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Pollution Reduction by Rationalization in Indian Firms

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Abstract

This paper uses data for Indian firms over the period 1987 to 2016 to estimate a panel data model that considers firm heterogeneity to estimate the relationship between energy intensity and internationalization strategies of the firm. Both, the extensive and intensive margins of exports are considered as explanatory factors of energy intensity together with a number of control variables including estimated total factor productivity, foreign ownership, size and innovation activities. The main results indicate that exporters are more energy efficient than non-exporters and that there is heterogeneity between industries. More energy-intensity industries present a higher reduction in energy intensity for exporters in comparison to non-exporters.

Key Words: Indian firms; energy intensity; exporting firms; trade liberalization; panel data.

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1. Introduction

The importance of analyzing the effects of trade liberalization on environmental quality has been widely recognized since the seminal paper by Grossman and Krueger (1991). The early empirical results showed that trade was good for the environment, however, later research has shown that the results are at best mixed and dependent on many factors.

In the early 2000s, as the new-new trade literature that started to consider the importance of accounting for heterogeneity in productivity at the level of the firm (Melitz, 2003), some authors set up theoretical models that derived testable predictions concerning the effects of increasing trade on the environment when the firm was taken as the main level of analysis. However, the existent empirical literature that should help to prove the theoretical predictions is still limited.

India is nowadays one of the fastest growing economies in the world with an annual average growth rate of around 6 percent between 1991 and 2017 (World Bank, 2019). This development has been accompanied by a profound trade liberalization proceed since the early 1990s. The growth path could come at the expense of higher levels of energy consumption and emissions; however, the increasing trade flows could also lead to improvements in energy efficiency and lower emissions.

This paper tests several hypotheses recently put forward by the new-new trade theories that investigate the effect of trade liberalization on the environment when firm heterogeneity is considered using a rich panel data set of Indian firms over the period 1987-2016. In this way, the main novelty is to enrich the findings of Barrows and Ollivier

(2018) and Soni et al (2017) for India, providing estimations obtained for a more recent period and a richer panel of Indian firms.

The main results indicate that exporters are more energy efficient than non-exporters, in particular, the results are driven by firms that belong to industries that use, in relative terms, more energy per unit of production than others.

The rest of the paper is organized as follows. Section 2 presents a review of the related literature for India. Section 3 summarizes the theoretical foundations for the relation between trade and environmental quality, and Section 4 presents the data, the variables and the empirical results. Section 5 concludes and offers some policy recommendations.

2. Trade Liberalization and the Environment: The Indian Case

In 1991, as a result of a severe balance of payments crisis, India adopted a structural adjustment programme proposed by the International Monetary Fund (IMF) as a condition to financial assistance. The programme encompassed industrial policy reform and trade liberalization, financial sector reform, privatization and fiscal austerity with an end goal of achieving economic growth and prosperity. Trade reforms broadly focussed on reduction of tariff rates, liberalization of the exchange rate management system, abolition of export subsidies and the reform of the import licensing system. These reforms accompanied by a reduction of foreign direct investment restrictions seem to be the main drivers of change in the composition of production and export in the manufacturing sector in India resulting in significant environmental impact. The general literature on trade liberalization suggests that its impact on the environment can be broken down into three components, namely the scale, composition and technique

(Grossman and Krueger, 1991 and Copeland and Taylor, 2004). With regards to large industrializing countries like India, the literature mainly focuses on the composition effect of low trade costs and weaker environmental enforcement policies making these countries potential candidates for attracting pollution intensive industries according to the Pollution Haven Hypothesis (PHH). However, empirical studies of this hypothesis, covering a wide range of countries at different stages of development, have yielded inconsistent results. Gamper-Rabindran and Jha (2004) show that in the case of India, post-liberalization was associated with a significant change in the composition of production and exports in manufacturing towards pollution-intensive industries. Using the Annual Survey of Industries (ASI) data and the Industrial Pollution Projection System (IPPS) pre (1988-90) and post liberalization (1992-97) they were able to show that air and water pollution intensive exports had increased in the post-liberalization period. They also found that foreign direct investment (FDI) grew in more polluting sectors relative to less polluting sectors between the pre- and post liberalization periods.

Contrary to the PHH, there is a significant area of research that concentrates on the ‘new theory approach’ of exploring the link between trade liberalization, productivity and firm-level environmental performance. The theoretical framework behind the ‘new theory approach’ based on the work of Melitz (2003) suggests that trade liberalization leads to lower tariffs and greater access to capital goods and technology leading to increased firm-level productivity and improvements in fuel (input) efficiency and energy intensity. The higher-productivity firms with higher levels of innovation and technology adoption emerge as the more competitive firms and successfully engage in export activities.

Therefore, theoretical and empirical research suggest a positive relation between export intensity and improvements in energy intensity.

A seminal paper by Topalova and Khandelwal (2011) studies the causal link between trade liberalization and firm productivity. The paper uses firm-level panel data from the Prowess database and trade protection data from the Indian Trade Classification Harmonized System (HS) for the period between 1987 and 2001. The authors use the Generalized Method of Moments (GMM) adopted from the Arellano & Bond (1991) paper to estimate the impact of trade reform on firm-level productivity. Their findings show significant improvements in productivity as a result of reductions in tariff rates. They also find evidence of productivity growth as a result of reduction in Effective Rates of Protection (ERP) and that the impact is strongest in import-competing industries and industries that are not subject to excessive domestic regulation.

A review of the evidence linking international trade to productivity and, consequently, to the environment in the context of India has revealed some interesting findings. The articles by Martin (2011) and Harrison et al. (2011) evidence a clear link between trade liberalization and market share reallocation in favor of energy-efficient firms in India. The article by Martin (2011) uses firm-level data in the manufacturing sector from India's Annual Survey of Industries (ASI), which includes 30000 firms per year, over a period of 19 years (from 1985 to 2004) and shows that the composition and technique effects play a larger role in the reduction of emissions after the 1991 liberalization. The paper uses tariff reduction on final goods and on intermediate goods, FDI reform and delicensing[1] as proxies of trade liberalization. Martin (2011) finds that tariff reduction on intermediate goods has a higher impact on firm level productivity and fuel efficiency than

[1] The elimination of import licenses.

tariff reduction on final goods. The author demonstrates that the reallocation effect of delicensing improves fuel efficiency by 7%.

The liberalization policies adopted by India since the early 1990s and the phenomenal growth of globalization over the past few decades has had a very positive impact on economic growth in India. India is now one of the fastest growing economies in the world with an annual average growth rate of 6.55% between 1991 and 2017 (World Bank, 2019). However, economic growth comes at the expense of higher levels of energy consumption and emissions, which has led the Indian government to introduce a wide range of policy measures to reduce carbon emissions and promote energy efficiency. In 2001 the Energy Conservation Act was passed by the Indian parliament, and the Bureau of Energy Efficiency (BEE) was set up in 2002 to implement and monitor progress of the various regulations of the Act. In addition to these measures, India's National Action Plan for Climate Change (NAPCC) was launched in 2008 and one of its aims focussed on improving energy efficiency through energy saving policy incentives, financing of public-private partnerships and other schemes. As part of the NAPCC, the first tradeable permit scheme in India called Perform-Achieve-Trade (PAT) was introduced in 2007 as an instrument to control emissions. According to this programme, high-energy intensive industries and plants within the industries were identified and assigned a Designated Consumer Status (DSC). These DSC were then set energy efficiency targets, which allowed them the opportunity to obtain energy saving certificates (ESCs) if they were able to achieve or surpass the given targets. These ESCs were then traded in the open market. A paper written by Oak and Bansal (2018) looks at the impact of the PAT scheme on energy efficiency in the fertilizer industry in India. The study includes a sample of 60 firms between the period 2004/05 to 2011/12 prior to the implementation of the PAT scheme and 2012/13 to 2014/15 after implementation. The sample covers over 73% of the firms identified as designated consumers within the Fertilizer Industry. Using firm level data from the Prowess data set and information from the Government of India's Perform-Achiev-trade (PAT) document (July 2012) and applying the difference-in-differences estimation technique, they found that after controlling for variables such as technology, R&D intensity, firm size, import intensity, ownership etc., the average energy intensity of designated consumers in the years 2012-13 to 2014-15 was lower with the implementation of this policy than without. Hence, the authors concluded that the PAT policy had the desired effect on the fertilizer industry. They also found that firm size and ownership significantly reduced energy efficiency if privately owned; however, import intensity had a negative but insignificant effect on energy efficiency.

Sahu & Narayan (2011) also study high energy-intensive industries and the determinants of energy efficiency at firm level. Their firm-level panel data is sourced from the Prowess dataset and includes the Indian manufacturing sector between 2000-2008. They find that foreign ownership and technology import activities reduce energy intensity. Whilst size of the firm has a U-shaped relationship with energy intensity, which implies that very large firms and very small ones tend to be more energy intensive. They also conclude that older firms are more energy intensive than younger ones.

Mukherjee (2008) studies the interstate variations in energy efficiency in India between 1998/99 until 2003/04 using the ASI data set. He looks at the industry-mix across the different states and finds that states that have a larger share of manufacturing output in energy-intensive industries have lower energy efficiency.

3. Trade Liberalization and the Environment: Theoretical Foundations

There is a vast amount of literature covering the relationship between trade and the environment. In this section, the survey of the literature is organized as follows. First, we present the literature covering the impact of free trade on the environment through decomposing the environmental impact of trade liberalization into scale, composition, and technique effects. Second, we look at the effects of trade liberalization on the environment through the lenses of the pollution haven hypothesis (PHH). In doing so, and for the sake of clarity, we differentiate between two concepts: the pollution haven effect (PHE) and the PHH. Third, we present the new theories and hypotheses related to firm heterogeneity (Cherniwchan et al., 2017, Forslid et al., 2018).

The question of 'how does trade, in general, impact the environment' has been at the heart of one of the most important debates in trade policy. The question is best answered by decomposing the environmental impact of trade liberalization into the scale, composition and technique effects (Antweiler, Copeland & Taylor, 2001, Cole and Elliot, 2003, Farhani, Chaibi & Rault, 2014, Grossman & Krueger, 1991, Lopez & Islam, 2008, Stoessel, 2001).

The scale effect asserts that holding both the composition of trade and the production technologies constant, an increase in the scale of global economic activity, partially due to international trade, will result in environmental damage. Therefore, it follows that the environment is negatively impacted by trade liberalization. On the other hand, there is evidence that trade and growth lead to increases in national incomes, which, in turn, lead to higher demand for environmental quality (Copeland & Taylor, 2004, Grossman & Krueger, 1991, Sun et al., 2019). Furthermore, stringent environmental regulations are known to incentivize firms to produce 'cleaner' goods. The literature provides evidence that higher incomes positively impact environmental quality. It is, therefore, unclear what the net impact of trade on the environment is. Also, holding trade responsible for environmental damage is not entirely justified.

The early literature, reviewing the impact of trade on the environment typically focused on national and industry-level aggregates and had its foundations in the following three hypotheses: The Environmental Kuznets Curve, the Competitiveness Hypothesis and the Pollution Haven Hypothesis. Copeland and Taylor (2004) and Copeland (2011) have detailed exposition on all these three hypotheses. The seminal paper by Grossman and Kruger (1993) on the environmental Kuznets curve (EKC) proposed an inverse U-shaped relationship between a country's per-capita income and the level of its environmental quality. Trade policy makers have used the EKC hypothesis and subsequent literature to support their proposition that trade and growth are, actually, good for the environment. They argue that an increase in per-capita income brought about by trade and growth would lead to higher levels of government investment in environmental protection and stricter regulations. Papers by Selden and Song (1994), Grossman and Krueger (1995), Shafik and Bandyopadhyay (1992) all come to similar conclusions based on empirical studies using various measures of environmental quality, time periods, countries etc. Jones and Manuelli (1995, 2001), John & Pecchenino (1994), Stokey (1998) and Andreoni and Levinson (2001) used abatement and the political process to explain the EKC. Hilton and Levinson (1998) were amongst the first to explore the distinct processes of the scale effect and the technique effect working together to produce the EKC.

The composition effect plays a key role of determining the impact of trade liberalization on the environment. Copeland & Taylor (2004) suggests that the composition effect depends upon a country's comparative advantage. Hence, they suggest that there are two competing theories. One is the pollution haven hypothesis that states that countries with relatively weak environmental policies will attract and specialize in highly polluting industries. The Pollution Haven theory has a strong grounding in theory as observed in studies conducted by Copeland and Taylor (1994, 1995), Chichilnisky (1994) and Brander and Taylor (1998). Empirical studies carried out by Levinson and Taylor (2008) Kellenberg (2009), Becker and Henderson (2000) and Hanna (2010) all support the existence of a Pollution Haven Effect.

The alternative theory suggests that environmental regulation does not impact trade patterns, instead the factor endowments (comparative advantage) of a country determine trade. The theoretical premise of this hypothesis suggests that countries that are relatively abundant in factors used in high-polluting industries will, on average, get dirtier, whereas countries that are relatively abundant in low-polluting industries will get cleaner with trade liberalization. When considering the impact of the pollution haven effect together with factor endowments the trade pattern will be determined by whichever force is more dominant. The interaction between the two effects has been reviewed in papers by Copeland and Taylor (1997, 2004), Yves Richelle (1996) and Antweiler et.al (2001).

The new theory and the new hypotheses put forward by Najjar and Cherniwchan (2020) and Forslid et al. (2018) concerning firm heterogeneity focus on the following hypotheses: Pollution Reduction by Rationalization Hypothesis, Distressed and Dirty Industry Hypothesis and Pollution Offshoring Hypothesis.

Najjar and Cherniwchan (2020) give a detailed exposition of all three hypotheses and suggest that they all have a common theoretical foundation as described by Melitz (2003). Melitz's paper uses a dynamic industry model with heterogenous firms to study the inter-industry effects of international trade. He concludes that trade liberalization leads to increased foreign competition and raises the productivity cutoff for domestic firms. As a result, low productivity firms exit the market, firms with intermediate productivity remain in the domestic market and high-productivity firms experience profit increases as they have more lucrative export opportunities. Najjar and Cherniwchan (2020) base the Pollution Reduction Rationalization Hypothesis (PRR) on Melitz's (2003) framework and look at the effect of trade liberalization on emissions. The PRR hypothesis concludes that trade liberalization shifts the market share towards the higher-productivity firms. These firms are able to drive down emissions better than the low-productivity firms and, therefore, these dirty firms eventually have to exit the market. The high-productivity firms then go on to become exporters and are cleaner than the other firms. The paper is also able to show increased abatement investments as productivity levels increase. Holladay (2016) looks at firm level U.S. data and finds that in 14 out of the 20 industries reviewed exporters pollute less per output. The study by Jinji and Sakamoto (2015) also show the same results for Japanese firms. Forslid et.al (2015) show that investments in abatement are positively related to productivity and exports. Their paper studies the impact of trade liberalization on Swedish manufacturing firms and concludes that as the scale of production increases for the exporters they are able to increase investments in abatement and, in turn, reduce emissions. The Distressed and Dirty Industry Hypothesis (DDI) suggests that trade liberalization may cause emissions to rise if the uncompetitive and distressed domestic firms forsake abatement expenditure or if pollution control is reduced. This theory has not widely been empirically tested.

The Pollution offshoring hypothesis (POH) is based on a similar premise as the PHH and both hypotheses envisage that trade liberalization leads to offshoring of emission intensive industries to countries with weaker environmental regulations. Whilst the PHH focuses on highly polluting industries that produce dirty final goods, the POH is more concerned with intermediate goods and the fragmentation of the production process that enables the most polluting intermediate stages of production to be offshored.

Empirical studies on the POH by Levinson (2010), Michel (2013), Li and Zhou (2017) and Cole et.al (2017) show conflicting results and, therefore, no conclusive decision can be made about the hypothesis given the limited literature on it.

4. Empirical Strategy

This section first describes the data and variables used and, next, it presents the estimated model and describes the methodology to test the hypotheses and outlines the main results.

4.1. Data and Variables

The main source for the firm level data is the PROWESS dataset for companies in the manufacturing sector we obtained 127,612 firm-year-observations that correspond to 13,448 firms out of the 40,000 firms included in the whole dataset that includes the service sector. The firms are grouped into 23 broader industries according to the categorization of the Indian National Industrial Classification (NIC). The overall time period covered goes from 1987 to 2016. Changed firm names, as well as acquired or sold firm divisions do not pose an empirical problem, as the company code gives a unique identifier to the firm and is not changed in these cases. Nevertheless, as new firms have been created (and thus entered the dataset) or closed (and thus left the dataset) over the considered period and hence, the panel is unbalanced.

4.2. Empirical Model, Methodology and Main Hypotheses

The estimation strategy used to test the hypotheses is based on the following panel data model of the determinants of energy efficiency (E):

$$\ln E_{ijt} = \delta_i + \beta_1 Export_{ijt} + \gamma_k X_{ijk} + \phi_{jt} + \varepsilon_{ijt} \qquad (1)$$

The model is estimated for two different dependent variables: energy expenditure and energy intensity. The main explanatory variables are two alternative proxies for export activities, representing the extensive and the intensive margins of export activities. For instance, in a first model we introduce a dummy that takes the value of one if the firm is an exporter in a given period t and zero otherwise. The second target variable used is export intensity calculated as exports divided by total sales.

Energy use is measured by the natural logarithm of an individual firm´s spending on energy for a given year, while energy intensity is defined as the ratio of power and fuel expenses divided by the total value of sales. This approach is similar to studies such as the one by Batrakova and Davies (2012) that uses energy purchases over total turnover or PROWESS-based studies such as the paper by Sahu and Narayan (2011), where the definition is similar to the one used in this paper. Energy, as an input factor, comprises a large variety of factors relevant to the environmental performance at the firm level. Electricity is one important component, but not the only energy source in production. The firms in PROWESS also use different fuels, wood products and other resources as a source of energy, for the present paper, all possible sources (excluding water) are incorporated in the energy use and energy intensity variables. A list of control variables with definitions and the expected signs is included in Table A.1 in the Appendix. Among the main controls are the firm's size and age, foreign ownership, the proxies for innovation activities, the know-how and the type of goods produced (final versus intermediate) and the total factor productivity (TFP).

TFP has been estimated using the estimation approach initially proposed by Levinsohn and Petrin (2003) and modified by Bos and Vannoorenberghe (2018). It is estimated using output (defined as the difference between total sales and the change in inventory), labor (employees compensation), intermediate inputs (expenses in raw materials) and capital (total assets). Employees compensation as provided in PROWESS includes not only salaries and wages, but also non-monetary benefits, social security contributions, etc., meaning that it represents, more precisely, the compensation to labor that a firm is willing to pay compared to methods including only wages or the number of employees.

The two main hypotheses to be tested are:

H1: The export activity of a firm raises the firm total consumption of energy compared to non-exporters.

H2: Exporters in the manufacturing sector show a lower energy-intensity in production than non-exporters.

In addition, we estimate the model for different groups of industries according to their energy intensity. See Table A.2 in the Appendix and Figure 1 for the energy intensity figures.

4.3. Main Results

The main results of the two models estimated in order to test the hypotheses put forward in the previous section are shown in Tables 1 and 2.

Table 1 shows the result when energy expenditure is used as dependent variable. The first two columns use the exporting status as target variable, and the third and fourth columns introduce export intensity as a proxy for the intensive margin of exports. Concerning the econometric specification, all models are estimated with firm fixed effects. Columns (1) and (3) introduce also year fixed effects, and columns (2) and (4) present the results adding industry-specific-year fixed effects.

Table 1. Energy expenditure and exporting activities

Dep Var: ln Energy Expenditure	(1)	(2)	(3)	(4)
		Time&Ind		Time&Ind
Explanatory VARIABLES	Time FE	FE	Time FE	FE
Export dummy	0.149***	0.155***		
	[0.0128]	[0.0127]		
Export intensity			0.000393	0.000382
			[0.000451]	[0.000450]
Size	0.746***	0.739***	0.761***	0.755***
	[0.0115]	[0.0119]	[0.0116]	[0.0120]
Young	-0.328***	-0.322***	-0.336***	-0.330***
	[0.0193]	[0.0192]	[0.0193]	[0.0193]
Foreign ownership	0.00284***	0.00231***	0.00290***	0.00236***
	[0.000748]	[0.000745]	[0.000756]	[0.000753]
R&D dummy	0.118***	0.119***	0.122***	0.123***
	[0.0156]	[0.0157]	[0.0157]	[0.0158]
Know how intensity	-0.0016***	-0.0015***	-0.0016***	-0.0015***
	[0.000375]	[0.000317]	[0.000384]	[0.000327]
Finished goods	-0.00271*	-0.00291*	-0.00272*	-0.00292**
	[0.00142]	[0.00150]	[0.00141]	[0.00149]
TFP	-0.00124	-0.00126	-0.00126	-0.00127
	[0.000880]	[0.000867]	[0.000889]	[0.000876]
Time FE	yes	-	yes	-
Time-Industry FE	-	yes	-	yes
Observations	103,704	103,704	103,704	103,704
R-squared	0.389	0.402	0.387	0.399
Number of firms	11,755	11,755	11,755	11,755

Notes: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Firm fixed effects are included in all columns, not reported to save space.

According to the results in column (2) of Table 1, energy expenditure is 15 percent higher in exporter firms in comparison to non-exporter firms. However, an increase in the export intensity does not seem to significantly affect energy expenditure in any of the two specifications in columns (3) and (4) of Table 1.

Concerning the control variables, there are three factors that are positively related to energy expenditure, namely, the size of the firm, foreign ownership and investments in R&D. That is, firms that are bigger, participated by foreign capital or those that innovate tend to have higher energy expenditure on average. Otherwise, younger firms, those that produce final goods and those whose know-how intensity is higher, tend to have lower energy expenditures on average.

With respect to the second dependent variable, energy intensity, the results in column (2) of Table 2 indicate that energy intensity is about 4.4 percent lower in exporter firms in comparison to non-exporter firms. Moreover, an increase in the export intensity also seems to significantly reduce energy intensity in both specifications in columns (3) and (4) of Table 2.

As regards the control variables, there are two factors that are positively related to energy intensity, namely, foreign ownership and know-how intensity. That is, firms participated by foreign capital or those with more know-how intensity have higher energy intensity on average. Otherwise, the size of the firm, younger firms, those that produce finished goods tend to have lower energy expenditures on average. In addition, TFP and R&D activities are not found to be significantly related to energy intensity.

Table 2. Energy intensity and exporting activities

Dep. Var. ln Energy intensity	(1)	(2)	(3)	(4)
VARIABLES	Time FE	Time&Ind FE	Time FE	Time&Ind FE

Export dummy	-0.0523***	-0.0447***		
	[0.0120]	[0.0115]		
Export intensity			-0.00114***	-0.00108**
			[0.000430]	[0.000421]
Size	-0.0921***	-0.0989***	-0.0946***	-0.101***
	[0.0102]	[0.0103]	[0.0102]	[0.0103]
Young	-0.0520***	-0.0408**	-0.0488***	-0.0381**
	[0.0175]	[0.0173]	[0.0174]	[0.0172]
Foreign ownership	0.00269***	0.00241***	0.00270***	0.00242***
	[0.000659]	[0.000660]	[0.000655]	[0.000658]
R&D dummy	-0.00291	-0.00235	-0.00351	-0.00274
	[0.0141]	[0.0137]	[0.0141]	[0.0137]
Know how intensity	0.00335*	0.00340*	0.00335*	0.00340*
	[0.00181]	[0.00188]	[0.00181]	[0.00188]
Finished goods	-0.00315*	-0.00346*	-0.00315*	-0.00347*
	[0.00182]	[0.00195]	[0.00183]	[0.00195]
TFP	-0.00152	-0.00154	-0.00152	-0.00154
	[0.00103]	[0.00102]	[0.00103]	[0.00102]
Time FE	yes	-	yes	-
Time-Industry FE	-	yes	-	yes
Observations	103,593	103,593	103,593	103,593
R-squared	0.058	0.090	0.058	0.090
Number of firms	11,755	11,755	11,755	11,755

Notes: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Firm fixed effects are included in all columns, not reported to save space.

Next, the model with energy intensity as dependent variable is estimated separately for low and high-energy intensity industries. The main results, shown in Table 3 indicate that exporters in high polluting industries have lower energy intensity on average (almost 9 percent lower, according to column (2)). Similarly, energy intensity decreases with export intensity according to the results in column (4), which is the preferred specification that includes time-varying industry dummy variables. The estimated effect is economically small.

Table 3. Heterogeneous effects by energy intensity

Dep. Var: Ln Energy Intensity VARIABLES	(1) LowEnint<5%	(2) HighEnint>10%	(3) LowEnint	(4) HighEnint
Export dummy	-0.0396	-0.0899***		
	[0.0257]	[0.0205]		
Export intensity			-0.000536	-0.00299***
			[0.000683]	[0.000987]
Size	-0.147***	-0.0592***	-0.151***	-0.0605***
	[0.0237]	[0.0162]	[0.0236]	[0.0162]
Young	-0.00589	-0.0372	-0.00290	-0.0291
	[0.0364]	[0.0291]	[0.0363]	[0.0290]
Foreign ownership	0.000714	0.00196**	0.000691	0.00204**
	[0.00103]	[0.000878]	[0.00102]	[0.000857]
R&D dummy	-0.0202	-0.00619	-0.0212	-0.00260
	[0.0295]	[0.0240]	[0.0297]	[0.0243]
Know how intensity	0.00301*	0.0156***	0.00301*	0.0158***
	[0.00170]	[0.00383]	[0.00170]	[0.00379]
Finished goods	-0.000270	-0.0106***	-0.000267	-0.0107***
	[0.000421]	[0.00168]	[0.000423]	[0.00169]
TFP	-0.00711***	-0.000726	-0.00708***	-0.000675
	[0.00268]	[0.000823]	[0.00268]	[0.000806]
Time FE	yes		yes	
Time-Industry FE		yes		yes
Observations	22,316	31,590	22,316	31,590
R-squared	0.095	0.112	0.095	0.113
Number of firms	2,722	3,448	2,722	3,448

Notes: Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1. Firm fixed effects are included in all columns, not reported to save space. Enint denotes energy intensity.

Moreover, given that different explanatory factors could affect energy intensity differently, Table 4 presents specific results for each industry. We focus on two target variables, the export status and the R&D activity dummy. The main estimates for the export status indicate that exporters have a lower energy intensity in most industries, in more than half of them the estimates are statistically significant and negatively signed.

Table 4. Industry Specific Results for Energy Intensity

Dep. Var: Ln Energy Intensity

Industries	Export_dummy	R&D_dummy
Food	0.0310	0.0460
Beverages	**-0.117****	-0.0290
Tobacco	0.207**	**0.298*****
Textiles	**-0.130*****	**0.0651****
Wearing apparel	**-0.117****	0.107
Leather	**-0.203*****	0.107
Wood	0.143*	-0.279*
Paper	-0.0332	-0.0237
Printing & repro	-0.0688	-0.245
Coke & refined petroleum	**-0.371*****	-0.661***
Chemicals	**-0.0339****	**0.0927*****
Pharmaceuticals	**-0.0558****	0.0182
Rubber & plastic	0.00199	0.0411
Other non-metal	**-0.0760*****	0.00753
Basic metals	**-0.0935*****	**0.0956*****
Fabricated metal	-0.00128	-0.0164
Computer, electronics	**-0.145*****	-0.0885**
Electrical equip	**-0.0605****	-0.0266
Machinery & equipment	0.0315	**0.108*****
Motor vehicles	**-0.167*****	**0.101***
Other transport	0.0408**	**0.0942*****
Furniture	-0.133	-

Note: *** p<0.01, ** p<0.05, * p<0.1.

Finally, Table 5 shows the results from a difference in differences estimation in which exporter and non-exporter firms are compared before and after 2000. For this estimation the sample in restricted to end in 2017 to avoid the years after the financial crisis. The results of the interaction between the period dummy and the exporter dummy indicate that the energy intensity is around 9.5 lower for exporters in comparison with non-exporters after 2000s. Since the trade liberalization was completed by the end of the 1990s, we expect that the effect found before in Table 1 is more pronounced in the early

2000s, and this is what Table 5 shows.

Table 5. DID before and after 2000

Dep var: ln Energy Intensity VARIABLES	(1) DID	(2) DID (with covariates)
Period	0.125***	0.0656***
	[0.0157]	[0.0186]
Export dummy	-0.263***	-0.199***
	[0.0150]	[0.0171]
Period*export dummy	-0.134***	-0.0951***
	[0.0246]	[0.0208]
Size		0.0375***
		[0.00432]
Young		-0.293***
		[0.0207]
Foreign ownership		-0.00440***
		[0.000209]
R&D dummy		-0.180***
		[0.0144]
Know how intensity		-0.0249***
		[0.00812]
Finished goods		-0.0179***
		[0.00374]
TFP		-0.000565
		[0.00178]
Observations	57,313	55,271
R-squared	0.017	0.067

Note: Robust standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions

This paper finds robust evidence that Indian exporters use more energy and have lower energy intensity than non-exporters in the Indian manufacturing sector. A panel data model that controls for unobserved heterogeneity has been estimated using firm level data over time for a panel of firms across all manufacturing industries in India. The results show that exporting increases the amount of energy used by these firms and decreases their energy intensity. The fact that exporters have higher energy productivity indicates that trade liberalization can induce an improvement in environmental performance in production. Furthermore, the results suggest that these effects are not uniform across industries and, hence, firm heterogeneity plays a role when examining the influence of internationalization on environmental performance. The results obtained from different industries indicate that in high polluting industries, exporters seem to be much more energy efficient than non exporters in comparison to low polluting industries, where there is no difference between exporters and non-exporters in terms of energy intensity.

Therefore, targeting policies that promote export support for firms in industries with high-energy intensity will benefit the environment more than supporting industries with lower initial energy intensity. Generalizing answers about the aggregated effect of trade on the environment are not sufficient to give policy recommendations. Analysis at the level of the firm allows us to obtain more specific results.

Finally, energy generation will always come at a certain cost for the environment. When trying to bring economic prosperity into accordance with environmental protection and climate change mitigation, overall reduction in energy intensity is a must. Since differences in terms of environmental performance exist between different sources of energy, targeted policies to encourage firms to use cleaner energy will, therefore, result in a strong improvement of the environmental performance of firms. This, however, is only feasible if cleaner sources of energy are available. In conclusion, a combination of cleaner energy sources, industry-specific policies and the inclusion of export-inherent costs for the environment in the analysis are important steps towards the compatibility of economic and environmental goals.

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Figure 1. Energy intensity by industry over time

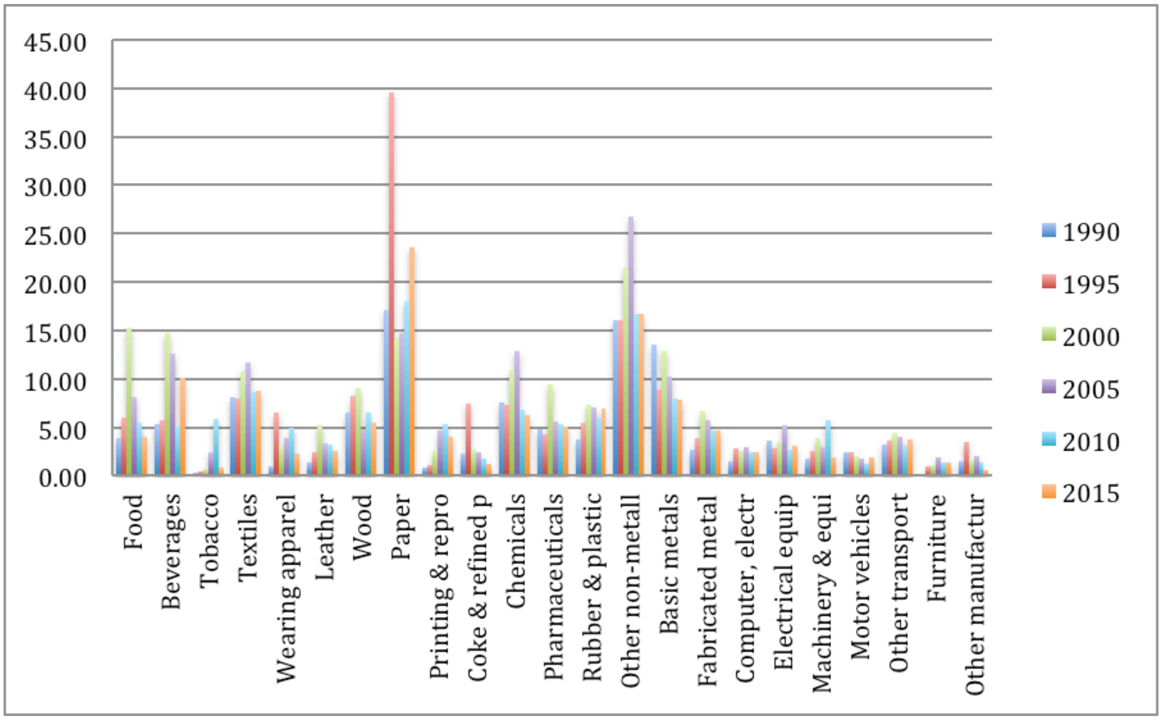

Table A.1. Variable Definitions and expected signs

Variable	**Definition/ description**	**Expected sign EU = energy use EI = energy intensity**
Energy use	Power and fuel expenses (log)	Dependent var
Energy intensity	Ratio of power and fuel expenses to sales in percent (log)	Dependent var
Export activity (dummy)	=1 if a firm generates earnings by exporting parts or all of its production	EU: + EI: -
Export Intensity	Ratio of export earnings to sales	EU: + EI: -
Size	Total assets (log)	EU: + EI: ?
Firm age	The age of the firm (year of observation minus year of incorporation)	EU: ? EI: ?
Young (dummy)	replace young = 1 if !missing(firm_age) & firm_age<=5	EU:? EI: +
Foreign Ownership (share)	Share of firm equity held by foreign promoters (%)	EU: + EI: ?
R&D intensity	Ratio of R&D expenses to sales (%)	EU: ? EI: ?
R&D (dummy)	=1 if a firm´s R&D intensity (ratio of R&D expenses to sales) is higher than 0%	EU: ? EI: ?
Know-how intensity	Ratio of the sum of spending for royalty, technical know-how fees and license fees to sales (%)	EU: ? EI: -
Finished goods intensity	Ratio of the spending for finished goods to sales	EU: - EI: -
TFP	Total factor productivity of a firm	EU: ? EI: -

Table A.2 Average Energy Intensity by Industry

Industry	**Energy Intensity**
Food	6.92
Beverages	8.37
Tobacco	2.10
Textiles	10.09
Wearing apparel	4.21
Leather	6.49
Wood	6.44
Paper	21.00
Printing & reprography	4.92
Coke & refined petroleum	4.88
Chemicals	8.81
Pharmaceuticals	6.68
Rubber & plastic	7.16
Other non-metal	19.70
Basic metals	11.04
Fabricated metal	5.51
Computer, electronics	3.08
Electrical equip	3.66
Machinery & equipment	5.81
Motor vehicles	2.58
Other transport	4.23
Furniture	1.60
Other manufactures	1.73
Average	8.202