Labour and Energy Intensity: A Study of Pulp & Paper Industries in India

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Abstract

This paper is an attempt to understand the relationship between the labour and energy intensity for firms drawn from pulp and paper industries in Indian manufacturing. Pulp and paper industry accounts for a considerable share of the industrial enterprises, production, employment and exports in the Indian economy and, one of the energy intensive industries in Indian manufacturing. This paper uses data from the Center for Monitoring Indian Economy (CMIE), at the unit level for the period 1992 to 2000. Analysis from the cross-tabulation of energy and labour intensity of the firms in this industry suggests that energy intensity is higher for the BSE listed firms however, the labour intensity is found higher for the non-listed firms. Further, energy and labour intensity is higher for the domestic when compared to foreign firms. The econometric analysis of the energy intensity and other firm specific characteristics suggests that labour intensity has a negative relationship with energy intensity, suggesting a substitution possibility between energy and labour for the pulp and paper industries in India. Further we found that higher labour intensive firms are more energy intensive. Profitability of the firm emerged negatively related to energy intensity. The listed firms are found to be more energy intensives as compared to the non-listed firms. More importantly, technology import is found negatively related to the energy intensity of the firms, suggesting that firms in these industries could be using technology import and knowledge sharing from their foreign collaborators for savings on energy.

Keywords: Energy Intensity, Labour Intensity, Indian Manufacturing Industries, Pulp & Paper Industries, Panel Data

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1.1 Introduction

The empirical research relating human capital and labour productivity, has widely shown that informal interactions developing inside the firm's workforce improve the diffusion of information and foster the creation of a stock of knowledge which constitutes an asset for future production processes. A number of recent studies on the determinants of economic growth highlight the importance of total factor productivity, such as Easterly and Levine (2000), who explain that the salient features of countries growth experience cannot be explained by factor accumulation alone. Several factors impact on changes in total factor productivity, including changes in technology and externalities, changes in the sectoral composition of production, and organizational changes such as the adoption of lower cost production methods. Recently there has been increasing interest in the environmental impacts of international trade, especially in emissions embodied in trade. Instigated by globally increasing attention on climate change, energy and carbon dioxide (CO_2) emissions embodied in trade has been investigated in particular, primarily at national, but also bilateral and global levels.

The developed as well as the developing countries are more worried regarding the climate change as well the energy demand issues. In December 1997, in Kyoto, the Annex I (industrialized) countries assumed differential commitments to reduce their greenhouse gas (GHG) emissions to an average of 5.2% below their 1990 emissions rates by approximately 2010 (UNFCCC, 1997). Earlier analyses of GHG emissions have shown, however, that it will not be possible to stabilize atmospheric CO_2 concentration levels if industrialized countries alone limit their emissions (Lashof and Tirpak, 1990). While the developing countries' (i.e. non-OECD countries excluding the former Soviet Union, Central and Eastern Europe) share

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of world fossil fuel consumption is presently small, rapid population and economic growth will result in a substantial increase of their share in the first part of the 21st century. From 15% of world energy demand in 1971, the developing countries are expected to account for 40% of this demand by 2010 if present trends continue (IEA, 1994). Even with aggressive policies to promote energy efficiency, developing countries' energy demand is likely to grow 5 to 10 fold over the next 30-40 years, resulting in a 3 fold increase in world energy demand. Consistent with a rapid growth in energy use, carbon emissions from the developing world increased at an annual rate of 4.4% between 1990 and 1996 (Sathaye and Ravindranath, 1998). Growth rates for the larger developing economies were same or higher at 4.4% for China, 6.7% for India and 10.3% for South Korea.

The participation of developing countries is essential for attaining the goal of global carbon abatement. Many developing countries however, are demonstrably concerned that aggressive carbon abatement efforts on their part may have adverse effects on their economic growth and efforts to improve living standards. Hence, there is a need for enhanced analysis of their long-run energy use, carbon emission and technological trends to determine how the joint goals of economic improvement and climate protection might best be achieved. Numerous integrated assessment models (IAMs) have been developed to analyze the economic impacts of climate change (Weyant et al., 1996). Most such models show that GDP growth rates may be reduced if policies such as carbon taxes are implemented to reduce emissions. At the same time however, most IAMs have not incorporated regional or country-specific disaggregation. In addition, the IAM’s canonical treatment of technological trends related to energy efficiency has been in terms of reduced form parameters (characteristically referred to as "autonomous energy efficiency improvement" parameters) that do not allow for refined analysis of the relations among energy use, economic growth, and policies. Consequently, an important frontier for IAM research is the simultaneous pursuit of developing country-specific analysis combined with more detailed investigation of technology, energy and productivity trends.

Following the oil shocks of the 1970s a large body of econometric work on energy use emerged (Roy, 1992, and Sarkar & Roy, 1995). These works focused primarily on understanding short-run patterns, particularly those of inter-fuel and inter-input substitution. However, for purposes of carbon policy, long-run trends are equally or more important. In particular, long-run patterns of technological change affecting the use of inputs, including energy, may have major consequences for estimates of the costs and benefits of various carbon policies. This fact has been the focus of considerable attention (and controversy) among energy analysts, who have focused on the magnitude and interpretation of "autonomous" trends of declining energy intensity. In the context of human capital and increasing attention on climate change, very few studies have focused on studying human capital and energy consumption for any industries. Therefore, this paper is an attempt to study this aspect. Labour intensity is considered as a proxy for the human capital, and energy intensity is considered as a factor showing how efficiently a firm is using the energy for its production. This study addresses the following questions:

1. Whether higher labour intensive firms are also higher energy intensive?
2. Whether labour and energy are substitutes?

In addressing the above two objectives, this paper uses data from the Center for Monitoring Indian Economy (CMIE), unit level data from the period 1992 to 2000. The outline of the paper is as follows. The next section of the paper presents a brief review of literature. This section is further classified in two subsections. The first subsection deals with studies dealing with productivity analysis and the second subsection deals with the studies on substitution possibilities between energy, capital and labour. Section three of the paper focuses on the Pulp and Paper industries in India with a historical introduction to the industries and the current trend. Section four deals with the analysis of the data and the empirical findings and the last section of the study, concludes the findings.

1.2 Review of Literature

There are a wide range of studies that analyze trends in total factor productivity growth in Indian industries. In addition most of the researchers have also focused on labour issues relating it to the capital and other factors of production for industrial sector in India. In addition to that a wide range of study also focuses on the substitution possibility between energy, capital and labour for any industry context. The debate is based on the analyses whether energy-capital, energy-labour are substitutes or complementary to each other. This section of the paper tries to review the work done so far on above issues and few other studies focusing on energy and climate related issues. For a better understanding, we have divided this section in two subsections. The first subsection deals with the productivity studies in general and for the Indian contest in particular. Consequently studies focusing on pulp and paper industries are also narrated. The second subsection of the study focuses on the substitution or complementarily among energy, capital and labour.

1.2.1 Studies on Productivity

In recent decades, several methodologies have been developed and applied to examine changes in productivity and technological development. A number of studies have estimated total factor productivity for the Indian economy using statistical indices within the standard growth accounting framework (Mongia and Sathaye, 1998, 1998a, Ahluwalia, 1991). Ahluwalia (1991) attempts to analyses the long-term trends in total productivity and partial productivities in the organised manufacturing sector in India over the period from 1959-60 to 1985-86. The role of factor input growth and total factor productivity growth in accounting for the growth in value added is also explored. The analysis conducted at a detailed level of disaggregation for 63 constituent industry groups at the three-digit level of as well as for the four use-based sectors of manufacturing, i.e., intermediate goods, consumer non-durables, consumer durables and capital goods. For as many as 36 industries accounting for over 50 per cent of the total value added in manufacturing in 1970-71, however, the contribution of total factor productivity growth was negative. The more important among these industries were food manufacturing except sugar, iron and steel and non-ferious metals. For almost all of the 63 industries, capital intensity showed a strong and significant positive growth for fewer industries accounting for 64 per cent of the valued added in manufacturing. There were a few industries which even experienced a decline in labour productivity.

A study by Pradhan and Barik (1999) attempts to open a solution channel by considering TFPG as a result of interaction between economies of scale and technical change. Thus, it seeks to lay emphasis on proper management of scale economies and technical change for producing a desired TFPG. For that purpose, estimation of TFPG is carried out with the help of translog cost function, which gives information on these two components simultaneously. The empirical findings of the exercise on data of aggregate manufacturing sector and eight selected industries of India indicate that both scale economies and technical change have registered a declining trend in recent years in the process of a declining TFPG. There exists, therefore, a good case for prescribing policy measures that lead to better exploitation of economies of scale and technical change in India.

Goldar (2000) showed that the growth rate in employment in the organized manufacturing sector in India for the period 1990-91 to 1997-98 was 2.69 per cent per annum which was well above the growth rate of 0.53 per cent per annum achieved in the 1980s. He attributed two major reasons for this growth in employment: slowdown in growth of real wages in the 1990s and faster growth of small and medium-sized factories in organized manufacturing, which are more labour intensive as compared to large sized factories. He also highlighted that the increase in employment in the organized manufacturing sector, which took place in the 1990s, was accounted for by private sector factories. Nagaraj (2004) pointed out that faster employment generation in organized manufacturing was restricted mainly to the first half of the 1990s. As the boom went bust, there was a steep fall in employment in the second half of the 1990s. Relative cost of labour did not seem to matter in employment decisions, as the wage-rental ratio declined secularly. According to him, about 1.1 million workers, or 15 per cent of the workers in the organized manufacturing sector in the country, lost their jobs between 1995-96 and 2000-01.

Chaudhuri (2002) studied the changes in labour intensity for 3-digit groups in the organized manufacturing sector for 1990-91 and 1997-98. He found that labour intensity had progressively gone down from 0.78 in 1990-91 to 0.56 in 1997-98. Umi and Unni (2004) observed a sharp growth in capital intensity (and declining labour intensity) in both the organized and unorganized sectors. The positive growth in capital intensity was not accompanied by a rise in capital productivity in both sectors, which again implied a substitution of capital for labour, without any technological up-gradation, across all industry groups at the 2-digit level in both the sectors.

In a study Das et al. (2009) attempt to identify and examine labour intensive industries in the organized manufacturing sector in India in order to understand their employment generation potential. Using the data from the Annual Survey of Industries, the labour intensity for 97 industries at the 4-digit disaggregate level was computed for the period 1990-91 to 2003-04. The study identifies 31 industries as ‘labour intensive industries’ within India’s organized manufacturing sector. The study finds that labour intensity has declined not only for capital intensive industries but also for labour intensive industries during the selected time period. The increase in output failed to generate enough employment growth resulting in a significant decline in employment elasticity. The paper briefly highlights the plausible factors that could have had an impact on labour intensity as well as on the performance of the organized manufacturing sector over the study period.

Roy et al (1999) report the analysis of productivity growth and input trends in six energy intensive sectors of the Indian economy, using growth accounting and econometric methods. The econometric work estimates rates and factor price biases of technological change using a translog production model with an explicit relationship defined for technological change. Estimates of own-price responses indicate that raising energy prices would be an effective carbon abatement policy for India. At the same time, their results suggest that, as with previous findings on the US economy, such policies in India could have negative long run effects on productivity in these sectors. Inter-input substitution possibilities are relatively weak, so that such policies might have negative short and medium term effects on sectoral growth. The study provides information relevant for the analysis of costs and benefits of carbon abatement policies applied to India and thus contribute to the emerging body of modeling and analysis of global climate policy.

Assuming a translog specification of a four input (KLEM) production function, Mongia et al (2001) use growth accounting to decompose the growth of output into growth of inputs and a residual representing total productivity growth. A major finding of the paper is that overall productivity growth in these industries was quite low during 1973-1994. However, there were significant deferences in productivity growth across industries during this time period. These differences can to a large extent be explained by the nature and timing of policy changes in individual sectors. Using the technique of growth accounting they estimated total productivity growth (TPG) for five energy intensive industries in India. The results show that total productivity growth in these industries during the period 1973-1994 was insignificant, although productivity growth varied across industries. It was significantly positive in the fertilizer industry, positive but low in aluminum and cement, and negative for iron and steel and paper industry. Productivity growth was not uniform over time either. The partial productivity growth of capital and energy appear to be significant determinants of total productivity growth. These in turn were crucially affected by capacity utilization. The analysis of results for two sub-periods, 1973-1981 and 1981-1994, shows that changes in technologies and production conditions triggered or induced by policy reforms helped increase productivity growth significantly in the cement and the fertilizer industry. The effect of policy changes was less significant in the case of aluminum because of lumpiness of investment and because of the inherent nature of the technology. However, the removal of market constraints and the addition of a modern plant did raise the growth rate in the second sub period significantly. Productivity growth was adversely affected in the case of iron and steel and paper, where due to lack of a clear long-term perspective, the positive effects of policy reforms were overwhelmed by institutional and market conditions, at least temporarily. Overall, policy reforms did not go far enough to significantly affect productivity growth in India's energy intensive manufacturing sectors.

Schumacher and Sathaye (1999) derive both statistical and econometric estimates of productivity growth for the pulp and paper industries in India. Using a translog specification, they reveal that technical progress in India's pulp and paper sector has been biased towards the use of energy and material, while it has been capital and labour saving. The decline in productivity was caused largely by the protection afforded by high tariffs on imported paper products and other policies, which allowed inefficient, small plants to enter the market and flourish. To verify whether these trends will continue into the future, particularly where energy uses is concerned, they examined the current changes in structure and energy efficiency undergoing in the sector. Their analysis shows that with liberalization, and tighter environmental controls, the industry is moving towards higher efficiency and productivity.

1.2.1 Studies on Energy substitution

Estimates of energy substitution are sensitive to the industries and regions of study. The economics of substitution is based on the microeconomics of production. Allen (1938) remains a fundamental source along with Varian (1984) and Takayama (1993). Cameron and Schwartz (1980), Field and Gerbenstein (1980), and Denny, Fuss and Waverman (1981) find differences in estimated energy substitution across industries and countries. Caloghiro, Mourelatos, and Thompson (1997) find electricity a weak substitute for capital and labour in Greek manufacturing during the 1980s, implying electricity subsidies lowered the demand for capital and labour. Bamett et al (1998) show that electricity is a weak substitute for both capital and labour in major Alabama industries and note that regulatory constraints are binding due to inelastic electricity demand. Kemfert (1998) reports that aggregate energy, capital, and labour are substitutes in German manufacturing. Mahmud (2000) finds very little substitution between energy and other inputs but weak substitution between electricity and gas in Pakistan manufacturing.

There has also been a considerable amount of econometric work on inter-fuel and inter-input substitution for the Indian economy (Ganguli and Roy 1995), but very little (Jha et al., 1993) on long-run trends in the relations between technological change and fuel or input substitution. A comprehensive survey of research on total factor productivity in East Asia reveals a focus on capital and labour inputs, rather than energy (Felipe, 1997). The standard growth accounting approach, pioneered by Solow (1957) and further developed by Denison (1974, 1979, 1985) and others, can be employed to study long run trends in energy use and its relationship to other economic variables. In addition, Christensen and Jorgenson (1971), Hogan and Jorgenson (1991), Hudson and Jorgenson (1974), and Jorgenson et al. (1981, 1987) have developed and applied methods that allow for an enhanced analysis of the relations between substitution effects induced by changes in relative factor prices, and pure 'productivity' trends, on a sector specific basis over long time periods. They have demonstrated that combining a finer level of analysis (in particular, sectoral disaggregation) with a form of "endogeneity" in the modeling of technological change can reveal patterns that are not readily detected by more traditional methods. These patterns can have substantial implications for conclusions regarding the long run costs and effects of price-based carbon abatement policies.

Chang (1994) finds little difference between translog and constant elasticity production functions in Taiwanese manufacturing and reports that energy and capital are substitutes. Yi (2000) finds substitution varies across Translog and Leontief production functions in Swedish manufacturing industries. Urga and Walters (2003) show that function specification has an effect on estimates of substitution, reporting that coal and oil are substitutes in US industry. An issue of interest has been the impact of various monitoring and enforcement actions undertaken by environmental regulators. A number of authors have examined whether or not the public disclosure of environmental performance may create incentives for pollution control [Foulon et al. (2002), Cohen (1998) and World Bank (2000)].

In taking account of the interrelationship between energy and other primary resources, labour and capital, Mountain (1985) presents a methodology for quantifying regional efficiency differentials using Taylor series approximations to profit functions representing regional economies. The resulting formulation makes it possible to decompose labour productivity into its contributing factors which now include energy price differentials in addition to such traditional variables like differentials involving capital employee ratios and the quality of labour. This approach has applied to Canadian regional data from 1962 to 1978. On average, between 5.2% and 9.2% of Canadian regional productivity differentials can be attributed to regional energy price differentials. When quantifying regional efficiency differentials, instead of only taking account of differences in capital-employee ratios and differences in quality of labour, this study has also factored energy price differentials into the calculation. By starting with a regional production relation, which models regional output as a function of all primary resources, [including energy as well as labour and capital] an indirect profit function forms the basis of a modified efficiency computation. A Taylor series approximation to the profit representation of real value added was used to quantify the relative importance to differences, in average labour productivity of energy price differentials, in addition to capital-employee and quality of labour differentials. This technique also provided a consistent time series of regional efficiency in Canada.

Ma et al (2009) measures technological change, factor demand and inter-factor and inter-fuel substitutability measures for China. They use individual fuel price data and a two-stage approach to estimate total factor cost functions and fuel share equations. Both inter-factor and inter-fuel substitution elasticities are calculated and the change in energy intensity is decomposed into its driving forces. Their results suggest that energy is substitutable for capital regionally and for labour nationally. Capital substitutes for energy more easily than labour does. Energy intensity changes vary by region but the major drivers seem to be ‘‘budget effect’’ and the adoption of energy-intensive technologies, which might be embodied in high-level energy-using exports and sectors, capital investment and even old technique and equipment imports. They conclude that, after decomposing energy intensity, the budget effect and technological changes are the two major driving forces of the changes in energy intensity nationally. The variations in budget effect across regions are most likely related to the differences in regional economic growth and industrial structure. Further he finds that the technological changes or innovative activities can be embodied in capital investment, equipped labour, export goods and even sectoral shifts.

According to Li et al. (2004), the performance of the pulp and paper industries are mostly dependent on the size and age of the firms. As the size and age of the firm grows they become more productive. Based on the analysis on the US paper mills they found that the growth of pulp and paper mills in the US from 1970 to 2000 depended mostly on size and age. Mills grew according to Gibrat’s law, and post-1970 mills grew faster than pre-1971 mills. Mills stopped growing at approximately 22 years of age. But most mills survived beyond that, thus growth was not necessary for survival, but characteristic of the early phase of the mill life cycle. Less integrated mills grew slower. So did more specialized mills and more so if they produced mostly paper products. Mill location was uncorrelated with growth, but location mattered indirectly by facilitating or hindering mills with growth-conducive characteristics.

Hseu and Shang (2005) tried to measure the productivity of pulp and paper industry in OECD countries over the period of 1991 to 2000. They calculated the malmquist productivity index by using the nonparametric-frontier approach, and decomposed the index into two components: technical change and efficiency change. Their results showed that the productivity change of pulp and paper industry in OECD countries ranged from Switzerland's 0.9% to Japan's 2.4% over the sample period. The Nordic nations (Finland, Norway and Sweden) recorded 1.2% to 1.5% improvement in their performance. The productivity of the Canadian pulp and paper industry increased by 2%, while that of its United States counterpart increased only by 0.8%. The results also showed that the last decade's productivity growth was attributed more to the technical change than efficiency change.

Doonan et al. (2005) examined the role that communities may play to create incentives for local industrial facilities to reduce their pollution. They found that firms face both internal and external pressures to improve their environmental performance. Using primary data collected for 750 pulp and paper industries in Canadian pulp and paper industries during 1992 they further found that the government policies are much of a barrier for the Canadian pulp and paper industries however, financial and consumer markets are not the most important barrier. They found that the education of employees, are important determinants of environmental performance. The regulatory intervention is also found as the major determinants of environmental performance of the pulp and paper industries. Unlike other industrial sectors, the pulp and paper industry produces energy as by-product. As according to Beer (1998), emerging technologies, that is completely new process designs and processing techniques, could bring long-term energy efficiency improvements of 75 to 90% in paper production (Beer, 1998).

Balasubrahmanya (2006) probes the role of labour efficiency in promoting energy efficiency and economic performance with reference to small scale brick enterprises cluster in Malur, Karnataka State, India. He narrates that in the bricks industry, the technology in use being similar, labour efficiency has a negative influence on energy cost. Therefore, those enterprises that exhibited higher labour productivities had lower average energy intensity and higher returns to scale as compared to those that had lower labour productivities. Considering this, improvement of labour efficiency can be an alternative approach for energy efficiency improvement in energy intensive small scale industries in developing countries like India, which face the obstacle of financial constraints in up-grading technology as a means of energy efficiency improvement. Since labour productivity had a negative influence on energy cost, he grouped the bricks enterprises into two groups based on their average labour productivity. He found that the two groups, which are differentiated based on average labour productivity, differed in terms of other economic ratios, such as capital intensity, capital productivity, energy intensity and value added share in the value of output. The group where labour is more efficient had higher capital intensity and, more importantly, had lower energy intensity, higher capital productivity and higher value added share in the value of output as compared to the group where labour is less efficient.

Based on the above discussion on studies in the manufacturing industries in general and pulp and paper industries in particular for India, we can observe that most of the research except Balasubrahmanya (2006), have not explicitly tried to focus on the relationship between the labour intensity and the energy intensity. Therefore, this paper intends to fill this research gap. Both the issues are of importance for an emerging economy like India. As pulp and paper industries in India is one of the highly energy consuming industries in the manufacturing sector. We have tried to look at the relationship between labour and energy intensity using unit level data. The next section of the study focuses on a brief introduction and the current state of the pulp and paper industry in India.

1.3 The Pulp & Paper Industry in India

The first paper mill in India was set up at Sreerampur, West Bengal, in the year 1812. However, large scale mechanized technology of papermaking was introduced in India in early 1905. Since then the raw material for the paper industry underwent a number of changes and over a period of time, besides wood and bamboo, other non-conventional raw materials have been developed for use in the papermaking. The paper industry is categorized as forest-based and agro-based and others (waste paper, secondary fibre, bast fibers and market pulp). Currently, the Pulp and Paper industry in India is the 15th largest paper industries in the world. The paper industries in India have been categorized into large-scale and small-scale. Those paper industries, which have capacity above 24,000 tonnes per annum, were designated as large-scale paper industries. Indian paper industry has been de-licensed under the Industries (Development & Regulation Act, 1951) with effect from 17th July, 1997. Foreign Direct Investment (FDI) up to 100% is allowed on automatic route on all activities except those requiring industrial licenses where prior governmental approval is required.

Growth of paper industry in India has been constrained due to high cost of production caused by inadequate availability and high cost of raw materials, power cost and concentration of mills in a particular area. Government has taken several policy measures to remove the bottlenecks of availability of raw materials and infrastructure development. For instance, to overcome short supply of raw materials, duty on pulp and waste paper and wood logs/chips has been reduced. As of 2007-08, the Indian paper industry has a total turnover of more than Rs 10,000 crore and provides direct employment to 200,000 people and indirectly to another 100,000 persons. Despite low per capita (4 kg) consumption of paper and paper boards, the industry has made a steady progress in the last five decades. At present, about 60.8 per cent of the total production is based on non-wood raw material and 39.2 per cent on wood. The capacity utilisation of the industry is low at 60 per cent as about 194 paper mills particularly small mills are sick/or lying closed. Import of paper and paper products have been growing over the years. The imports during 2000-01 were to the tune of 0.152 million metric tons and are estimated to be 0.165 million metric tons in 2001-02. About 0.14 mmt of paper was exported in 2000-01. The domestic demand for newsprint is met partly from indigenous production and partly by import. Free imports and low customs duty have made the newsprint market competitive.

The demand of paper and paper products in India has continuously been increasing over the time. However, per capita paper consumption in India is about 5.5 kg in the year 2003 as against of world average of 50 kg (TERI, 2006). There are about 525 pulp and paper mills with an installed capacity of 6.5 million tonne. The installed capacities of Indian mills vary over a wide range of 5 tpd to 600 tpd. Indian paper mills are categorized into (1) large mills with installed capacity of more than 100 tonne per day, and (2) small mills with capacity less than 100 tonne per day. The small units account for more than 50% production capacity, and characterized by poor energy efficiency. About 80–85% of energy is used for process heating while the share of electricity accounts for 15–20%. More than 80% of electricity used in large wood–based mills is met by cogeneration units.

Table 1: Share of different indicators as compared to Indian Industries (In %)

Year	Units*	Fixed Capital	Workers	Wages
2007	2.80	2.59	2.55	2.04
2006	2.67	2.44	1.91	1.98
2005	2.67	2.46	1.94	2.17
2004	2.76	2.53	2.09	2.30
2003	2.77	2.66	2.25	2.38
2002	2.72	3.30	2.20	2.31
2001	2.63	2.69	2.21	2.48
Growth Rate (Pulp & Paper Industries)	1.16	0.99	0.88	0.93
Growth Rate (All Industries)	1.46	1.04	1.26	1.04

Note: *: No. of Pulp & Paper Units to total manufacturing industries
Source: own calculation based on data from the Principal Characteristics by Major Industry Group, ASI, Various Years, MOSPI, GoI

Table 1, gives a picture of the pulp and paper industries from 2001 to 2007. The data is drawn from the principle characteristics by major industry group published by the Annual survey of industries. In 2001 the share of pulp and paper industries to the total manufacturing industries is at 2.63% which increased to 2.80% in the year 2007. The growth rate in number of firms for the manufacturing industries is calculated to be 1.46% from 2001 to 2007. At the same time the growth rate of the number of firms in the pulp and paper industries is calculated to be 1.16%. Therefore, we can observe that the growth in number of firms for the total manufacturing industries is higher than the growth in number of firms in the pulp and paper industries in India. When we consider the fixed capital in the pulp and paper industries from 2001 to 2007, we can observe that the pulp and paper industries hold 2.69% of the fixed capital in the entire manufacturing industries in 2001. The share went up to 3.30% in 2002, and in the subsequent years till 2007 the share in the fixed capital started decreasing and in the year 2007, the share of the fixed capital of the pulp and paper industries is calculated to be at 2.59% of the total manufacturing industries in India. The growth rate in for the fixed capital was calculated at 1.04% for the manufacturing industries however, the growth rate in the fixed capital for the pulp and paper industries was calculated to be at 0.99% for the entire period. Therefore, as in case of the growth in the number of firms, in case of the growth in the capital for the pulp and paper industries is also less than that of the growth in the manufacturing industries in India. The percentage share of number of employees in the pulp and paper industries increased from 2.21% in 2001 to 2.55% in 2007. In 2007, the industries have recorded the highest share of employee (workers) from 2001. The growth of the employees in the pulp and paper industries increased at 0.88% from 2001 to 2007. However, at the same time when we consider the wages paid to the workers as a share of the total wages paid to the entire manufacturing industries in India we can observe that the share has declined from 2.48% in 2001 to 2.04% in 2007. With this brief introduction to the pulp and paper industries the next section of the study is focused on the data analysis of the pulp and paper industries.

1.4 Data, Methodology, & Analysis

As discussed earlier, energy intensity is one of the important areas of studies for economists as well as climate scientists. For Indian case we can find few works dealing with the energy intensity at the firm level. In an earlier attempt Kumar (2003), Sahu and Narayanan (2008), Sahu and Narayanan (2010), and Goldar (2010) have tried to study factors affecting the energy intensity at firm level for the Indian manufacturing using the structure-conduct-performance variables. They found that labour, capital, age of the firm, MNE affiliation of the firm, R&D expenditure are one of the major determinants of the energy intensity for Indian manufacturing industries. This study follows a similar approach to look at the relationship between the labour intensity and the energy intensity for the Pulp and paper industries in Indian manufacturing industries. Labour intensity is a crucial issue in linking the energy intensity as it gives the complementarities or substitution possibility between the labour and energy. As stated earlier, there are wide range of studies focusing on the substitution possibility between energy, capital and labour. For instance, Ma et al. (2009) studied the Chinese economy on the substitution possibility. He found that energy substitutes for capital at the regional level and labour substitutes for the national level. However, overall he finds capital substitutes more easily than labour does. This study focus on energy and labour intensity and uses few more firm characteristics The variables used and their definitions are given in Table 2.

Table 2: Definition of the Variables used in the study

Sl. No	Variable	Symbol Used	Definition
1	Energy Intensity	EI	The ratio of the expenses on the energy consumption to sales
2	Capital Intensity	CI	The ratio of the total capital employed to the total value of the output
3	Labour Intensity	WI	Ratio of the wages and salaries to the sales
5	Profit Intensity	PI	Profit after sales as a ratio to the sales
4	Age	AGE	As a measure of age, we subtract the year of incorporation from the year of the study.
5	Size	SIZE	Size of the firm is measured by log of sales
6	Research Intensity	RI	R&D intensity is measured as the ratio of R&D expenses to the sales.
7	Technology Intensity	ETI	Expenditure on import of capital goods / Sales turnover of the firm
9	Industry Dummy	MNE	This dummy takes the value one for the foreign owned firms and zero for the rest
10	BSE dummy	BSE	This dummy takes the value one for the BSE registered firms and zero for the rest

As stated earlier we have used data from the CMIE PROWESS electronic database. The data consists of 2075 units of observations before cleaning. However, after cleaning 1949 observations left for the analysis (unbalanced panel from 1992 to 2009). The data is cleaned from the database those who have reported no data for most of the variables used in the study. Based on the classification of economic activity as classified in the CMIE classification we have further classified the data in five different groups as group-1 to group-5. The five major classifications are as follows:

We have tried to analyze three major indicators of the pulp and paper firms based on the five groups. In addition we have also classified the sample based on BSE listed and ownership status. The basic idea of classifying is to understand the changes in energy intensity, labour intensity and the capital intensity among the groups. Table 2 presents the result of the mean of the three indicators.

Table 3: Classification of the firms as per their economic activity

Economic Activity	Group Code
Paper, paper board	1
Newsprint	2
Kraft paper	3
Paper tarred, plastic coated, etc.	4
Paper & paperboard, corrugated, crepped, embossed	5

Source: CMIE economic group activity classification codes

From table-4, it is clear that the first group of the firms represents only domestic firms. We can see that the energy intensity is higher for the firms those are listed (0.16) as compared to the non-listed domestic firms. However, the labour intensity is found higher for the non-listed firms (0.26) as compared to the listed domestic firms (0.06). In case of the capital intensity we found that the domestic non-listed firms are higher capital intensive. In this classification we can observe that the domestic listed firms are lesser labour intensive and higher energy intensives.

For the economic activity group-2, we can see that there are four classifications; the non-listed domestic and foreign firms as well as the listed domestic and foreign firms. In this classification we can observe that energy intensity is higher for the listed foreign firms as compared to the other three categories and least for firms those are listed and domestic firms. In case of the labour intensity we can observe that the listed foreign firms are higher labour intensive and the non-listed domestic firms are less labour intensives. However, for the capital intensity we can see that listed domestic firms are higher capital intensives and the non-listed foreign firms are the least capital intensives. Therefore, we can summarize that the listed foreign firms are higher energy intensives and higher labour intensives too.

Based on the mean values on the economic activity group three, we can see that in this group also we have four further classifications; the non-listed domestic and foreign firms as well as the listed domestic and foreign firms. We can observe that listed domestic firms are higher energy intensives as compared to the other classifications and the least energy intensives are the listed foreign firms. In case of the labour intensity we can see that the non-listed domestic firms are higher labour intensives and the non-listed foreign firms are the least labour intensives. The listed domestic firms are found to be higher capital intensives and the listed foreign firms are found to be least capital intensives.

Table 4: Energy intensity, labour intensity & capital intensity based on grouping of different firm specific characteristics

		Energy Intensity	Labour Intensity	Capital Intensity
Economic Activity Code 1				
Domestic Firms	Non-Listed	0.126	0.260	1.650
	Listed	0.163	0.064	1.057
Foreign Firms	Non-Listed	NA	NA	NA
	Listed	NA	NA	NA
Economic Activity Code 2				
Domestic Firms	Non-Listed	0.178	0.055	1.270
	Listed	0.175	0.074	2.369
Foreign Firms	Non-Listed	0.187	0.064	0.825
	Listed	0.217	0.087	0.909
Economic Activity Code 3				
Domestic Firms	Non-Listed	0.176	0.452	5.755
	Listed	0.225	0.166	12.677
Foreign Firms	Non-Listed	0.187	0.072	0.604
	Listed	0.130	0.078	0.417
Economic Activity Code 4				
Domestic Firms	Non-Listed	0.148	0.110	1.675
	Listed	0.183	0.066	1.258
Foreign Firms	Non-Listed	NA	NA	NA
	Listed	NA	NA	NA
Economic Activity Code 5				
Domestic Firms	Non-Listed	0.208	0.645	16.082
	Listed	0.193	0.079	2.029
Foreign Firms	Non-Listed	0.190	0.081	0.831
	Listed	NA	NA	NA

In case of the fourth classification of the economic activity we can found only two sub-classifications; the non-listed domestic firms and the listed domestic firms. Among these two calcifications we can see that the listed domestic firms are higher energy intensives and the non-listed domestic firms are the higher labour intensives. In case of the capital intensity we can see that the non-listed domestic firms are higher capital intensive (1.67) as compared to the listed domestic firms (1.25).

The economic activity group five comprises three sub-classifications; non-listed domestic firms, non-listed foreign firms and the listed domestic firms. From the table it is evident that the energy intensity is higher for the non-listed domestic firms and least for the non-listed foreign firms. In case of the labour intensity we can see that the non-listed domestic firms are higher labour intensive and the listed domestic firms are the least labour intensives. However, capital intensive is highest for the firms those are non-listed domestic and least for the firms those are non-listed foreign.

Table 5: Energy intensity, labour intensity & capital intensity based on each economic group

Economic Activity Group	Energy Intensity	Labour Intensity	Capital Intensity
Group: 1	0.145	0.160	1.347
Group: 2	0.180	0.063	1.592
Group: 3	0.192	0.315	8.999
Group: 4	0.165	0.088	1.472
Group: 5	0.201	0.373	9.330
Full sample	0.195	0.299	8.146

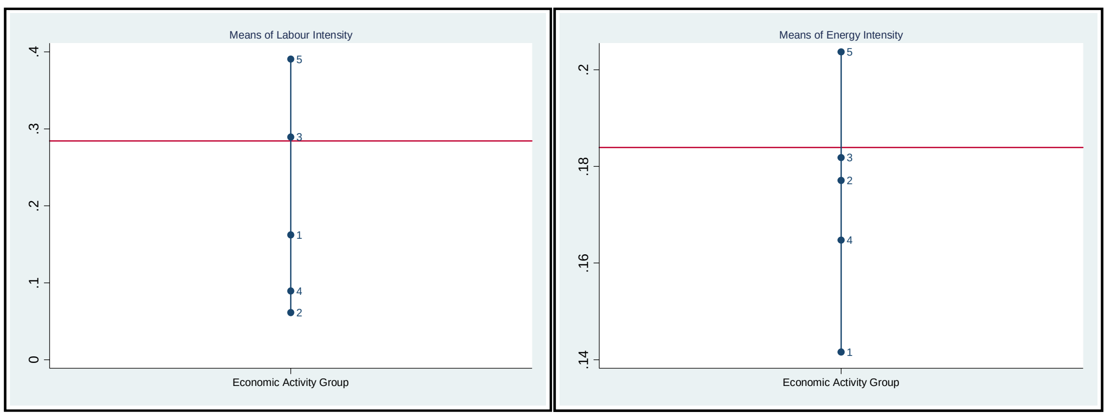

Figure1: Classification of labour and Energy Intensity for different Subgroups

Further, we have classified only based on five economic activity groups to understand the major energy consumed, labour intensives and capital intensive firms. Based on the classification as per the sample we can observe that the class five on the economics activity group is the highest energy intensive group and the group one is the least energy intensive ones. In case of the labour intensity we can see that group five are highest labour intensives and group two are the least labour intensives. In case of the capital intensity we can observe that the group five is the major capital intensive and the group one is the least capital intensive group. In comparison to the mean energy intensity of the sample we can observe that three groups (1, 2, 3 & 4) are less energy intensive and the fifth group of the pulp and paper industries is higher energy intensives. In case of the labour intensity we can observe that two groups (3 & 5) are higher energy labour intensive as compared to the mean labour intensity of the full sample. The result for the capital intensity is also same as group 3 & 5 are higher capital intensive as compared to the mean capital intensity of the full sample.

Table 6: Energy intensity, labour intensity & capital intensity based on BSE listing of firms

	Energy Intensity	Labour Intensity	Capital Intensity
BSE Non listed Firms	0.180	0.442	7.115
BSE Listed Firms	0.213	0.138	9.307
Full sample	0.195	0.299	8.146

Further, we have classified the sample firms in two major groups based on the BSE listing. We can see that the non-listing firms are less energy intensives as compared to the listed firms. In this case we can also see that the non-listing firms are also lesser energy intensives as compared to the mean energy consumption of the full sample. In labour intensity we can see that the non-listing firms are higher labour intensity as compared to the listed firms as well as from the mean of the full sample. In capital intensity we can observe that the listed firms are higher capital intensive as compared to the non-listed firms as well as from the mean capital intensity of the full sample.

Table 7: Energy intensity, labour intensity & capital intensity based on ownership of firm

Ownership Group	Energy Intensity	Labour Intensity	Capital Intensity
Domestic Firms	0.195	0.301	8.218
Foreign Firms	0.188	0.074	0.747
Total	0.194	0.299	8.146

We have further attempted to look at the difference between the three indicators based on either the firm is a domestic one or foreign firm. Hence the data has been divided based on the ownership group. From the table we can observe that energy intensity is higher for the domestic firms and less for the foreign owned firms. However, the energy intensity for the domestic firm and the full sample are much nearer. Looking at the labour intensity we can observe that the labour intensity is higher for the domestic firms as compared to the foreign firms, which is even higher as compared to the full sample. We found the domestic firms to be more capital intensive as compared to the foreign firms and from the full sample.

Further, the analysis of the energy, labour and capital intensity for the full sample of the pulp and paper industries is carried out to look at the changing pattern of the parameter over the period of time. In case of the energy intensity we can see that in 1994 the industry has recorded least energy intensity, followed by most recently in 2009. However, during 1995 the industries have recorded the highest energy intensity, followed by the year 2005. In case of labour intensity we can see that the labour intensity recorded highest in 1995, f. However, 1994 the industries have recorded the lease labour intensity. In 1992 the pulp and paper industries have recorded the least capital intensity. The highest capital intensity can be seen for the year 1999. Figure 2 gives the graph representing the changes in labour intensity and energy intensity over the period of time. Except for the years 1993, 1995, 1999, 2003 and 2004 the labour intensity of the sample is lower than that of the energy intensity. For all other years the energy intensity is higher when compared to the labour intensity.

Table 8: Energy, Labour and capital intensity changes from 1992-2009

Year	Energy Intensity	Labour intensity	capital intensity
1992	0.163	0.076	0.933
1993	0.210	0.493	4.149
1994	0.140	0.065	1.439
1995	0.257	1.149	7.378
1996	0.206	0.139	1.820
1997	0.184	0.106	1.886
1998	0.182	0.121	4.213
1999	0.207	1.891	31.440
2000	0.160	0.084	1.320
2001	0.158	0.075	3.159
2002	0.181	0.120	1.905
2003	0.196	0.294	7.543
2004	0.235	0.488	13.499
2005	0.162	0.124	10.323
2006	0.179	0.071	1.590
2007	0.174	0.079	5.406
2008	0.178	0.073	1.598
2009	0.153	0.065	1.430
1992-2009	0.184	0.284	5.881

Figure 2: Mean Energy and Labour Intensity during 1992 to 2009

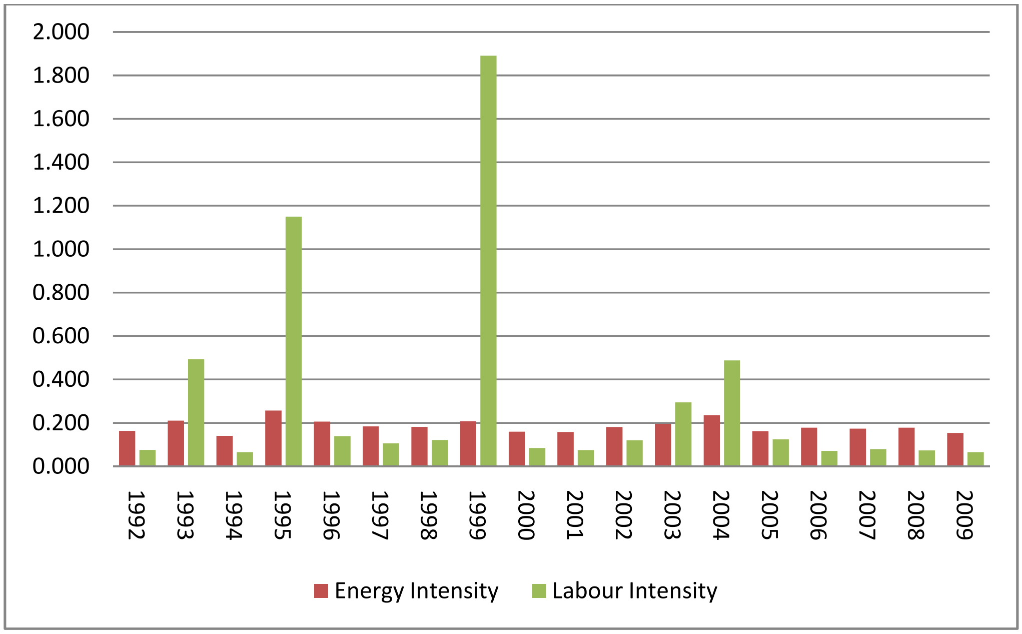

Figure 3: CAGR of Energy and labour intensity for different time period

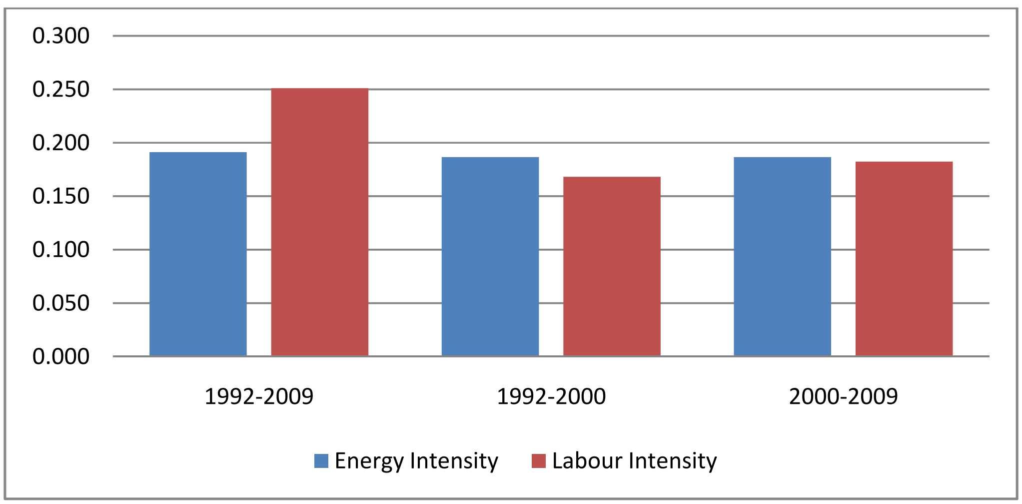

Figure 3 gives the growth rate of energy and labour intensity for the pulp and paper industries in three different periods. We have divided the time periods in three different phases. The first is from 1992 to 2009, the second being 1992 to 2000 and the third period is from 2000 to 2009. We can see from the figure that the growth in energy intensity from 1992 to 2000 and from 2000 to 2009 is higher from that of the labour intensity however, the growth in the first period is little higher than that of the second period. However, when we consider the full time period we can see that the growth in labour intensity is much higher than that of energy intensity.

To check whether the labour intensive industries are also highly energy intensive, we have tried to cross tabulate the energy intensity and the labour intensity of the full sample. The labour intensity is classified into four major groups from 1 to 4. Where group one represents the lease labour intensive and group four stands for higher labour intensive firms. The mean energy intensity of the firms falling in each of the categories is given in table 9.

Table 9: Classification of energy intensity based on labour intensity categories

Labour Intensity Group	Energy Intensity	Labour Intensity
1	0.165	0-0.25
2	0.158	0.25-0.50
3	0.184	0.50-0.75
4	0.229	0.75-0.99

From table 9 it is clear that firms with least labour intensity are more energy intensive as compared to group 2 which is higher labour intensive. Further we can see that, higher labour intensive firms falling in group 4 are higher energy consumed too. Except for group 3, we can see that in all other groups where there is an increase in the labour intensity, the energy intensity has also increased. However, the phenomenon is not clear from the cross tabulation. Therefore, we have utilized an econometric specification to capture the phenomenon. In the econometric investigation we have tried to look at the energy intensity change that explained by the other factors of production. To make the argument more focused we have also used other factors of production at the firm level those are the structure, conduct and performance variables of the firm. Here we consider the labour intensity as the proxy for the human capital of the firm and energy intensity as the proxy for better performance of the firms. As stated earlier we have used the unbalanced panel data of the pulp and paper industries from 1992 to 2009. Initially after getting the descriptive statistics and the correlation matrix of the variables, we have initially tried the OLS regression. Further fixed and random effect models are being used for better explanation. The functional form of the econometric specification takes the following:

$$EI = \alpha + \beta_1 CI + \beta_2 LI + \beta_3 AGE + \beta_4 SIZE + \beta_5 PI + \beta_6 TI + \beta_7 BSE + \beta_8 MNE + \beta_9 RD + \beta_{10} LID + u_i \quad (1.1)$$

This specification follows Sahu and Narayanan (2010) and Goldar (2010). To avoid possible heterogeneity, we have defined the size as the natural logarithmic of sales. The definitions of the variables are given in table 2.

Table 10: Descriptive statistics of full sample

Variable	Mean	Std. Dev.	Min	Max
EI	0.196	0.604	0.001	25.000
LI	0.299	4.822	0.003	185.000
CI	8.147	135.843	0.000	5205.000
TI	0.568	0.222	0.000	6.000
PI	-1.073	16.744	-500.000	21.164
Size	3.271	1.512	-3.507	7.782
Age	18.840	13.490	1.000	106.000
RD	0.000	0.003	0.000	0.067
Observations	1949			

The descriptive statistics of the sample if given in table 10. We can observe from the table that that the mean energy intensity is found at 0.19, with a standard deviation of 0.60 and the minimum energy intensity is found at 0.001 and the maximum at 25.0. In case of the labour intensity the mean is found at 0.299 where the minimum labour intensity is at 0.003 and the maximum labour intensity is found at 185 and the mean capital intensity of the full sample of 1949 firms are found to be 8.14. The detail descriptive statistics of the full sample is given in table 10.

Table 11: Correlation Matrix

Variables	EI	LI	CI	TI	PI	Size	Age	MNE	BSE
EI	1.000								
LI	0.423	1.000							
CI	**0.860**	**0.641**	1.000						
TI	-0.115	-0.112	-0.107	1.000					
PI	-0.368	-0.907	**-0.513**	0.116	1.000				
Size	0.016	0.055	0.036	-0.022	-0.052	1.000			
Age	-0.038	-0.031	-0.032	0.000	0.035	0.010	1.000		
MNE	-0.001	-0.005	-0.005	-0.006	0.006	0.079	-0.052	1.000	
BSE	0.028	-0.032	0.008	-0.080	0.045	-0.023	-0.062	-0.034	1.000

The correlation matrix of variables in the study is given above in table 11. From the correlation analysis we can see that energy intensity has a positive relationship with labour intensity, capital intensity, size of the firm and dummy representing the BSE. However, correlation coefficient is found higher in case of energy intensity and capital intensity of the firm. On the other hand we can see that technology intensity, profit intensity, age of the firm, MNE affiliation of the firm are found to be negatively related to energy intensity of the firm. In case of labour intensity we can see that energy intensity, capital intensity, size of the firm are found to be positively related and all other variables are negatively related. However, in this case also the capital intensity of the firms, are found to be having higher correlation coefficient. Further, we have tried the OLS regression, and panel data regression. As we have found a better result in the panel data analysis we have presenting the panel data model result. In panel we have also tried the fixed and the random effect model. The Hausman test statistics suggests that the random effect model is a better explanation of the model as compared to the fixed effect model. Hence the result of the random effect model is explained here. In the data set the firm specific variable is considered as the panel variable, and year is considered as the time variable. Therefore, we have 303 groups with 1949 firms. The Hausman statistics is insignificant and the DW d statistics and the F statistics are highly significant. The Wald Chi^2 is also significant highly as evidence from the table 12.

Table 12: Result of the Panel Data regression (Random effect)

Variables	**Coefficient**	**Standard Error**	**z Statistics**
Labour Intensity	-0.019	0.003	-7.140***
Capital Intensity	0.000	0.000	-2.370***
Technology Intensity	-0.089	0.020	-4.400***
Profit Intensity	-0.015	0.001	-23.310***
Size	0.003	0.003	1.000
Age	0.000	0.000	0.070
Research Intensity	0.017	0.013	1.280
BSE Dummy	0.026	0.009	2.820***
Labour Intensity Dummy	0.153	0.033	4.610***
MNE Dummy	0.017	0.046	0.370
Constant	0.197	0.018	10.900
Hausman $Chi^2(8)$	15.17(0.04)	R^2 within	0.44
Wald Chi^2	1588.74***	R^2 Between	0.42
DW d-statistic	(9, 22) = 2.55***	R^2 Overall	0.45
Number of Observations	1949	No of Groups	303

From the results we can observe that the labour intensity is negatively related and highly significant with the energy intensity of the firms. That shows that highly energy intensive firms are less labour intensive. Therefore, those firms that exhibited higher labour productivities had lower average energy intensity. Considering this, improvement of labour efficiency can be an alternative approach for energy efficiency improvement in energy intensive pulp and paper industries in a developing country like India. In case of the capital intensity, it is negatively related with the energy intensity, this means that the higher energy efficient firms are higher capital intensive too. Technology import intensity is also found to be negative related to energy intensity of the firm. That indicates that firms which are importing technology either embodied or disembodied are more energy efficient. Profit intensity of the firm found to be negatively related to the energy intensity of the firm. That implies that firms that are earning higher profits are less energy intensives. Size of the firm turned out to be positively related to energy intensity; however, it's not statistically significant as the case of research and development intensity. The listed firms are found to be more energy intensives as compared to the non-listed firms, as the result found a negative relationship between the energy intensity and BSE dummy.

As the pulp and paper industries are one of the most energy intensive industries, labour would play a major role in the level of energy efficiency and economic performance. Since labour intensity has negative influence on the energy intensity higher labour intensive industries are energy saving. To capture effectively the role of higher labour intensive firm on energy intensity we have created a dummy capturing the higher labour intensive firms. The regression result suggests a positive relation of labour intensity dummy with the energy intensity. The construction of dummy takes the value one for firms which are lower labour intensives. Therefore, the result indicates that higher labour intensive firms are energy intensives as compared to the lower labour intensive firms. Further between the higher and lower labour intensive firms (since both the constant and the labour intensity dummy are significant we have tried to look at the difference between the higher labour industries and the lower labour intensive industries) we can see that the higher labour intensive firms are higher energy efficient having a positive sing in the regression coefficient (0.051). As we found the labour intensity and the energy intensity are negatively related (both in case of the labour intensity as well as from the dummy) we can assume that labour and energy are substitutes in case of Indian pulp and paper industries for this sample.

1.5 Summary and Conclusion

This paper is an attempt to understand the relationship between the labour and energy intensity for firms drawn from pulp and paper industries in Indian manufacturing. Pulp and paper industry accounts for a considerable share of the industrial enterprises, production, employment and exports in the Indian economy. As per the GoI today, these industries are finding itself in a competitive environment and to facilitate its survival and growth, it is indispensable to enhance the competitiveness of the sector. In energy intensive pulp and paper industries, improving energy efficiency by reducing energy intensity can be an important means of enhancing competitiveness, among others.

Analysis from the cross-tabulation of energy and labour intensity of the firms in this industry suggests that energy intensity is higher for the BSE listed firms as compared to the non-listed domestic firms. However, the labour intensity is found higher for the non-listed firms as compared to the listed domestic firms. When the full sample is taken into consideration, the non-listed firms are less energy intensives as compared to the listed firms. In this case we can also see that the non-listing firms are also lesser energy intensive as compared to the mean energy consumption of the full sample. In labour intensity we can see that the non-listing firms are higher labour intensive as compared to the listed firms as well as from the mean of the full sample. Further, energy intensity is higher for the domestic firms and less for the foreign owned firms. However, the energy intensity for the domestic firm and the full sample are much nearer. Looking at the labour intensity we can observe that the labour intensity is higher for the domestic firms as compared to the foreign firms, which is even higher as compared to the full sample.

The econometric analysis of the energy intensity and other firm specific characteristics including the labour intensity suggests that labour intensity had a negative relationship with energy intensity. Therefore, we found a substitution possibility among energy and labour for the pulp and paper industries in India. Hence these industries should focus on employment generation. As the technology import is also found negatively related to the energy intensity of the firms, firms have to focus more on the technology import and knowledge sharing. One of the major components of the technology import is the training and knowhow fees paid by the firms. Hence firms should also focus on providing training to the workforce in the firms. That in turn will help the pulp and paper industries to become highly energy saving firms.

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