WORKING PAPER 92/2014

ENERGY USE PATTERNS AND FIRM PERFORMANCE: EVIDENCE FROM INDIAN INDUSTRIES

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September 2014

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Price : Rs. 35

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Abstract

This paper is an attempt to understand the relationship between firm performances based on energy use patterns of Indian manufacturing industries. Determinates of firm performances are estimated for the full sample and for the sample of firms using similar energy sources. Econometric analysis of the data collected from the CMIE PROWESS at firm level from 2005-2013 reveals that the determinants of profitability vary across groups. Energy intensity is positively related to profitability for three models except for the firms using natural gas as primary source of energy. R and D intensity is positively related to profitability for the full sample and for the firms using petroleum. For the firms using coal as primary source of energy, less R and D intensive firms are found to be profitable. For all the cases, firm size is found to be nonlinearly related to profitability. In the policy front, shifting primary energy source from coal and petroleum to natural gas; firms can become energy efficient and profitable.

Keywords: *Energy Use, Firm Performance, Indian Manufacturing, Energy Intensity, Profitability*

JEL Codes: *Q4, B23*

ACKNOWLEDGMENT

A recent version of this paper was presented in the India China Relations and the Future of Asia-Pacific Region at the Academy of World Watch (AWW) Shanghai, China in 2014. I am grateful to Prof. Mao Jikang, Zeng Xianglai and the participants of the conference for their valuable comments and suggestions in improving this paper. I am grateful to Prof. K. Narayanan for his valuable suggestions and comments in an earlier draft of this paper. The errors that remain are my own.

INTRODUCTION

Energy efficiency and conservation have long been critical elements in the energy policy dialogue as concerns about global climate change and energy security have intensified. Many advocates and policy makers argue that reducing demand for energy is essential to meet these challenges. 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 at different levels of any economy. 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. 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*"[1]. The distinction is also important in understanding the short versus long-run price elasticity of energy demand, whereby short-run changes may depend principally on

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

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 the society. Market conditions may depart from efficiency if there are market failures, such as environmental externalities or information asymmetry. Aside from such market failures, most economic analysis of energy efficiency has taken cost-minimizing (or utility/profit-maximizing) behavior of households or firms. Some literature however, has focused more closely on the decision-making behavior of economic agents identifying potential "*behavioral failures*" that lead to deviations from cost minimization and motivated at least partly by the results from 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. With this background, this paper tries to form three groups/sample of firms based on energy consumption pattern and tries to link with firm performance. The motivation for such an attempt is to find out the relationship between energy intensity (or energy efficiency) with firm performance. Therefore, the objective is to examine whether firms that consume similar source of energy have similarities in determining firm profitability and hence, performance. The rest of this study is designed as follows. Section-2 reviews select literature on determinants of profitability. Section-3 presents the data sources, econometric framework and construction of variables. Section-4 presents the empirical results and Section-5 concludes with plausible policy implications.

REVIEW OF LITERATURE

Porter (1990) 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 (1990) further found that "*the phenomenon of industry clustering is so pervasive that it appears to be a central feature of advanced national economies*". 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[2] (O'Connell *et. al.*, 1997; Clancy and Twomey, 1997), and further discussion of their broader implications

[2] National Economic and Social Council, Dublin.

can be found in NESC (1998)[3]. 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[4] 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 (1) domestic factor conditions; (2) the nature of domestic demand conditions; (3) the presence of related and supporting industries and (4) firm strategy, structure and rivalry in the industry concerned. In the field of regional studies, many contributions have been put forth in attempts to identify regional and industrial clusters and

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

[4] 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 (O'Malley and Egeraat, 2000).

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 and (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 our case we have assumed that Industries X_1 and X_2 have similar input purchasing patterns. However, the industrial cluster is mostly related to the geographical location of firms hence, we are not defining them as industrial clusters based on the energy choice, but sample of firms consuming similar energy source as one of the inputs.

Hirschey and Wichern (1984) analyze the consistency, determinants, and uses of accounting and market-value measures of profitability. They find that there exists a significant explanatory role for R and D intensity, advertisement, leverage, and industry growth as determinants of profitability. Hansen and Wernerfelt (1989) integrated two sample models of firm performance; one used economic factors and the other with organizational factors. The economic factor model is based primarily on economic tradition, emphasizing the importance of external market factors in determining performance of firm. The other model, organizational, is built on the behavioral paradigm and sees organizational factors and their fit with the environment as the major determinants of performance. 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.

Kessides (1990) found 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). Kessides (1990) also found that presence of industry effects signifies cross-industry differences in the height of effective entry barriers and net advantage of size. Brush *et. al.* (1999) found 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 analysis of variance (ANOVA) or variance components analysis (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. They found a sizable corporate effect on business segment performance, one which appears to be greater than the industry effect. Firm can gain comparative advantage by doing research and development (R and D) as differentiation strategy. This is because R and D activities results new products and/or processes that can gain the competitive advantages as long as it is successfully imitated. 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 the link between R and D and innovation, we assume that firms consume different energy sources based on the technology they adopt for production. For example, firms consume efficient energy sources when they are technological superior than other firms. Hence, performance of firm is related to the choice of energy use and therefore energy intensity.

As the cost of energy input rises, producer prefers to employ smaller quantity of energy inputs and substitute cheaper inputs for more expensive energy during the production (Schurr, 1982; Jorgenson, 1984). The relationship between energy prices and technological process is investigated by setting energy patents as a proxy for innovation. 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 showed that energy intensity is different for regions with different rate of privatization. Cornillie and Fankhauser (2004) claim, that unchanged level of energy intensity is associated with a big share of heavy industry in the economy. Changes in use of energy inputs are also found to be strongly correlated with technological development (Rose and Chen, 1991; Murillo-Zamorano, 2005). Therefore, investments into innovations are associated with the efficient energy use (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 any business environment.

Among the specific firm level characteristics of overall performance of producer are labor and capital productivity and their ratios. These factors are frequently considered as the significant determinants for energy efficiency (Martinez, 2010, Faruq and Yi, 2010). Incidentally, firms those 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 firm size can improve energy efficiency is also tested and proven, for example, in Oczkowski and Sharma (2005). Still, the relation between the firm size and efficiency is not straightforward, and can be either negative or positive (Faruq and Yi, 2010). Different empirical works those study reasons for energy (in)efficiencies pay attention to the market share or value added to the industry output and find 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 fuels are characterized by considerable undesirable outcomes (such as CO_2 emissions) and still their share in total energy generation is dominant (Zhou *et. al.*, 2008).

There are several papers on firm level energy intensity determinants made on India. After Kumar (2003), Sahu and Narayanan (2009 and 2010) and Goldar (2010) have investigated this question. They have not followed the production function approach to examine the role of energy in the production function system. Departing from a reduced form model of the determinants of the energy intensity in industrial firms, they have applied multiple regression analysis to identify the main firm characteristics related to Indian manufacturing energy intensity. A very similar empirical strategy has been undertaken by Papadogonas *et. al.* (2007) to analyze the energy intensity of Greek manufacturing firms. The energy intensity variable is approximated by the fuel and power expanses over total sales ratio. The results strongly indicate that when firms are more capital intensive, they are more energy intensive. Capital intensity seems to be positively related with energy intensity, as well as expenditure on repairs and the age of firms. It can be argued that capital-intensive industries use more energy due to complementarities between both factors. Repairing implies older and worn plant and machinery, which are probably less energy efficient. And past and more energy intensive processes characterize aged firms.

The relationship between the size and the energy consumption is not obvious. Indeed, larger firms have an energy cost advantage only in the low energy consuming industries since Papadogonas *et. al.* (2007). A negative relationship is found in Kumar (2003) and Goldar (2010), while Sahu and Narayanan (2009) first finds an inverted U relationship in cross-sectional study in 2008, and subsequently an U shaped relationship between both variables using a pooled of cross-section data over 9 years (Sahu and Narayanan, 2010). Bigger firms may benefit from economies of scale with decreasing returns in the use of energy, but this effect is not strongly related in those papers. Foreign firms are more energy efficient in Kumar (2003), Sahu and Narayanan (2009) and Goldar (2010) but not in Sahu and Narayanan (2010). The impact of foreign ownership on energy consumption is not obvious regarding those results. It could depend on the country environmental regulation and energy prices. Moreover, it should be interesting to look at the impact of ownership structure on energy efficiency, as differences can emerge between private and public structures. Surprisingly, R and D investment intensity is not related to less energy intensity (Kumar, 2003; Sahu and Narayanan 2009) and even seems to be positively correlated (Sahu and Narayanan, 2010). But, using R and D dummy, Goldar (2010) obtains the expected negative effect on energy intensity. In addition, according to the paper of Papadogonas *et. al.* (2007), the energy intensity is smaller in high technology industries.

Using a different approach compare to the previous set of papers, other authors tries to analyze the most relevant drivers and barriers influencing the firm-level energy intensity. Vanden *et. al.* (2004) uses a structural model of a Cobb-Douglas cost function for the functional form of their estimation to identify drivers determining the decrease in energy intensity of 2500 medium and large-sized Chinese industrial firms. From a cost minimization program, they derive the firm-level factor demand for energy. They have found that changes in relative energy prices and R and D expenditures are the main contributors to the decline in firm-level energy intensity. To a lesser extent, shifts in output across industry, in ownership and region have contributed to the variation in energy intensity. Morikawa (2012) underlies a positive relationship between population density and the energy efficiency consumption in service enterprises. When the population density of the locality doubles, the author estimates a 12 percent decrease of firm-level energy intensity in services sector. He also emphasizes a negative link between capital and labour intensities and energy efficiency.

A large economic literature tries to understand the so-called "energy-efficiency gap". This term refers to the difference between cost-effective energy efficient investments and the level of such investments actually implemented. Related academic papers disentangle the barriers explaining this gap between market failures, market barriers (DeCanio (1988), Brown (2001)) and, more recently, management practices (Backlund *et. al.* (2012), Martin *et. al.* (2012)). Market failures refer to all the situations violating the neoclassical assumptions (rationality, perfect information and no transaction costs). The market barriers to energy-efficient use concern three main problems: the low priority of energy issues, incomplete markets for energy efficient products and the capital market obstacles. Barriers related to access to capital have been stressed as very critical. Energy efficiency technologies and investments need funds to be implemented. But, lack of capital limit funds to be devoted to energy efficiency measures, which are furthermore considered as low on priority list (DeCanio, 1998). The paper of Trianni and Cagno (2012) also highlights this kind of evidence departing from an investigation of Italian small and medium sized firms. They find, after controlling for some firm's characteristics, that access to finance is the more severe obstacle to energy efficiency investments. In over than 128 interviewed manufacturing enterprises, the lack of capital is perceived as the main constraint to energy efficiency measures. Finally, recent empirical papers emphasize the crucial role of organizational structures and management best practices on enhancing firm-level energy efficiency. Using information about firm's managerial quality and census data containing energy consumption expenditures of UK establishments, Bloom *et. al.* (2010) find that better-managed plants are significantly less energy intensive. This relationship seems to be related to the firm's productivity. Better managed firms adopt modern and energy-efficient measures, which increase their productivity. The authors estimate that an improvement from the bottom to the top quartile of their management variable is associated with a 17 percent increase in energy efficiency.

The paper of Martin *et. al.* (2012) provides further evidence about the negative link between management practices and energy intensity. They argue that better management is also related to the firm's energy efficiency innovations (process and product). Moreover, they provide another finding about the role played by organizational structure. Firms where energy issues are devoted to the environmental manager (when such a function exists) have more climate friendly management practices. Bloom *et. al.* (2010) and Martin *et. al.* (2012) employ two different proxies for energy intensity. Both energy cost over total sales and energy cost over total variable cost are used in their regressions. In order to ensure for the robustness of our results we also run our analysis with both variables. In an attempt to relate technology energy intensity, Sahu and Narayanan (2013) computed the Carbon Dioxide (CO2) emission from fossil fuel consumption for firms in Indian manufacturing sector from 2000 to 2011 by adopting the IPCC Reference Approach. Their results indicate that there are differences in firm-level emission intensity and they, in turn, are systematically related to identifiable firm specific characteristics. They found size, age, energy intensity and technology intensity as the major determinants of CO_2 emission of Indian manufacturing firms.

The industrial energy use reached 150 million tones of oil equivalent (Mtoe) in 2007 accounting for 38 percent of the country's final energy used. From a global perspective, India is the fourth- largest industrial energy consumer with a 5 percent 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 percent of worldwide carbon dioxide (CO_2) emissions. In 2010, the 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. The International Energy Agency (IEA) analysis shows that industry will need to reduce its current direct emissions by about 24 percent of 2010 levels if it is to halve global emissions from 2010 levels by 2050. The five most energy-intensive industrial sectors (iron and steel, cement, chemicals and petrochemicals, pulp and paper, and aluminum) accounted for 56 percent of India's industrial energy consumption in 2010. In Indian economy, these five sectors accounted for 66 percent of industrial energy consumption. It is evidence that industrial clusters are based on a certain geographical locations and mostly they are characterized as the small and medium scale industries. In the process of integration (horizontal or vertical) firms also form clusters. Firms also form cluster on the resource availability for production. As the motive of any firm is either profit seeking or growth at long run resource availability becomes one of the major determinants of firm performance. Selection of certain energy source(s) is directly related to the technology and machinery installed or the R and D capability of any firm. In this context, choice of energy source for production and performance of firms are important and needs special attention.

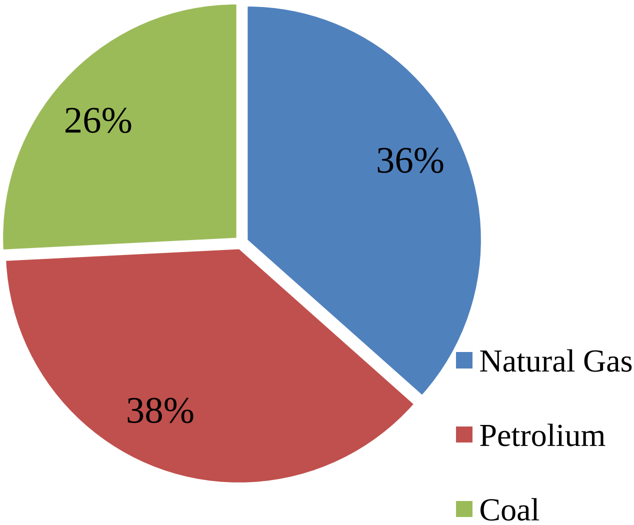
To summarize, energy intensity is related to some firm characteristics, such as input composition, firm's size and age, the ownership structure and the population density. Moreover, several economic factors such as financial constraints, management practices or other market barriers seem to be important drivers of firm-level energy efficiency. From the review we can conclude that apart from input choices, firm characteristics matter for improving energy efficiency and performance. With these motivations, we focus on analyzing the determinants of profitability of firms consuming different energy sources for Indian manufacturing.

DATA SOURCE, MODEL AND CONSTRUCTION OF VARIABLES

We use data from the Center for Monitoring Indian Economy (CMIE[5]) PROWESS (Internet database accessed as on February 15, 2014) from 2005-2013. According to the database, Indian manufacturing firms uses 44 types of energy sources which are classified in 7 categories (as primary, secondary etc.). There is also evidence that firms shift in choice of fuel in two different time periods. Therefore, choice of energy source is dynamic at firm level when we consider energy mix. For the empirical analysis we have selected firms those are consistent in choice of energy input from 2005-2013. This study is restricted to primary source of energy consumption those include (1) natural gas, (2) petroleum and (3) coal. The sample consists of 23,434 firms from 2005-2013. The sample is divided into three categories based on the primary energy demand (henceforth energy groups). From Figure 1 we can observe that 38 per cent of sample are in petroleum group, 36 per cent in natural gas group and rest 26 per cent in coal group. However, more importantly, firms in the coal group are larger in size (based on sales) as compared to other classifications.

[5] Since a large number of SMEs do not report/appear in the CMIE database the analysis is restricted for the sample of large firms listed in CMIE database.

Figure 1: Distribution of Firms in Each Energy Groups in the Sample



Source: Authors' calculation from CMIE PROWESS database.

In an earlier attempt, Sahu and Narayanan (2011), Goldar (2010) estimated determinants of energy intensity for sample firms in Indian manufacturing industries. Analyzing growth and profit behavior of large scale Indian firms Siddharthan *et. al.* (1994) have estimated determinants of profitability. Above studies use the structure conduct performance theory in determining factors for energy intensity and profitability. Based on the above studies the econometric specification takes the following functional form.

$$P_{it} = \alpha_{it} + \beta_1 CI_{it} + \beta_2 EI_{it} + \beta_3 RD_{it} + \beta_4 S_{it} + \beta_5 S^2{}_{it} + \beta_6 A_{it} + \beta_7 M_{it} + \mu_{it} \quad (1)$$

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

Equation (1) is estimated four times, for the full sample and each of energy groups. Panel data econometric is applied for the full sample as well as for the three energy groups separately. Fixed effects and Random effects models are estimated and based on the result of Housman (1978) statistics Random effects are preferred over fixed effects. Definitions of variables used in equation 1 are as follows: Energy-intensity (proxy for energy efficiency), measured as a summation of all possible sources of energy consumed by a firm in British Thermal Unit (BTU) as a proportion of net sales. As a firm becomes energy efficient, its performance is likely to improve. Roberts and Tryout (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. We define profitability as ratio of net profit to net sales. Because of scale economies, larger firms may have lower average and or marginal costs, which would increase the likelihood of performing. Firm size is measured by the natural log of net sales. R and 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 and hence perform better. We define R and D intensity as the ratio of R and D expenditure to net sales. 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 net sale.

Net fixed assets include capital, work-in-progress and revalued assets. 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. Through learning by doing firms may improve the energy efficiency and hence become profitable as compared to the younger firms. There is empirical evidence 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 Selenium and Shea (2006) that reveals a negative correlation between foreign ownership and firm's efficiency level. MNE affiliation of firm is defined as a dummy where firm belonging to foreign affiliation takes the value 1 and the domestic firms takes the value 0. This study takes three primary sources of fuel choice.

DETERMINANTS OF PROFITABILITY FOR FULL SAMPLE AND THREE ENERGY GROUPS

This section deals with sample description and summery statistics. First, we divide sample based on multinational enterprises (MNE) affiliations. Energy intensity and profitability are calculated for both the sub-samples and for the full sample as well. Table 1 gives the results where firm characteristics are compared between the MNE and domestic firms.

Firms consuming coal as the primary energy input are the most profitable ones, whereas firms consuming natural gas are the less profitable firms. Capital intensity is higher for firms using natural gas. Firms become energy efficient when they consume natural gas and energy intensive when they use coal as primary energy source. R and D intensity is higher for firms using natural gas. From the MNE affiliated firms, 141 use natural gas, 127 use petroleum, and 99 use coal as the primary source of energy. The mean profitability of MNE affiliated firms found to be higher for those using coal when compared to other energy sources. Capital intensity of the MNE affiliated firms that use natural gas is higher as compared to others. Energy intensity and R and D intensity are found to be least for firms using natural gas and highest for firms using coal. The above results are also similar for the domestic firms. From the sample of domestic firms; 8427 use natural gas, 8694 use petroleum, and 5946 use coal as primary source of energy. The mean profitability is higher for firms using coal as compared to firm using natural gas or petroleum for the domestic ones. The capital intensity of domestic firms using natural gas is found to be higher as compared to others. Firms using natural gas are more energy efficient. R and D intensity is found higher for firms using petroleum and least for firms using coal as the primary source of energy.

From the two tables we can observe that profitability is higher for firms using coal for both MNE affiliated and domestic firms. Even domestic and MNE affiliated firms also report least profitability those use natural gas as primary source of energy. In both the cases (MNE affiliated and domestic) firms using natural gas, are capital intensive. Firms are categorized as energy efficient when they use natural gas and energy intensive when they use coal as primary source of energy. The comparison of firm characteristics for MNE affiliated and domestic firms are presented in Table 2. We can observe that MNE affiliated firms are profitable as compared to domestic firms, however the standard deviation for profitability among MNE affiliated as higher compared to the domestic ones. MNE affiliated firms are also capital intensive. Whereas domestic firms are energy intensive and R and D intensity is higher for MNE affiliated firms.

Table 1: Comparison of Indicators for Full Sample, MNE Affiliated and Domestic Firms in Three Energy Groups

Variables	Natural Gas Group		Petroleum Group		Coal Group	
	Mean	SD	Mean	SD	Mean	SD
Full Sample						
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 and D Intensity	0.084	1.295	0.073	0.498	0.081	0.533
Number of Observations	8568		8821		6045	
MNE Affiliated Firms						
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 and D Intensity	0.460	1.362	0.379	1.261	0.455	1.485
Number of Observations	141		127		99	
Domestic Firms						
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 and D Intensity	0.078	1.293	0.068	0.476	0.075	0.500
Number of Observations	8427		8694		5946	

Note: SD- Standard Deviation.
Source: Authors' calculation from CMIE PROWESS database.

Table 2: Comparison of Variables for MNE Affiliated and Domestic Firms (Full Sample)

Variables	MNE Affiliated Firms		Domestic firms	
	Mean	SD	Mean	SD
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 and D Intensity	0.431	1.360	0.074	0.872
Number of Observations	367		23067	

Note: SD- Standard Deviation.
Source: Authors' calculation from CMIE PROWESS database.

Table 3 presents the correlation matrix of select variables for the full sample. From the results we can observe that profitability is positively related to energy intensity, R and D intensity, size and age of the firms. The positive relationship of profitability suggests that increase in profitability there might be positive change for those variables. However, as the sample is further divided into three groups based on the primary source of energy consumption, it will be interesting to observe the correlation between energy intensity and firm characteristics for each of the groups. Table 4 gives the correlation coefficient of energy groups. From the table it is evident that firms consuming natural gas as primary energy source have negative relation with profitability, R and D intensity and firm size. However, positive relation is found with age of the firms. However, for the two other energy groups the result is similar to the full sample result and positively related to energy intensity.

Table 3: Correlation Matrix (Full Sample)

Variables	Profitability	Energy Intensity	R and D Intensity	Size of Firm	Age of Firm
Profitability	1.000				
Energy Intensity	0.480	1.000			
R and 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

Source: Authors' calculation from CMIE PROWESS database.

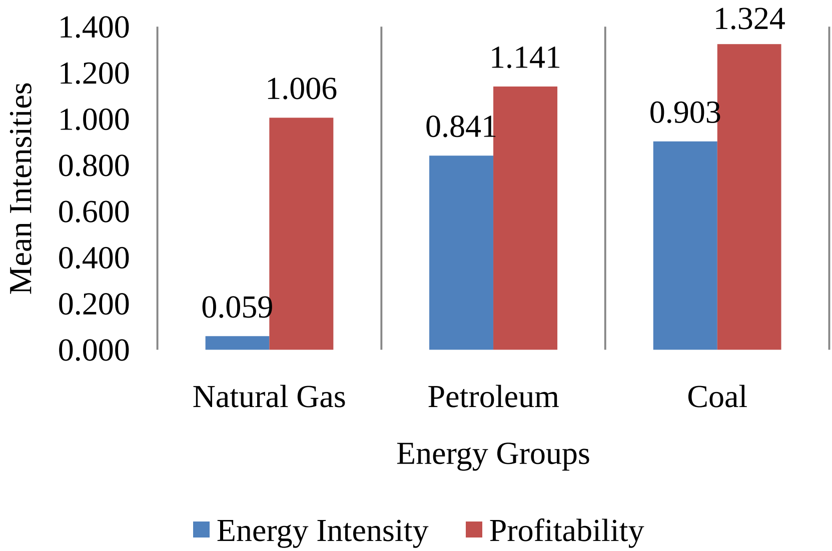
Table 4: Correlation between Energy Intensity and Firm Characteristics in Energy Groups

Variables	Energy intensity of Natural Gas Group	Energy intensity of Petroleum Group	Energy intensity of Coal Group
Profitability	-0.003	0.543	0.599
R and 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

Source: Authors' calculation from CMIE PROWESS database.

Figure 2 presents mean energy intensity and profitability for the three energy groups. 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 group, we can observe that firms in coal group are energy intensive as compared to petroleum group. In case of profitability firms that use coal are highly profitable as compared to two other group and natural gas using firms are least profitable. Cross tabulation and correlation matrix try to depict the relationship of energy intensity and other firm characteristics with profitability for the full sample as well as for three energy groups.

Figure 2: Mean Energy Intensity and Profitability for Three Energy Groups



Source: Authors' calculation from CMIE PROWESS database.

Further, we have estimated the determinants of profitability for energy group and full sample where we assume that determinants of profitability of firm differ for three energy groups. The result of the full sample is given in Table 5. The sample size for analysis is 23,434. The minimum profitability is found to be 1.0 percent, with average profitability of 4.6 percent and maximum profitability of 9.0 percent across the groups. The overall model R^2 is found to be 0.47. Wald chi^2 at 9 degrees of freedom is found to be highly statistically significant at 1 percent. Equation (1) is estimated using both Fixed and Random effects model. Housman test statistics of 0.98 rejects the efficiency of fixed effects estimates and hence, the Random effects model is selected. The robustness of random effects model is evident from the LM Chi^2 test (significant at 1 percent level).

From the estimates given in Table 5, we can observe that capital and energy intensity are positively related to profitability and significant at 1 percent level indicating that with increase in capital and energy intensity, profitability of firms increases. Meaning firms that are capital and energy intensives are profitable. Energy intensity represents all forms of energy use at firm level and therefore can be a catch all factors. R and D intensity is also found to be positively related and significant to profitability, indicating increase in R and D intensity increases the firm profitability. We found a nonlinear relationship between profitability and firm size indicating U shaped relationship. This indicates that bigger and smaller sized firms are more profitable compared to the medium sized firms. Further, older firms are found to be less profitable as compared to the younger firms. The MNE affiliated firms are found to be more profitable (estimate for MNE affiliation is significant at 10 percent level and negative, however as this variable is constructed as a dummy; adding to the coefficient of constant it gives a positive relationship) as compared to the domestic firms. This estimate of full sample based on panel data random effects model gives the determinants of profitability of firms. As we aim to find the determinants of profitability of firms for the three energy groups, we have also modeled similar econometric applications in determining factors affecting profitability for the energy groups.

Table 6 presents the estimates for the three sub-samples of energy groups. For natural gas group (model 2, second column in Table 6), the sample size is 8,568. The minimum profitability in this group is found to be 1.0 percent, with average profitability of 2.1 percent and maximum profitability of 5.0 percent across groups. The overall model R^2 is found to be 0.47. Wald chi^2 at 9 degrees of freedom is highly statistically significant at 1 percent. From the estimates of natural gas groups we can observe that capital intensity is positive and significant at 1 percent with profitability, indicating increase in capital intensity increases profitability of firms. Or capital intensive firms are profitable. The result for capital intensity is similar to the estimates of full sample.

Table 5: Estimates of Full Sample

Independent Variables	Coefficient	Standard Error	z statistics
Capital Intensity	0.039	0.023	2.690***
Energy Intensity	0.315	0.021	14.820***
R and D Intensity	0.026	0.013	2.030**
Firm Size	-3.782	0.090	-41.830***
Square of Firm 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	1.589	Number of observations	23434
sigma	1.445	R^2: Within	0.24
rho	0.547	R^2 : Between	0.40
Obis per group: Min	1.000	R^2 : Overall	0.47
Obis per group: Avgas	4.600	Wald $chi^2(9)$	9706.58***
Obis per group: Max	9.000	LM Chi^2	21733.40***
Housman Chi^2	0.98		

Note: ***: Statistically significant at 1 percent, **: Statistically significant at 5 percent, and *: Statistically significant at 10 percent. Dependent Variable: Profitability.
Source: Authors' calculation from CMIE PROWESS database.

Table 6: Determinants of Profitability for Natural Gas, Petroleum and Coal Groups

Model	**Model 2: Natural Gas Group**			**Model 3: Petroleum Group**			**Model 4: Coal Group**		
Independent Variables	Coefficient	S.E.	z Statistics	Coefficient	S.E.	z Statistics	Coefficient	S.E.	z Statistics
Capital Intensity	0.291	0.023	12.490***	1.088	0.288	3.780***	0.220	0.447	2.490**
Energy Intensity	-0.468	0.287	-2.630**	0.262	0.028	9.370***	0.800	0.035	22.880***
R and D Intensity	0.008	0.013	0.610	0.383	0.046	8.320***	-0.131	0.073	-2.120**
Firm Size	-2.995	0.108	-27.680***	3.406	0.115	29.540***	-4.055	0.165	-24.610***
Square of Firm Size	1.204	0.030	40.170***	-1.365	0.032	-43.060***	1.453	0.043	33.470***
Age of the Firm	-0.005	0.001	-4.090***	-0.004	0.002	-2.900***	-0.011	0.002	-5.510***
MNE Affiliation (Dummy)	-0.294	0.208	-1.420	-0.508	0.240	-1.110	0.409	0.314	1.300
Constant	2.088	0.227	9.190***	2.412	0.260	9.260***	2.191	0.347	6.320***
sigma	1.193			1.326			1.530		
sigma	1.222			1.464			1.951		
R^2: within	0.21			0.26			0.24		
R^2: between	0.45			0.46			0.50		
R^2: overall	0.47			0.49			0.50		
rho	0.488			0.451			0.381		
Obis per group: Min	1.000			1.000			1.000		
Obis per group: Avgas	2.100			2.100			1.600		
Obis per group: Max	5.000			4.000			3.000		
Wald $Chi^2(9)$	4982.440***			5743.800***			5018.38***		
Number of observations	8568			8821			6045		
Housman Chi^2	1.28			1.08			1.21		
LM Chi^2	1753.23***			2133.34***			1736.12***		

Note: ***: Statistically significant at 1 percent, **: Statistically significant at 5 percent, and *: Statistically significant at 10 percent, S.E.: Standard Error. Dependent Variable: Profitability.

Source: Authors' calculation from CMIE PROWESS database.

However the relationship of energy intensity to profitability is negative and significant at 1 percent, which is a deviation from the full sample estimates. This suggests that firms that use natural gas are profitable and energy efficient. In other words increase in energy efficiencies makes firms profitable. Hence, shifting to natural gas as primary energy source could be beneficial for firms in achieving profitability and energy efficiency. Further, we found a nonlinear relationship between profitability and size of firm indicating U shaped relationship. This indicates that bigger and smaller sized firms are more profitable as compared to the medium sized firms. This result is similar to the result of the full sample estimates. Further, older firms are found to be less profitable as compared to the younger firms.

In case of petroleum group (model 3, third column in Table 6), the sample size is 8,821. The minimum profitability is found to be 1.0 percent, with average profitability of 2.1 percent and maximum profitability of 4.0 percent across the groups. The overall model R^2 is found to be 0.49. Wald chi^2 at 9 degrees of freedom is found to be highly statistically significant at 1 percent. From the estimates of petroleum groups, we can find that capital intensity is positively significant at 1 percent level indicating that when capital intensity increases the profitability of firms also increases. This result is similar to the results of the full sample as well as for the natural gas sample. R and D intensity is found to be positively significant at 1 percent, indicating that increase in R and D intensity also increase in profitability of firms. We found a nonlinear relationship between profitability and size of firm indicating an inverted U shaped relationship. This indicates that bigger firms and smaller size firms are less profitable as compared to the medium sized firms. However, for the full and the natural gas groups we found an opposite relationship between firm size and profitability. That means firm size matters till a threshold level to achieve profitability and beyond the threshold level profitability declines for firms in petroleum groups. Further, older firms are found to be less profitable as compared to the younger firm which is similar to the estimates of the full and the coal groups. The estimate of energy intensity is similar as the estimates of the full sample. Energy intensity is positively related to profitability. This implies energy intensive firms in these groups are profitable.

In case of coal group (model 3, fourth column in Table 6), the sample size is 6,045. The minimum profitability is found to be 1.0 percent, with average profitability of 1.6 percent and maximum profitability of 3.0 percent across the groups. The overall model R^2 is found to be 0.50. Wald chi^2 at 9 degrees of freedom is found to be highly statistically significant at 1 percent. From the estimates of full sample we can observe that capital intensity is positively significant at 1 percent level indicating that profitability increases when capital intensity increases which is similar to the results of the full sample as well as the natural gas and petroleum group sample. R and D intensity is found to be negatively significant at 1 percent, firms those are having less R and D intensity are also profitable. We found a nonlinear relationship between profitability and size of firm indicating U shaped 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 results of firm size and age of firms are similar to the full and the natural gas group. The estimate of energy intensity is also similar to the estimates of the full sample that is positively related to profitability. This implies that energy intensive firms in coal groups are profitable.

CONCLUSION AND POLICY IMPLICATIONS

This paper is an attempt to understand relationship between the profitability and energy intensity of Indian manufacturing industries in general and for three energy groups in particular. Determinates of profitability of firms is estimated for full sample and for three energy groups. Econometric analysis of the data collected from the CMIE

PROWESS at firm level reveals that the relationship between profitability and energy intensity vary across groups. Energy intensity is positively related to profitability for all the three models except for the natural gas group. This suggests that firms adopting petroleum and coal as the primary energy sources are both energy intensive and profitable. However, firms in natural gas group are energy efficient and profitable. R and D intensity is positively related to profitability for full sample and petroleum group, suggesting that firms with higher R and D intensity are profitable. However, for the coal group less R and D intensive firms are also are found to be profitable. For all the cases, firm size is found to be nonlinearly related to profitability. Other than petroleum group in all other cases medium sized firms are less profitable. Age of the firm has a negative relationship with profitability of firms in all the cases implying younger firms are more profitable.

Further, capital intensity is positively related to the profitability in all the cases indicating capital intensive firms are profitable. Most of the earlier literatures dealing with determinants of inter-firm differences in profitability have only examined the role of firm size, age, and R and D and capital intensity. No specific analysis has been carried out in examining the role of energy intensity (or efficiency) in determining profitability of firms in Indian manufacturing. This paper is an attempt to fill this gap in looking at the role of energy intensity in determining profitability. Moreover, since there are large scale differences in not only energy intensity but also firm size, R and D and capital intensity across different energy groups, this paper documents those differences as well. The findings do indicate variable role of energy as well as other firm specific characteristics in determining profitability.

Based on the findings above, we may have these following policy suggestions to increase the firm performance along with being energy efficient for the Indian manufacturing industries. The econometric results indicate that firms using natural gas are becoming energy efficient as well as profitable. Hence, shifting from coal or petroleum to natural gas as the primary energy source, firms can become energy efficient and profitable. In addition, using natural gas there is a possibility of reducing CO_2 emissions from the fuel use. In the debate of Clean Development Mechanism and issues in 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. Higher research and development and technological advancement in production process as well as for product development will also help Indian manufacturing firms in achieving higher profitability and energy efficiency. Fiscal incentives are effective means to stimulate firms to realize energy conservation projects in their organization. A possible step could be to reach an agreement between industries and the Government, where the sector commits itself to reduce CO_2 emissions and on the other hand the Government commits itself to provide favorable investment conditions for adopting cleaner fuels.

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