industry effect.

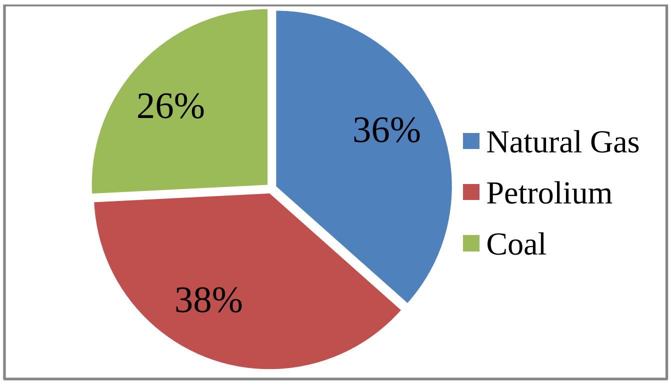
3. Data and variable construction

Based on the literature we attempt to focus on the following objectives in this work. The first objective is to understand whether Indian manufacturing firms can be classified as energy clusters. The second objective of the study is to find out the determinants of profitability of those energy clusters and to compare the determinants between energy clusters. This study used data from the Center for Monitoring Indian Economy (CMIE) PROWESS (Internet database accessed as on February 15, 2011) from 2000-2008. The data structure as provided in CMIE PROWESS on energy statistics of manufacturing firms reports 44 types of energy sources in 7 categories (as primary, secondary etc.). Another dimension of the energy statistics is that there are firms those shift from one energy sources to another in different categories at different times. That means firms reporting energy source-1 as primary energy consumption shifts to source-2. Hence, the energy statistics becomes dynamic in nature. In this attempt we have not considered such firms that shift from one source to another. Hence, firms selected in this study reports same energy source from 2000-2008. Furthermore even firms report 7 categories (out of which there are missing data) of energy sources, we have considered only the primary source of energy consumption in this study. In the primary source of energy consumption the following sources of energy consumption are considered (1) Natural Gas, (2) Petroleum and (3) Coal. Electricity is mostly reported as the secondary sources of energy consumption hence not considered.

According to the basic law of supply and demand, as the cost of energy input rises, ceteris paribus, producer prefers to employ smaller quantity of energy input and substitute cheaper inputs for more expensive energy during the production process (Schurr, 1982; Jorgenson, 1984). Moreover, there is a certain correlation between the changes in energy prices and additional incentives for technological innovations. The relationship between prices of energy sources and technological process is investigated by setting energy patents as a proxy for innovations. Metcalf (2008) uses price indices and prove that at the state level energy use improvement can be achieved by changing the activity to the one with less energy consumption. Besides, they state that in the long run the energy prices are stated to affect energy intensity significantly though with some lingering.

The sample consists of 23,434 firms from 2000-2008. Based on the discussion on consumption of primary energy source the sample is divided in three category (henceforth energy clusters). From figure-1 we can see that 38 percent of firms are in the petroleum clusters, 36 percent firms are in natural gas clusters and rest 26 percent firms are classified in coal clusters. However, the coal cluster firms are larger in size (based on sales) as compared to other classification of energy clusters.

Figure-1: Energy clusters in Indian manufacturing firms (2000-2008)



Source: Authors' own calculation from CMIE database

Empirical study by Cornillie and Fankhauser (2004) focuses more deeply on the energy intensity of the emerging markets. They apply decomposition technique to macro-level data and show that energy intensity is different for regions with different rate of privatization. The group of countries with big share of heavy industry like in the Slovakia, Romania and Poland the level of energy intensity stayed constant for the period of investigation from 1992 to 1998. Cornillie and Fankhauser (2004) claim, that unchanged level of energy intensity is associated with a big share of heavy industry in the economy as well as poor reforms in the sector.

The energy intensity increased during the transition period and Cornillie and Fankhauser (2004) link it to inappropriate process of privatization, which was either postponed or didn't lead to improvements of the production process in industrial sector. Besides, unadjusted to the market level energy tariffs is found to be the case. Remarkable inference made that private ownership without access to the innovation technologies and capital inflows is found to be not enough for energy efficiency improvement. Whereas the ownership structure can be regarded as firm specific and dealt with features of country, the energy prices are mostly set up by the market. Prices of energy sources are one of the most obvious drivers of efficient use of energy inputs.

Another focus is to look for energy consumption patterns and notice that changes in use of energy inputs are strongly correlated with technological development (Rose and Chen, 1991; Murillo-Zamorano, 2005). Therefore, investments into innovations are associated with the efficient energy usage (Groot et *al*., 2001), as investments can result in saving energy while improving technologies. Another way of contribution to energy efficiency through investments is stated in Martinez (2010). He argues that positive result can be achieved through a "demonstration effect" in business environment.

Among the specific firm level characteristics of overall performance of producer are labor and capital productivity and their ratio. These factors are frequently considered as the significant determinants for energy efficiency (Martinez, 2010, Faruq and Yi, 2010). Incidentally, firms that operate in transition and developing countries are likely to be characterized by comparatively low level of wages and therefore gain an advantage by using labor more intensively than other inputs (Oczkowski and Sharma, 2005). At the same time, over-employment of labor can be the cause of inefficiency as proved in Couto and Graham (2009). Nevertheless, in Lachaal et *al*. (2005) the impact of labor costs is found to be not significant for the technical efficiency measure, while the share of skilled labor force is significant and positive. Hence, labor quality could be taken into consideration while analyzing firm's performance with respect to energy recourses.

The hypothesis that the size of company can improve energy efficiency is also tested and proven, for example, in Oczkowski and Sharma (2005). Still, the relation between the company's size and efficiency is not straightforward and can be negative as well as positive (Faruq and Yi, 2010). Hence, the marginal impact of firm's volume on energy efficiency is to be verified in the current research for the sample of transition countries.

Different empirical works that study reasons for energy (in)efficiencies pay attention to the market share or value added to the industry output and find the evidence that it can make a contribution to the explanation of inefficiencies as the factor of market power (Hrovatin and Urib, 2002). It is worth mentioning, that fossil energy resources are characterized by the considerable undesirable outcome (such as CO_2 emissions) and still their share in total energy generation is dominant1, while the role of renewable energy sources is comparatively low, though extended recently. Implementation of environmental conservation regulation influences the incentives for green energy and energy efficiency improvement, therefore the existence of undesirable outcomes as well as the level of environmental regulation is to be incorporated while estimating energy efficiency of a DMU (Zhou et *al*., 2008). Based on the review of different variables those can influence the energy intensity of firm we used the following select variables.

1. Energy intensity

Energy-intensity (proxy for energy efficiency), measured as a summation of all possible sources of energy consumed by the firm in British thermal unit (BTU) as a proportion of sales as energy intensity is an important factor that may influence profitability of the firm. As firm becomes energy efficient it might perform better and hence performance of the firm is assumed to improve. However, initially at short run most of the firms may invest higher in shifting from earlier energy sources and this investment can affect the profitability of firms at short run. Hence the relation between energy and profitability has to be statistically tested based on the sample of firms in consideration.

2. Profit Intensity

Roberts and Tybout (1997) found that the most productive firms find it profitable to incur the sunk costs in export markets. Higher profit earning firms can more easily face competitiveness in the foreign markets. The existence of fixed production costs implies that the firms producing below the zero-profit productivity cut-off would make negative profits if they produce and therefore they choose to exit the industry.

3. Firm Size

Size is the proxy for several effects as observed by Bernard and Jensen (2001). Because of scale economies, larger firms may have lower average and or marginal costs, which would increase the likelihood of performing. A non-linear relationship between firm size and export propensity was found by Kumar and Siddharthan (1994). In the present study, firm size is measured by the natural log of total sales.

4. R&D Intensity

Previous studies provide strong evidence that R&D intensity contributes to firm’s export performance. R&D expenditure has the potential to enhance quality and to generate economy in the production process, and these factors that may increase the likelihood of entering the export market. We assume that the effect of R&D on profitability is likely to be positive.

5. Capital Intensity

Firms can gain a technological advancement not only through their own innovation but also through purchases of new capital or intermediate goods from other sectors. Capital intensity, measured in terms of net fixed asset (i.e. total fixed assets net of accumulated depreciation) as a proportion of sale. Net fixed assets include capital, work-in-progress and revalued assets.

6. Age of the firm

Age of the firm is calculated as the deference between years of the study to year of the incorporation of the firm as reported in the CMIE database. By learning by doing firms may improve the energy intensity and might be profitable as compared to the older firms.

7. MNE affiliation of the firms

There is empirical confirmation that foreign-owned companies tend to be more efficient in energy conservation (Faruq and Yi, 2010) and, at the same time, there is evidence provided in Zelenyuk and Zheka (2006) that reveals a negative correlation between foreign ownership and firm’s efficiency level. In this study we have created dummy capturing the MNE affiliation, where firm belonging to foreign affiliation takes a value 1 and the domestic firms takes a value of 0.

8. Fuel Choice

This study takes three primary sources of fuel choice. To capture the difference between profitability we have defined dummy (2 dummies) for two types of fuel. We assume that choice of fuel can be one of the major determinants of profitability of the firms.

4. Determinants of profitability based on energy clusters

This study is an attempt to understand the difference or similarities between profitability and energy intensity between the energy clusters. This section of the study deals the description of sample that includes the cross tabulation and summery statistics of the variable undertaken. In the first attempt of the study we have classified the firms based on the ownership of firms and tabulated with the energy intensity and profitability of the firms along with other variables. Table-1 gives the result of the sample divided in three energy clusters.

Table-1: Comparison of variables based on energy clusters

	Natural Gas		Petroleum		Coal	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Profitability	1.006	2.446	1.141	2.900	1.324	3.802
Capital Intensity	0.833	1.369	0.058	0.084	0.056	0.079
Energy Intensity	0.059	0.076	0.841	1.298	0.903	1.512
R&D Intensity	0.084	1.295	0.073	0.498	0.081	0.533
Number of Observations	8568		8821		6045	

Based on the result of table-1 we can see that profitability is higher for firms using coal and least for firms using natural gas. Capital intensity is higher for firms using natural gas. Firms are energy efficient those use natural and energy intensive those use coal. R&D intensity is higher for firms those use natural gas as the primary source of energy. Further, we have divided the sample in two groups based on the ownership of firms. Table-2 give the result of this exercise.

Table-2: Classification of variables based on different energy clusters for foreign firms

Foreign firms	Natural Gas		Petroleum		Coal	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Profitability	5.055	8.152	6.347	10.310	7.618	13.142
Capital Intensity	4.405	5.688	0.065	0.089	0.071	0.092
Energy Intensity	0.055	0.081	4.055	4.617	4.559	6.325
R&D Intensity	0.460	1.362	0.379	1.261	0.455	1.485
Number of Observations	141		127		99	

Out of the foreign firms, 141 firms use natural gas, 127 firms use petroleum, 99 firms use coal as the primary source of energy. From the table we can observe that the mean profitability of firms, are higher for the firms using coal as compared to firm using natural gas or petroleum. However, the standard deviation of profitability of firms using coal is higher as compared to the other two categories. The capital intensity of the foreign firms using natural gas is found to be higher as compared to others. The energy intensity and R&D intensity are found to be least for the firms using natural gas and highest for firms using coal. The similar findings for the domestics firms are given in table-3.

Table-3: Classification of variables based on different energy clusters for domestic firms

Domestic firms	Natural Gas		Petroleum		Coal	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Profitability	0.938	2.168	1.065	2.567	1.219	3.344
Capital Intensity	0.773	1.072	0.058	0.084	0.056	0.079
Energy Intensity	0.059	0.076	0.794	1.117	0.842	1.200
R&D Intensity	0.078	1.293	0.068	0.476	0.075	0.500
Number of Observations	8427		8694		5946	

Out of the domestic firms, 8427 firms use natural gas, 8694 firms use petroleum, 5946 firms use coal as the primary source of energy. From the table we can observe that the mean profitability of firms, are higher for the firms using coal as compared to firm using natural gas or petroleum. However, the standard deviation of profitability of firms using coal is higher as compared to the other two categories. The capital intensity of the foreign firms using natural gas is found to be higher as compared to others. The energy intensity and is found to be least for the firms using natural gas and highest for firms using coal. The R&D intensity of the firm is found to be higher for firms using petroleum and least for firms using coal as the primary source of energy. From the two tables we can observer that profitability is higher for firms using coal for both foreign and the domestic firms. Even domestic and foreign firms also report least profitability those use natural gas as the primary source of energy. In both the cases (foreign and domestic) firms using natural gas are capital intensive. Energy intensity is found least for firms using natural gas and more for those using coal.

Table-3: Comparison of variables based on MNE affiliation

	Foreign firms		Domestic firms	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
Profitability	6.193	10.455	1.058	2.663
Capital Intensity	1.734	4.104	0.319	0.737
Energy Intensity	0.538	4.724	2.654	0.988
R&D Intensity	0.431	1.360	0.074	0.872
Number of Observations	367		23067	

The comparison of the foreign and domestic firms, are given in table-3. Apart from the energy clusters table-4 gives the difference between foreign and the domestic firms on different variables. We can observe that foreign firms are more profitable as compared to the domestic firms. Foreign firms are capital intensive. Domestic firms are energy intensive. R&D intensity is higher for foreign firms.

Table-4: Correlation Matrix (full sample)

	Profitability	Energy Intensity	R&D Intensity	Size of Firm	Age of Firm
Profitability	1.000				
Energy Intensity	0.480	1.000			
R&D Intensity	0.151	0.158	1.000		
Size of Firm	0.485	0.418	0.125	1.000	
Age of Firm	0.134	0.260	0.026	0.205	1.000

Table-4 gives the correlation matrix of select variables. From the table we can see that profitability is positively related to energy intensity, R&D intensity, Size and age of the firms. The positive relationship of profitability with other variables for the full sample suggests that an increase in profitability there might be positive crease in other variables. However, as the sample is further divided into three clusters based on the primary source of energy consumption, it will be of interest to observe the correlation for each of the clusters.

Table-5: Correlation Matrix based on the energy clusters

Variables	Energy Intensity		
	Natural Gas (C-1)	Petroleum (C-2)	Coal (C-3)
Profitability	-0.003	0.543	0.599
R&D Intensity	-0.020	0.335	0.408
Size of Firm	-0.093	0.548	0.524
Age of Firm	0.067	0.380	0.331

Note: C-1: Energy cluster 1, classified for firms those use natural gas
C-2: Energy cluster 1, classified for firms those use natural gas
C-3: Energy cluster 1, classified for firms those use natural gas

Table-5 gives the correlation coefficient of energy clusters of sample. As stated earlier we have created three energy clusters. From the table it is evident that cluster-1 explaining the relationship between energy intensity and other variables in considerations are based on the firms using natural gas as primary energy source. This cluster has negative relation with profitability, R&D intensity and size of firms. However, a positive relation is found with age of the firms. All other variables have positively related with energy intensity for the second and the third clusters of firms.

Graph-1: Energy intensity classified based on three energy clusters of firms

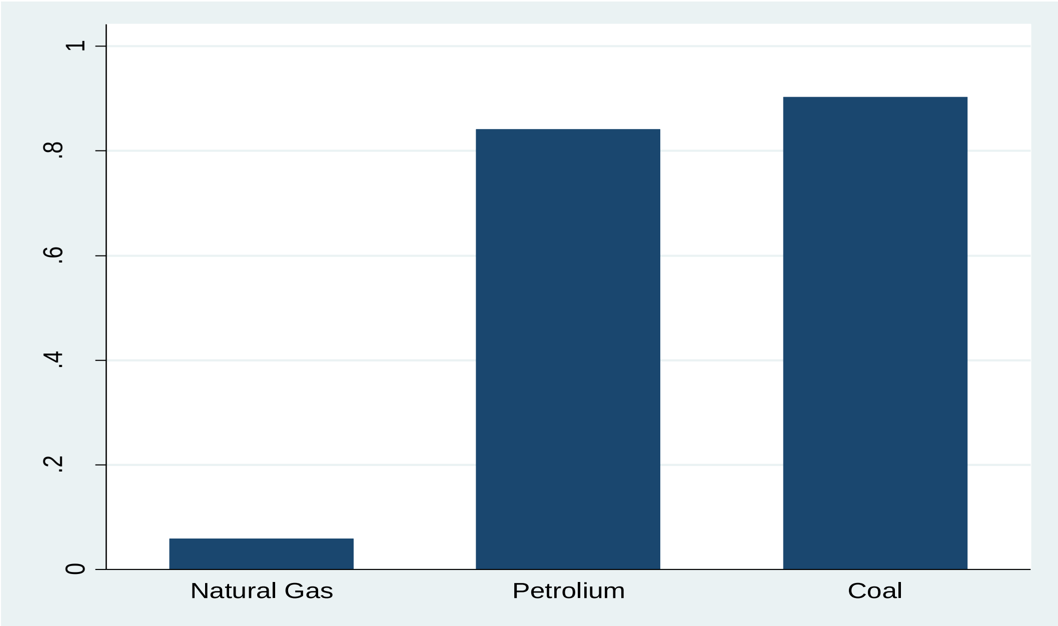


Figure-1 above gives the classification of firms energy intensity based on three energy clusters. From the graph it is evident that firms using natural gas as primary source are energy efficient as compared to those using petroleum and coal. In comparing between petroleum and coal clusters we can observe that coal cluster firms are energy intensive as compared to the petroleum clusters.

This section deals with the econometric specification for attaining the determinants of profitability of energy clusters. Results of correlation analysis and differences in energy intensity in previous section, we can assume that determinants of profitability of firm may differ for the energy clusters. To verify this assumption we have employed panel data econometrics (adopted from structure-conduct-performance). The definition of variable is given in the previous section. Based on the review of similar studies the econometric specification takes the following functional form.

$$P = \alpha_{it} + \beta_1 CI_{it} + \beta_2 EI_{it} + \beta_3 RD_{it} + \beta_4 S_{it} + \beta_5 S^2{}_{it} + \beta_6 A_{it} + \beta_7 M_{it} + \mu_{it} \tag{0.1}$$

Where, P = Profitability of firms, CI = Capital intensity of firms, EI = Energy intensity of firms, RD = Research and Development intensity of firms, S = Size of firms, S^2 = Square of size of firms, A = Age of firms, and M = MNE affiliation of firms

Equation 1.1 is estimated for four times, for the full sample and each of the three energy clusters. Initially we begin with OLS estimates of the equation. Further, panel data econometric is applied for the full sample as well as for the three energy clusters separately. Fixed effect and random effect analysis is carried out and following the result of hausman specification test the estimates of random effect is selected. Different specifications on equation 1.1 are estimated and the results of random effect are selected over OLS estimates.

Table-6: Estimates of full sample

Profitability	Coefficient	Std. Err.	z
Capital Intensity	0.039	0.023	2.690***
Energy Intensity	0.315	0.021	14.820***
R&D Intensity	0.026	0.013	2.030**
Size of Firm	-3.782	0.090	-41.830***
Square of Size	1.524	0.025	61.000***
Age of the Firm	-0.004	0.001	-3.240***
MNE affiliation of firms (Dummy)	-0.366	0.221	-1.660*
Constant	2.452	0.238	10.310***
sigma_u	1.589	Number of observation	23434
sigma_e	1.445	R^2: within	0.24
rho	0.547	R^2 :Between	0.40
Obs per group: Min	1.000	R^2 :Overall	0.47
Obs per group: Avg	4.600	Wald chi^2(9)	9706.58***
Obs per group: Max	9.000		

Note: ***: Statistically significant at 1%, **: Statistically significant at 5%, and *: Statistically significant at 10%

The result of the full sample is given in table-6. The sample size is 23,434. The minimum profitability is found to be 1.0, with average profitability of 4.6 and maximum profitability of 9.0 across the groups. The overall model R^2 found to be 0.47. Wald chi^2 at 9 degree of freedom is found to be highly statistically significant at 1%. Further from the estimates of full sample we can see that capital intensity and energy intensity are positively significant at 1% level indicating that profitability increases when capital intensity and energy intensity increases. R&D intensity is found to be also positively related to profitability of firms indicating that increase in profitability of firm also increases the research and development intensity of firms. We found a nonlinear relationship between profitability and size of firm indicating an inverted U shape relationship. This indicates that bigger firms and smaller size firms are less profitable as compared to the medium sized firms. Further, older firms are found to be less profitable as compared to the younger firms. The MNE affiliated (foreign) are also found to be more profitable (estimate is significant at 10% level and negative, however as this is s dummy; adding to the coefficient value it gives a positive relationship) as compared to the domestic firms. This estimate of full sample based on panel data random effect model gives the basic determinants of profitability of firms where apart from other firm characteristics energy intensity is also considered. As this study is focused to get the determinants of firms based on energy clusters we have modeled similar econometric application for three energy clusters using the same sample. The composition of clusters is given in figure-1.

Table-7: Estimates of Energy cluster (Natural Gas)

Profitability	Coefficient	Std. Err.	z
Capital Intensity	0.291	0.023	12.490***
Energy Intensity	-0.468	0.287	-2.630**
R&D Intensity	0.008	0.013	0.610
Size of Firm	-2.995	0.108	-27.680***
Square of Size	1.204	0.030	40.170***
Age of the Firm	-0.005	0.001	-4.090***
MNE affiliation of firms (Dummy)	-0.294	0.208	-1.420
Constant	2.088	0.227	9.190***
sigma_u	1.193	Number of observations	8568
sigma_e	1.222	R^2: within	0.21
rho	0.488	R^2: between	0.45
Obs per group: Min	1.000	R^2: overall	0.47
Obs per group: Avg	2.100	Wald chi^2(9)	4982.440***
Obs per group: Max	5.000		

Note: ***: Statistically significant at 1%, **: Statistically significant at 5%, and *: Statistically significant at 10%

Table-7 presents the estimates for the natural gas cluster. The sample size is 8,568. The minimum profitability is found to be 1.0, with average profitability of 2.1 and maximum profitability of 5.0 across the groups. The overall model R^2 found to be 0.47. Wald chi^2 at 9 degree of freedom is found to be highly statistically significant at 1%. Further from the estimates of full sample we can see that capital intensity is positively significant at 1% level indicating that profitability increases when capital intensity increases. R&D intensity is found to statistically not significant in this case. We found a nonlinear relationship between profitability and size of firm indicating an inverted U shape relationship. This indicates that bigger firms and smaller size firms are less profitable as compared to the medium sized firms. Further, older firms are found to be less profitable as compared to the younger firms. The MNE affiliated (foreign) are also found to be more profitable (estimate is not significant, however as this is s dummy; adding to the coefficient value it gives a positive relationship) as compared to the domestic firms. The major deviation in the estimates is the coefficient of energy intensity is negatively related to profitability. That suggests that firms those use natural gas are profitable when they are less energy intensive. Hence, using natural gas as a primary source of energy increases the profitability of firms.

Table-8: Estimates of Energy cluster (Petroleum)

Profitability	Coefficient	Std. Err.	z
Capital Intensity	1.088	0.288	3.780***
Energy Intensity	0.262	0.028	9.370***
R&D Intensity	0.383	0.046	8.320***
Size of Firm	3.406	0.115	29.540***
Square of Size	-1.365	0.032	-43.060***
Age of the Firm	-0.004	0.002	-2.900***
MNE affiliation of firms (Dummy)	-0.508	0.240	-1.110
Constant	2.412	0.260	9.260***
sigma_u	1.326	Number of observation	8821
sigma_e	1.464	R^2: within	0.26
rho	0.451	R^2: between	0.46
Obs per group: Min	1.000	R^2: overall	0.49
Obs per group: Avg	2.100	Wald $chi^2(9)$	5743.800***
Obs per group: Max	4.000		

Note: ***: Statistically significant at 1%, **: Statistically significant at 5%, and *: Statistically significant at 10%

The third estimates of econometric specification for the firms using petroleum is given in table-8. The sample size is 8,821. The minimum profitability is found to be 1.0, with average profitability of 2.1 and maximum profitability of 4.0 across the groups. The overall model R^2 found to be 0.49. Wald chi^2 at 9 degree of freedom is found to be highly statistically significant at 1%. Further from the estimates of full sample we can see that capital intensity is positively significant at 1% level indicating that profitability increases when capital intensity increases. R&D intensity is found to be positively significant at 1%, indicating that firms increase R&D intensity when there is an increase in profitability of firms. We found a nonlinear relationship between profitability and size of firm indicating U shape relationship. This indicates that bigger firms and smaller size firms are more profitable as compared to the medium sized firms. Further, older firms are found to be less profitable as compared to the younger firms. The MNE affiliated (foreign) are also found to be more profitable (estimate is not significant, however as this is s dummy; adding to the coefficient value it gives a positive relationship) as compared to the domestic firms. The estimate of energy intensity is similar as the estimates of the full sample. Energy intensity is positively related to profitability. This implies that when profitability of firms increase the energy intensity of firms also increases.

Table-9: Estimates of Energy cluster (Coal)

Profitability	Coefficient	Std. Err.	z
Capital Intensity	0.220	0.447	2.490**
Energy Intensity	0.800	0.035	22.880***
R&D Intensity	-0.131	0.073	-2.120**
Size of Firm	-4.055	0.165	-24.610***
Square of Size	1.453	0.043	33.470***
Age of the Firm	-0.011	0.002	-5.510***
MNE affiliation of firms (Dummy)	0.409	0.314	1.300
Constant	2.191	0.347	6.320***
sigma_u	1.530	Number of observation	6045
sigma_e	1.951	R^2: within	0.24
rho	0.381	R^2: between	0.50
Obs per group: Min	1.000	R^2: overall	0.50
Obs per group: Avg	1.600	Wald $chi^2(9)$	5018.38***
Obs per group: Max	3.000		

Note: ***: Statistically significant at 1%, **: Statistically significant at 5%, and *: Statistically significant at 10%

The fourth estimates of econometric specification for the firms using coal is given in table-9. The sample size is 6,045. The minimum profitability is found to be 1.0, with average profitability of 1.6 and maximum profitability of 3.0 across the groups. The overall model R^2 found to be 0.50. Wald chi^2 at 9 degree of freedom is found to be highly statistically significant at 1%. Further from the estimates of full sample we can see that capital intensity is positively significant at 1% level indicating that profitability increases when capital intensity increases. R&D intensity is found to be negatively significant at 1%, indicating that when profitability of firms increases R&D intensity decreases. We found a nonlinear relationship between profitability and size of firm indicating an inverted U shape relationship. This indicates that bigger firms and smaller size firms are less profitable as compared to the medium sized firms. Further, older firms are found to be less profitable as compared to the younger firms. The MNE affiliated (foreign) are also found to be more profitable (estimate is not significant, however as this is s dummy; adding to the coefficient value it gives a positive relationship) as compared to the domestic firms. The estimate of energy intensity is similar as the estimates of the full sample. Energy intensity is positively related to profitability. This implies that when profitability of firms increase the energy intensity of firms also increases.

5. Conclusion and Policy Suggestions

This paper is an attempt to understand the profitability and energy intensity of Indian manufacturing industries. Determinates of profitability of firms is estimated from full sample as well as based on three energy clusters. This section of the study tries to analyze the similarity or differences of profitability for the full sample as well as for the three energy clusters. From the estimates we can see that capital intensity is positively related to the profitability of firms in all the cases (for full sample as well as for the different energy cluster). This indicates that capital intensive firms are profitable compared to their counterparts. Energy intensity however has related positively for the full sample and for the petroleum and coal clusters of firms. This suggests that firms adopting petroleum and coal are achieving higher profit as well as achieving higher energy intensity (meaning energy intensive). However, in case of firms using natural gas the results suggest a negative relationship between energy intensity and profitability. Hence, for this clusters of firms we can see that while achieving profitability, firms also turn out to be energy efficient. R&D intensity has positive relationship with profitability in case of the full sample as well as for the petroleum cluster, suggesting profitable firms also invest on research and development. In case of the natural gas cluster R&D intensity does not turned out to be a major determinant of profitability. In case of coal cluster we can see a negative relationship between profitability and R&D intensity. This result suggests that firms using coal as primary source of energy invest less on R&D, and increase in R&D intensity reduces their profits. In all the cases size of the firm has found to be nonlinear with profitability. However, the shape of the U curve case is opposite for coal cluster as compared to the full sample and rest of the clusters. Age of the firm has a negative relationship with profitability of firms in all the cases hence this result suggest that older firms are less profitable as compared to the younger ones. Further, the analysis has found that foreign firms are more profitable in all the cases as compared to the domestic firms. Based on the findings of this study we can have the following policy suggestions for better performances of firms in Indian manufacturing industries.

The econometric results indicate that firms using natural gas are becoming energy efficient and profitable simultaneously. In using natural gas there is a possibility that the firms are reducing the CO_2 emissions. In the debate of CDM, climate change shifting from traditional fuel sources to recent fuel source might help in reducing CO_2 emissions specifically for developing country such as India. Fiscal incentives are an effective means to stimulate firms to realize energy conservation projects in their organization. In case of China these fiscal policies included loan payment before tax, three-year product tax and value-added tax exemption for new energy conservation products, import duty reduction and exemption for energy conservation technology and equipment introduction (China's Energy Conservation Policy, 2010). In case of Japan the "Energy Conservation Assistance Law" sets out financial incentives for energy conservation in the form of tax exemptions, low-interest financing and industrial improvement bonds to support approved voluntary efforts by business operators and building owners for energy conservation. Comparable policy schemes are also likely to be adopted for medium and small firms. A possible step could be to reach an agreement between industries and the government, where the sector commits itself to reduce CO_2 emissions (by a certain percentage), and where on the other hand the government commits itself to providing favourable investment conditions.

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