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**ADB Working Paper Series**

**TRADE, FOREIGN DIRECT INVESTMENT,  
AND POLLUTION ABATEMENT**

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**Abstract**

This paper analyzes the impact of tariff liberalization and foreign direct investment on pollution from a plant-level perspective. It considers how globalization impacts plant-level investment in pollution abatement expenditure. Popular hypotheses on trade and pollution cite the pollution haven effect—that trade leads to a worsening of environmental conditions in developing countries. By analyzing the differential impact of input and output tariff liberalization, however, this paper finds that input tariff liberalization actually induces plants to invest more in pollution abatement equipment. Further, it finds that an increase in competition through output tariff liberalization does not in fact lead to a decline in spending on pollution control equipment in order to cut costs, as some theories might suggest. Further, it also finds a positive impact of increased inflows of foreign direct investment on spending in pollution control equipment, arguably through access to cleaner foreign technology. These effects are mainly driven by states that are newly emerging as the main attractions for foreign direct investment.

**Keywords:** pollution control capital, input tariffs, foreign direct investment, plant heterogeneity, India

**JEL Classification:** Q52, F61, F64, F18

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# 1. INTRODUCTION

The evidence on the effects of international trade and investment on the levels of pollution in developing countries is highly inconclusive. Most studies examine this question by understanding the impact of trade liberalization on emissions, such as levels of nitrogen dioxide and sulfur dioxide in a particular region or country. This paper uses a more direct method of investigating how international trade and investment might be impacting plant-level behavior towards pollution, by examining plants' spending on pollution abatement equipment. In doing so, it provides a new approach to understanding the relationship between trade, investment, and pollution from an applied microeconomics perspective. To the best of my knowledge, this is the first plant-level study to examine the effects of tariff liberalization on pollution abatement expenditure in a developing-country context. It is also the first study to consider the differential effects of output and input tariff liberalization on plant-level pollution abatement expenditure.

A popular hypothesis regarding the impact on trade and labor is that of Copeland and Taylor (2003). They posit that with increased international trade, developing countries are becoming pollution havens, attracting investment and exporting goods in industries where regulations are typically more lax than in developed countries. Developing and less developed countries have thus been known to develop a "comparative advantage" in industries known for generating high levels of pollution as lax regulations allow them to produce goods at lower cost than their developed-country competitors. The increase in exports due to their sustained comparative advantage worsens the levels of pollution in their respective countries, thereby adversely affecting the environmental conditions. Trade is therefore known to have an adverse impact on the environment of developing countries.

Various studies have empirically tested this hypothesis and have found conflicting results. Cole (2004) finds evidence of pollution haven effects, although these are small compared to the role of other explanatory variables. Levinson (2009), on the other hand, examines this in the context of the US manufacturing sector and finds that pollution levels in the US have declined in the past 30 years, but the main contributing factor is in fact investment in pollution abatement technology and not the change in the mix of goods manufactured. Further, he shows that increases in net imports of pollution-intensive goods do not play an important role in explaining the reduction in pollution in the US, leading him to conclude that the shifting of pollution-intensive industries overseas is not mainly responsible for the reduction of the levels of pollution in the US. In the context of India, Kathuria (2018) uses data from the manufacturing sector to create an index to compare abatement costs in a particular region (state) at an aggregate level after adjusting for industrial composition, and further measures whether lower-abatement-cost regions experience higher FDI flows. He finds no evidence of the pollution haven hypothesis in the case of India. Melo et. al (2012) find that the magnitude of the polluting effect through delocalization of activities for regional pollutants is small, although the effects might be present.

This analysis, however, considers the differential impact of output tariffs and input tariffs on plant-level investment in pollution abatement technology. It draws from the literature that studies the differential effect of output and input tariffs on firm-level productivity and wages. Amiti and Konings (2007) find that input tariff liberalization has a bigger impact on firm-level productivity than output tariffs. This has been confirmed in the case of India by Topalova and Khandelwal (2011) for an analysis of India's manufacturing sector. In fact, Goldberg et al. (2010) also find that input tariff liberalization allows for increased

access to a variety of inputs, which allows firms to produce various kinds of products, thereby increasing their market access.

In a study more relevant to this paper, Bas and Berthou (2012) study the effect of input tariff liberalization on foreign technology adoption for Indian firms. They show both theoretically and empirically that a reduction in input tariffs causes firms to source foreign technology in the form of capital goods from abroad. Further, Bas and Strauss-Kahn (2015) show that input tariff liberalization in the Chinese context led to imports of higher-quality products. Sharma (2018a) shows that plants can import out of quality, cost, or variety concerns, and plants that import inputs of a better quality also experience an increase in skill composition. The plants that are quality conscious might also seek access to better production technologies in terms of pollution abatement equipment.

In this paper, I investigate whether tariff liberalization or increased FDI inflows allow plants to access superior technology in terms of pollution abatement equipment. Do quality-conscious plants extend their quality consciousness to environmental standards? One can expect output tariff liberalization to have a negative effect on pollution abatement expenditure, as increased competition might pressurize plants to cut costs and maintain their comparative advantage. On the other hand, as input tariffs liberalize, through complementarities between superior technology and imports of intermediate inputs, one might expect an increase in investment in pollution abatement technology. Similarly, an increase in FDI at the industry level might increase access to better, cheaper abatement technology, or improve the quality consciousness of plants, thereby causing them to improve plant-level environmental standards and invest more in pollution control equipment.

I study this in the Indian context using plant-level data from the Annual Survey of Industries. This is the most comprehensive survey of the Indian manufacturing sector. The tariff data have been obtained from the World Bank WITS database<sup>1</sup>, and the period under consideration is 2002–2008. The data for foreign direct investment is from the National Council for Applied Economic Relations, and the period of analysis is 2000–2006. I find that a decline in input tariffs induces plants to spend more on pollution control capital, while a decline in output tariffs has no significant effect on the same. Secondly, I find that with an increase in inward FDI, there is also a positive impact on plant-level spending on pollution abatement equipment. This is mainly driven by states that are emerging in terms of attracting FDI, where the spillover effects are likely the strongest.

The paper is divided into six sections. Section 2 provides a summary and statistics from the plant-level, tariff, and FDI data used for this analysis. The empirical strategy used for the analysis is presented in Section 3. A discussion of the empirical findings using the data and based on the empirical strategy can be found in Section 4. In Section 5, I show that the results are robust to alternative specifications. A concluding discussion is presented in Section 6.

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<sup>1</sup> WITS-TRAINS, <http://wits.worldbank.org/WITS/WITS/Default-A.aspx?Page=Default>.

## 2. DATA AND SUMMARY STATISTICS

### 2.1 Plant-Level Data

This study focuses on India's manufacturing using the most comprehensive plant-level data set available from the Annual Survey of Industries (ASI) by the Ministry of Statistics and Planning in India. The data contain information on various plant-level characteristics, including that of workers employed by the plant, and on products produced by the plant. Further, it provides information on various capital outlays by the plant, including information on "pollution abatement capital," which is important for this study. This data on pollution abatement equipment used by plants is available from the year 2002. For the analysis relating to tariff liberalization, the period under analysis is 2004–2008 and has a total of 2,259 plant-year observations. The summary statistics are presented in Table 1. Based on the data available for FDI, the period of analysis is 2002–06 and comprises a total of 6,633 observations. The summary statistics used in this panel are presented in Table 2.

**Table 1: Summary Statistics for Tariff Panel**

Log(Total Workers)	5.764 (1.136)
Log(Total Pollution Control Capital)	15.08 (2.350)
Log(Fixed Capital)	19.58 (1.811)
Log(Working Capital)	18.03 (1.916)
Log(Total Sales)	20.47 (1.895)
Input Tariff	2.395 (1.269)
Output Tariff	16.52 (8.779)
Observations	2,259

**Table 2: Summary Statistics for FDI Panel**

Log(Total Workers)	5.975 (0.956)
Log(Total Pollution Control Capital)	14.80 (2.208)
Log(Fixed Capital)	19.54 (1.621)
Log(Working Capital)	17.94 (1.852)
Log(Total Sales)	20.19 (1.707)
Log(FDI)	16.91 (1.792)
Observations	6,633



### 2.2.1 Input Tariffs

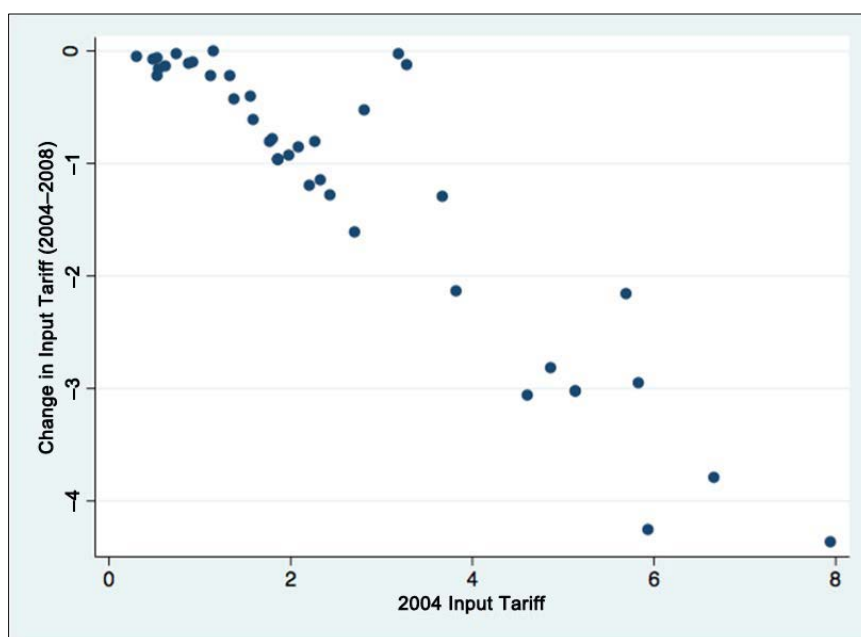
Changes in output tariffs as well as input tariffs are used for identification in the empirical exercise of this paper. While output tariffs are the tariffs on the final product category produced by the plant (a reduction in these tariffs would induce greater competition from imports in the industry), input tariffs are the tariffs on inputs used by the plants in the production process. A reduction of input tariffs would reduce the price of imports of these inputs, and thus induce a plant to import more such inputs. In order to calculate input tariffs, industry-level shares of inputs used by a particular industry are calculated. The formula used in order to calculate the same has been given as follows, where an industry (j) uses inputs from various other industries (k):

$$Inputtariff_{jt} = s_{jk} * finalgoodstariff_{kt}$$

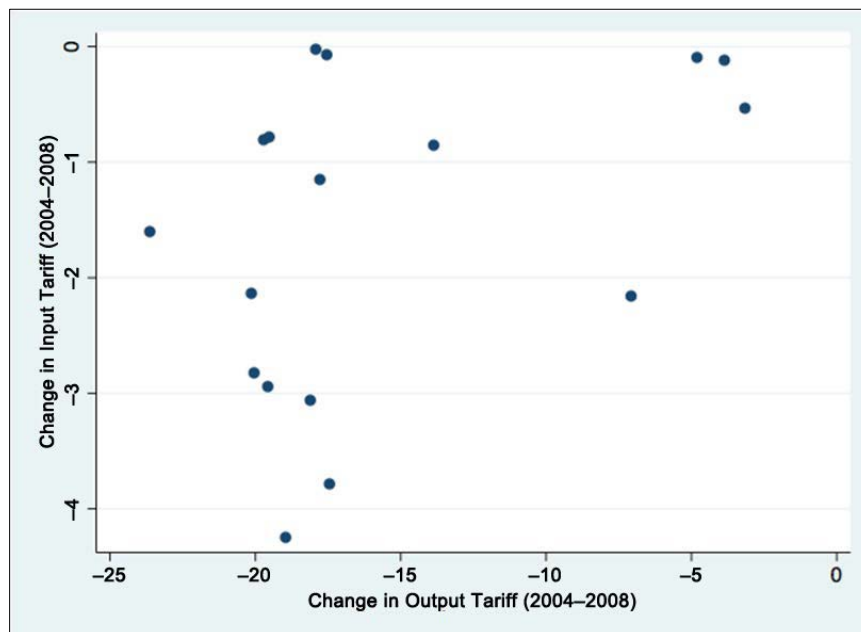
In order to produce output j, the share of input used from industry k is denoted by  $s_{jk}$ . Input-output (IO) tables from India's Central Statistical Organization have been used to obtain these shares. These shares have been obtained from the tables for the year 2003, which is the year before the period of analysis (2004–2006), and these don't change for the period under consideration. Output tariffs are collected from the World Bank Database at the three-digit level of NIC. I use a concordance from Ahsan (2013) to map the sector codes from the input-output tables to the three-digit National Industrial Classification (1998) codes for the input tariff data.

For the period under consideration (2004–2008), output and input tariffs both declined, as part of India's ongoing trade reform process. It can be inferred that the rule followed by policymakers was to reduce significantly the tariffs on industries that began with high output and input tariffs. Figure 1 reflects this strategy. Also, no strong correlation exists between changes in input tariffs and changes in output tariffs at the three-digit level, with a correlation coefficient of 0.41 (Figure 2).

**Figure 1: Change in Input Tariffs Relative to Initial Tariff Levels**



Note: Based on author's calculations. Data are from WITS-TRANS, <http://wits.worldbank.org/WITS/WITS/Default-A.aspx?Page=Default>.

**Figure 2: Correlation between Change in Input and Output Tariffs**

Note: Based on author's calculations. Data are from WITS-TRAINS, <http://wits.worldbank.org/WITS/WITS/Default-A.aspx?Page=Default>.

### 2.2.2 India's Tariff Liberalization

One may assume that post 1991, tariff liberalization in India was exogenous, especially because it was a response to its balance of payments crisis in August 1991 and due to pressures from the International Monetary Fund to liberalize. This change in trade policy as part of India's economic reform was unanticipated by plants. Since then, India has been reducing tariffs as part of the structural adjustment program. India has also been reducing its tariffs as per the guidelines of the World Trade Organization as a member since 1995. There have been, however, some concerns regarding the endogeneity of trade reform in recent years, especially because the pressure from the IMF may have abated, or due to possible government protection of laggard industries, or lobbying from industries to lower tariffs on upstream industries.

I try to address these issues by running robustness checks in this paper. The tests try to determine whether there is any significant relationship between changes in tariffs and the size of the industry. Previous studies that also consider tariffs for identification in the same period in India have conducted similar tests. One such study that considers input tariffs during the same period as this paper to analyze the impact of imports on contract enforcement finds no relationship between total factor productivity at the industry level and input tariffs (Ahsan 2013). I extend this test to consider whether industry size, as measured by various variables, might have any effect on input tariffs. This is to rule out the possibility that big industries, which may not be as productive as others, may also have influenced trade policy. I regress input tariffs at the three-digit NIC level on various measures of industry size (lagged), such as total sales and total employment. The estimation results reveal that there is no significant relationship between input tariffs and industry size (Models 1 and 3, Table 3) or between output tariffs and industry size (Models 2 and 4, Table 3).

**Table 3: Endogeneity Tests for Input and Output Tariffs**

	(1) Input Tariff	(2) Output Tariff	(3) Input Tariff	(4) Output Tariff
Lagged Log(Total Workers)	−0.0907 (0.676)	−3.561 (3.631)		
Lagged Log(Total Sales)			−0.147 (0.458)	−2.217 (2.445)
Constant	2.860 (6.906)	4.380 (6.846)	5.563 (11.33)	−1.857 (1.422)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Observations	72	72	72	72
Adjusted $R^2$	0.529	0.530	0.530	0.570

Standard errors in parentheses.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

## 2.2 Data on Foreign Direct Investment

This study uses FDI data available from a report by the National Council of Applied Economic Research in 2009 using data from the Department of Industrial Policy and Promotion (DIPP). The report uses statistics from the Reserve Bank of India. Data are available for the years 2000–2006. I have used inward FDI flows at the three-digit NIC 1998 level—these were obtained using a concordance provided in the report that maps the DIPP’s sector-level codes to the three-digit NIC 2004 codes, and further using a concordance between three-digit NIC codes from 2004 to 1998 provided on the Ministry of Commerce and Industry website. For this analysis, a total of 75 industries have been included in the manufacturing sector with significant variation across industries. Because the data on pollution control equipment are only available from 2002 in the ASI, data have been considered for the years 2002–2006.

Studies on inward FDI in India investigate the determinants of FDI inflows into the country. Banga (2003) examines the role of the investment policies of various states in attracting FDI. She finds that developing economies are able to attract FDI from developed economies by removing restrictions on FDI, whereas in order to attract FDI from other developing economies, fiscal incentives and bilateral treaties play a more important role. Another study (Aggarwal 2005) finds that rigid labor market institutions, while discouraging both domestic-market-seeking and export-oriented FDI, have a stronger impact on domestic-market-seeking FDI.

Thus, inflows of FDI are impacted by state-level policies. This causes FDI in India to be highly regionally concentrated. According to Mukherjee (2011), other state-level factors that have a positive and significant role are the size of the services and manufacturing base in a state, the market size, and the agglomeration effect. Labor costs and taxation policies, on the other hand, negatively impact FDI inflows.

Given these findings, it becomes important to control for these effects in empirical investigations that study the relationship between FDI and plant-level outcomes. My regressions control for these effects, and additionally, I also divide all states into three regions—low-FDI-receiving states, those receiving medium FDI inflows, and those receiving high inflows of FDI.

### 3. ESTIMATION STRATEGY

In order to understand the differential effects of input and output tariffs on expenditure in pollution abatement capital by plants, I estimate the following specification:

$$\log \text{pollutioncapital}_{it} = \alpha + \beta_1 \text{inputtariff}_{it} + \beta_2 \text{outputtariff}_{it} + \beta_4 X_{it} + \theta_i + \theta_t + \varepsilon_{it} \quad (1)$$

Input tariff and output tariff vary at the four-digit NIC level.  $X_{it}$  controls for the size of the plant; in this case, size is measured as total employment. Fixed effects,  $\theta_i$ , control for any unobserved time-invariant characteristics of the plant that might affect the coefficients.  $\theta_t$  controls for time fixed effects—any year-wise changes that affected all plants equally and could potentially influence the relationship being estimated. Standard errors are robust and have been clustered at the four-digit industry-year level.

Here, I expect  $\beta_1$  to be negative, which implies that as tariffs decline, plants spend more on pollution control equipment. One can expect that with an increase in access to imported intermediate inputs, both directly and indirectly through importing suppliers, plants might gain access to superior, cleaner technologies. Further, I expect  $\beta_2$  to be positive, because with increased competition, a decline in tariffs on the final good might motivate plants to cut costs and reduce expenditure on pollution abatement equipment, especially if environmental regulations are not stringent.

Further, I investigate whether these effects are differential for plants that import more intermediate inputs. From Bas and Berthou (2012) we know that there are complementarities between importing foreign capital and plants that import intermediate inputs. Does this extend to spending on pollution abatement equipment? Below is the specification I estimate:

$$\log \text{pollutioncapital}_{it} = \alpha + \beta_1 \text{inputtariff}_{it} + \beta_2 \text{shareimportedinputs}_{it} + \beta_3 \text{inputtariff}_{it} * \text{shareimportedinputs}_{it} + \beta_4 \text{outputtariff}_{it} + \beta_5 X_{it} + \theta_i + \theta_t + \varepsilon_{it} \quad (2)$$

Finally, as a control for exporting behavior, following Bernard and Jensen (1997), I use a proxy that measures the size of the plant. In this case, it is the log of total employment. In order to make it easier to interpret, a model in Table 3 (Model 4) also considers log total employment centered around its mean.

$$\log \text{pollutioncapital}_{it} = \alpha + \beta_1 \text{inputtariff}_{it} + \beta_2 \text{shareimportedinputs}_{it} + \beta_3 \text{inputtariff}_{it} * \text{shareimportedinputs}_{it} + \beta_4 \text{outputtariff}_{it} + \beta_5 \log \text{total employment}_{it} + \beta_6 \text{outputtariff}_{it} * \log \text{total employment}_{it} + \theta_i + \theta_t + \varepsilon_{it} \quad (3)$$

I move on to analyzing the effects of FDI on  $\log \text{total pollution capital}$ . Below is the specification I estimate:

$$\log \text{pollutioncapital}_{it} = \alpha + \beta_1 \log \text{FDI}_{it} + \beta_2 \log \text{total employment}_{it} + \beta_3 \log \text{FDI}_{it} * \log \text{total employment}_{it} + \theta_i + \theta_t + \varepsilon_{it} \quad (4)$$

Here again, FDI varies at the three-digit NIC industry level. With access to better technology in the industry through increased FDI, one can expect an increase in the investment on pollution abatement equipment; for this we expect  $\beta_1 > 0$ .

## 4. ESTIMATION RESULTS AND DISCUSSION

Table 4 considers the impact of input and output tariffs on the opening stock of log(pollution capital). The first model considers the effect of input tariff only. The coefficient on input tariffs is negative and significant at the 5% level, suggesting that as input tariffs in their respective industries decline, plants spend more on pollution abatement equipment. This corroborates the hypothesis that input tariff liberalization, with access to better inputs and superior technology, actually improves the quality consciousness of a plant, and induces it to invest more in FDI. In Model 2, the impact of a decline in output tariffs only is considered. The impact of output tariffs on logpollutioncontrolcapital turns out to be positive, but insignificant. The positive coefficient suggests that an increase in competition might induce plants to cut costs and reduce investment in pollution control capital. This effect, however, is insignificant. The third model considers the impact of both input and output tariffs on pollution control equipment. The inclusion of output tariffs does not affect the sign or significance of the coefficient on input tariffs. The coefficient on output tariffs continues to be positive and insignificant. In the final model, logtotalemployment as a measure of plant size is introduced with both tariffs. I find that the effects remain the same, negative and significant on input tariffs and positive and insignificant on output tariffs. This exercise corroborates the hypothesis that tariff liberalization might actually motivate plants to adhere to higher environmental standards, especially with access to cheaper and technologically superior inputs, which brings down the cost of production and provides better access to cleaner technologies. Furthermore, there is no strong evidence of the fact that increased competition through trade has an adverse impact on investment in pollution abatement equipment.

**Table 4: Impact of Input and Output Tariff on Pollution Control Expenditure**

	(1) Log(Total Pollution Control Capital)	(2) Log(Total Pollution Control Capital)	(3) Log(Total Pollution Control Capital)	(4) Log(Total Pollution Control Capital)
Input Tariff	-0.0502** (0.0237)		-0.0620** (0.0223)	-0.0586** (0.0195)
Output Tariff		0.00207 (0.00466)	0.00526 (0.00408)	0.00539 (0.00403)
Log(Total Workers)				0.169** (0.0660)
Constant	15.07*** (0.0816)	14.86*** (0.126)	14.97*** (0.136)	13.99*** (0.370)
Year FE	Yes	Yes	Yes	Yes
Observations	2,259	2,259	2,259	2,253
Adjusted $R^2$	0.038	0.036	0.038	0.047

All regressions include plant fixed effects. Standard errors are robust and clustered at the three-digit NIC year level. Standard errors in parentheses.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

In the next set of analyses, I consider another aspect of globalization—foreign direct investment. Table 5 examines the effect of inward FDI on log pollution capital. Inward FDI is considered at the three-digit NIC industry level. Model 1 considers the impact of inward FDI only, and the coefficient on logFDI is positive and significant at the 10% level, suggesting that increased inflows of FDI in an industry a plant belongs to are associated with higher levels of spending on pollution abatement capital, i.e., as an industry gets more globalized in terms of increased inflows of FDI, plants start investing more in pollution abatement equipment. Model 2 controls for plant size by including log total employment, and I find that the coefficient on Log FDI continues to be positive and significant. Given that FDI inflows are influenced by state legislations as highlighted in Section 3.3, I control for state fixed effects in Model 3 and state-year fixed effects in Model 4. I find that effects on FDI on spending on pollution control capital continue to be positive and significant.

**Table 5: Impact of FDI on Pollution Control Expenditure**

	(1) Log(Total Pollution Control Capital)	(2) Log(Total Pollution Control Capital)	(3) Log(Total Pollution Control Capital)	(4) Log(Total Pollution Control Capital)
Log(FDI)	0.0134 <sup>*</sup> (0.00726)	0.0126 <sup>*</sup> (0.00706)	0.0126 <sup>*</sup> (0.00706)	0.0126 <sup>*</sup> (0.00660)
Log(Total Workers)		0.0830 <sup>***</sup> (0.0246)	0.0830 <sup>***</sup> (0.0246)	0.0746 <sup>***</sup> (0.0223)
Constant	14.45 <sup>***</sup> (0.115)	13.96 <sup>***</sup> (0.197)	13.96 <sup>***</sup> (0.197)	14.15 <sup>***</sup> (0.176)
Year FE	Yes	Yes	Yes	No
State-year FE	No	No	No	Yes
State FE	No	No	Yes	No
Observations	6,493	6,485	6,485	6,485
Adjusted $R^2$	0.024	0.025	0.025	0.028

All regressions include plant fixed effects. Standard errors are robust and clustered at the three-digit NIC year level. Standard errors in parentheses.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

## 5. ROBUSTNESS CHECKS

In this section, I consider robustness checks for the analysis relating to the impact of tariff liberalization on pollution control equipment, and a region-wise analysis on the impact of FDI. The robustness checks for the tariff liberalization analyses are presented in Table 6. Here, I consider the differential effects of input tariffs and output tariffs on importing and non-importing plants, as well as potentially exporting and non-exporting plants. While information on the exporting status of plants is not available, following Bernard and Jensen (1997), I use the size of the plant as a proxy for exporting behavior. Model 1 considers the share of imported intermediate inputs in the total inputs purchased by the plant. I find that on average, there is no significant difference between plants that import intermediate inputs and plants that do not in terms of expenditure on pollution control equipment. Model 2 includes the interaction of this share of imported intermediate inputs with input tariffs. I do not find that there are any differential effects of directly importing intermediate inputs. One explanation is that there could be a large supply of imported inputs that plants access through domestic suppliers. The coefficient on input tariffs continues to be negative and significant, suggesting that access to these inputs

plays an important role in pollution abatement expenditure. Model 3 considers the interaction term of two continuous variables, output tariffs and log total employment, to show that plants that have more workers (or are bigger in size and thus more likely to export) invest more in pollution equipment as output tariffs decline than plants that are smaller in size. This, however, is not very informative, as the differential effect is between plants with nonzero workers and those with zero workers. To make this more informative, Model 4 centers log total employment around the mean, so we can compare the effect of a decline in output tariff between plants that are mean-sized and higher and plants that are below the mean size. I find that there are no differential effects on spending in pollution control equipment based on potential exporter status. This suggests that exporters and nonexporters are equally unlikely to reduce investment in pollution control equipment as competition increases through a decline in output tariffs.

**Table 6: Differential Effects for Importing and Potentially Exporting Plants**

	(1) Log(Total Pollution Control Capital)	(2) Log(Total Pollution Control Capital)	(3) Log(Total Pollution Control Capital)	(4) Log(Total Pollution Control Capital)
Input Tariff	-0.0582** (0.0172)	-0.0794** (0.0236)	-0.0791** (0.0261)	-0.0689** (0.0255)
Share of imported expense (%)	0.00291 (0.00224)	-0.000957 (0.00347)	-0.000753 (0.00344)	-0.000462 (0.00328)
Output Tariff	0.00540 (0.00401)	0.00519 (0.00411)		
Log(Total Workers)	0.187** (0.0834)	0.188** (0.0822)	0.172** (0.0786)	
shareInputTariff		0.00138 (0.00102)	0.00130 (0.00101)	0.00121 (0.000949)
outputWorkers			0.000999 (0.000712)	
cOutputWorkers				0.00232 (0.00215)
Centered Log(Total Workers)				0.151** (0.0625)
Constant	13.87*** (0.481)	13.93*** (0.447)	14.00*** (0.437)	14.93*** (0.0968)
Year FE	Yes	Yes	Yes	Yes
Observations	2,200	2,200	2,200	2,200
Adjusted $R^2$	0.053	0.054	0.055	0.054

All regressions include plant fixed effects. Standard errors are robust and clustered at the three-digit NIC year level. Standard errors in parentheses.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

Based on the extensive literature on FDI inflows in India, which highlights the concentration of FDI to certain regions, and the role of state-level policies in determining the same, I conduct a region-wise analysis on the impact of FDI on plant-level pollution abatement. I divide the regions into low FDI recipients, medium FDI recipients, and high FDI recipients and investigate the effects. The results are presented in Table 7. I find that most of the effects are driven by states receiving medium FDI. This is an interesting finding, and perhaps suggests that for the time period under consideration, the effects of

access to better technology for pollution abatement were most important for regions that were becoming more prominent in terms of contenders for inward FDI. Sharma (2018b) argues that a critical mass of FDI needs to be achieved in a region before the spillover effects are actually experienced by plants. Thus, these benefits are not yet experienced by plants in states that receive small inflows of FDI. On the other hand, it's also possible that those that received high levels of FDI, had already benefitted from access to technology and plant-level spillovers, and therefore no longer experience such benefits from increased investments.

**Table 7: Regional Heterogeneity in Differential Effects of FDI**

	Low FDI	Medium FDI	High FDI
	Log(Total Pollution Control Capital)	Log(Total Pollution Control Capital)	Log(Total Pollution Control Capital)
Log(FDI)	0.0136 (0.0138)	0.0324 <sup>*</sup> (0.0190)	0.0105 (0.00816)
Log(Total Workers)	-0.116 (0.0738)	0.273 <sup>***</sup> (0.0515)	0.0437 <sup>**</sup> (0.0217)
Constant	14.25 <sup>***</sup> (0.439)	12.52 <sup>***</sup> (0.470)	14.32 <sup>***</sup> (0.215)
Year FE	Yes	Yes	Yes
Observations	470	1,030	4,970
Adjusted $R^2$	0.026	0.036	0.027

All regressions include plant fixed effects. Standard errors are robust and clustered at the three-digit NIC year level. Standard errors in parentheses.

\*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.001$ .

## 6. CONCLUSION

This paper considers the impact of globalization, both in terms of tariff liberalization and inward FDI, on plant-level pollution abatement expenditure. In the debate on the impact of trade and investment on pollution, it adds a new perspective—a microeconomic foundation for understanding how plants behave in a globalized environment. The analyses focused on tariff liberalization consider the differential impact of output and input tariffs on plant-level expenditure in pollution control equipment. I find that input tariff liberalization, through increased access to better technology, induces plants to invest more in pollution control equipment. Further, a decline in output tariffs that increase competition in an industry does not seem to play an important role in discouraging plants from investing in pollution abatement capital, as the pollution haven theories might indicate. The second main analysis focuses on the role of FDI. I find that with increased inflows of FDI in their industry, plants get access to better, cleaner technologies, which is complementary to higher spending on pollution abatement capital. The effect, although less strong, is similar to that of access to imports of intermediate inputs. This is robust to the inclusion of state-year fixed effects, and state fixed effects, as various studies on India suggest that FDI inflows are highly regionally concentrated. I further analyze the relationship between FDI and pollution abatement equipment across regions—I divide the states into low FDI, medium FDI, and high FDI recipients. I find that plants in states that are medium FDI recipients largely drive this effect. These states are relatively new in terms of receiving inflows of FDI compared to other states (high FDI recipients) that have been receiving these flows historically. Thus, they are still enjoying the spillover effects of better technology access as industry-level inflows of FDI increase.



The findings in this paper suggest that it is important to understand the relationship between trade, investment, and pollution from a microeconomic perspective. From a policy perspective, it is an interesting finding that input tariffs can actually induce plants into spending more on pollution abatement equipment. Further, it is also informative that spending on pollution abatement equipment might not be affected by increased competition in the industry. Overall, these findings add a new dimension to the whole debate on globalization and pollution, by focusing on an aspect aside from levels of pollutants in a region, but actually understanding plant-level behavior in terms of investment in pollution abatement.

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