The Effects of Increased Environmental Enforcement on Manufacturing Firms: Firm and Product Level Evidence from India

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Abstract:

This paper uses firm and product level data to identify the effects of environmental regulation in India. Environmental enforcement was devolved to the states in India in 1997, prior to which enforcement occurred only through the courts which were too slow-moving to be effectual. In addition to firm level financial data for 2500 firms from 1992-2005 and firm-product level data for 8000 firm-product combinations over the same period, this paper uses state level data on firm closures and firms listed as defaulting by the state regulatory agencies which focus on 17 highly polluting industries for 1997-2005. State level enforcement variables are weighted by the intensity with which the dirty industries are used in production by each 2-digit manufacturing industry in order to differentiate the effect on manufacturing firms most directly affected by changes in enforcement on dirty input suppliers.

I find that enforcement through firm closures has a negative effect on productivity, but enforcement through fines and regulations has a positive impact on productivity. The effect of closures on firm productivity is in excess of the direct effect on the closed firms: effects are measured on downstream manufacturers. Several instruments are proposed in order to ensure the robustness of the results to potential endogeneity arising from legislative responses to more productive firms requesting special treatment or legislators avoiding imposing constraints on the firms most likely to have strong productivity responses. The results are robust to use of a Herfindahl index for dirty industries by state and year, although the instrument is quite weak.

The mechanism through which enforcement affects firm productivity is considered in a Bernard, Redding and Schott product choice framework. I find that firms are more likely to drop products which use pollution intensive raw materials as environmental enforcements are increased. The propensity to drop pollution intensive products decreases as fixed costs increase, but high productivity firms are more likely to drop the pollution intensive goods as fixed costs go up. Similar effects are not, however, found for the propensity to add pollution intensive products.

Introduction

Environmental regulation in developing countries has been a highly controversial issue. Negotiation over the optimal level of environmental regulation in developing countries was a primary difficulty in reaching accord during the Kyoto protocol. It has been argued that high levels of regulation put an undue burden on newly developing economies by restricting their growth. However, it is also possible that increased enforcement pushes less productive companies out of producing certain goods, and thereby increases productivity. Improved enforcement could foster Schumpeterian "creative destruction" if less productive companies producing highly polluting products respond to regulations by dropping from the market and new cleaner companies are formed. Similarly, companies which produce dirty products may drop pollution intensive products when environmental enforcement increases and begin production with cleaner technologies. Although there has been significant work on the effects of changes in regulations on manufacturing productivity, the firm level changes in product mix in response to changes in environmental regulations in developing countries has not yet been empirically examined to the best of the author's knowledge.

Alternative types of regulations and enforcement have quite different effects on the firm. While restrictions which impede production and reduce incentives for creative adaptation to new regulations reduce productivity, enforcement mechanisms which allow companies to adjust to the policies may have a lower direct cost to the targeted firms. The Porter hypothesis (1992) suggests that through fostering innovation, environmental regulation may actually benefit productivity. Empirical support for the Porter hypothesis has been lacking, and it is difficult to model a mechanism which would create improved innovation under increased constraints. However, product switching may have a similar effect as more productive firms drop highly polluting products when enforcement increases, thereby focusing on relatively high productivity clean products.

This paper takes advantage of the different levels of environmental enforcement across India's states to measure the effect of environmental regulations on firm productivity. In addition, I examine the mechanism through which environmental regulations affect product switching through the Bernard, Redding and Schott heterogeneous products framework and test its implications.

I test the effects of the regulations using data from Capitaline, a firm level data set in India. The dataset has 2,900 firms over which I test the productivity effects of environmental regulations, and 8,000 firm-product combinations over which I test the implications of the Bernard, Redding and Schott model. I find that increases in environmental enforcement lead to an overall decrease in productivity. This effect is strongest for firm closures. However, increases in enforcement through citation of firms for defaulting on environmental regulation leads to an increase in productivity.

A state's choice of how heavily to enforce environmental regulations may be endogeneously determined—state governments which believe that expensive environmental regulations will reduce local growth may be less likely to heavily regulate their industries. This paper proposes several instruments for state level enforcement. One, which has been implemented, the state level Herfindahl index for highly polluting industries, has been found to maintain the signs of the coefficients, although the instrument is quite weak and the coefficients lose their significance.

India affords a particularly attractive environment in which to examine the effects of changes in environmental enforcement. Increased regulations came as a surprise to companies in India, as relatively lax enforcement was common until 1997. Prior to 1997, most environmental enforcement occurred through the courts and forcing a company to reduce their pollution levels required long legal battles through a notoriously slowly moving justice system. The recent development of state level regulatory enforcement reduces potential concerns over endogeneity in the location of companies as the vast majority of the firms in the data set were installed prior to the onset of environmental enforcement by the states.

In 1997 a World Bank program strongly backed increasing the regulatory powers of state pollution control boards. This corresponded with a worldwide push to increase environmental awareness at the local level from both the World Bank and the UN. The pollution control boards were set up to enforce standards set by the central pollution control board, but enforcement is determined at the state level. State pollution control boards have the authority to either fine a company for being in default of regulations or to close the company and disconnect it from the electricity and water network. In addition, they must grant a company a license to operate in order for a company to produce in any one of 17 highly polluting industries. The control boards do take advantage of these enforcement mechanisms. In 1999 Andhra Pradesh closed 29 of 143 factories in highly polluting industries and cited two as defaulters on the environmental standards.

To the extent that citation of a firm for being in default of environmental compliance regulations is a substitute for closure of the firm, high default states may be seen as relatively lax in terms of environmental enforcement. However, firm adaptation of product mix in response to increases in enforcement is similar across both closures and citations for defaulting behavior. This suggests that the incentives created for firms through the enforcement mechanisms are similar. Closures may increase uncertainty and variability in the supply chain which could decrease productivity without affecting incentives for compliant behavior directly.

Empirical Strategy and Results

a. Productivity Effects of Changes in Environmental Enforcement

I estimate the models using both OLS and Levinson Petrin (LP) productivity in order to ensure that the results are robust to the specification of productivity. Productivity is estimated using sales deflated by industry specific price indices minus energy costs as the output variable for the OLS specification, and deflated sales as the output variable for the LP specification. Materials costs are deflated by wholesale price indices weighted by industry specific input output weights. Salaries are used to proxy for labor and are deflated by industry specific average wages. Capital is aggregated from separately categorized investments by the firm, each deflated by the relevant wholesale price index. Energy costs are deflated by an energy price index.

The enforcement variable has three specifications. Citations of firms in highly polluting industries for defaults in environmental management (defaults), closure of firms in highly polluting industries (closure), and a structural break at 1997 when state level enforcement of environmental regulations began (environment break). In order to identify the impact of increased regulations on manufacturing companies, I weight each observation of state level regulatory enforcement by the intensity with which local companies in a given manufacturing industry use dirty inputs in production. Companies which rely on cement or caustic soda for production are more heavily affected by enhanced environmental enforcement against cement companies than are companies which do not use any dirty goods in production. Because identification occurs primarily at this secondary effects level, the potential for endogeneity is somewhat reduced as states are less likely to be lobbied by companies which feel only secondary effects from regulations.

The variables are created as follows:

$$weighted\_index = \sum a_{ij}\, pct_{st}$$

where a_{ij} is the intensity with which inputs from highly polluting industries i are used in the production of industry j, and percent is the number of firms which have been cited or closed in a given year and state (or the indicator for break years).

Productivity regressions are run according to the following model:

(1). $Logprod_{ft} = \alpha_f + \beta\ weighted\_index_{ist} + \gamma\ yeardum$

Standard errors are clustered by state, industry, year, which is the level of variation in the independent variable of interest.

Many companies in the sample have factories in more than one state. A company with plants in multiple states may be able to switch the location of its highly polluting activities in the event that the local state pollution control board increases its regulatory enforcement. This adds an additional level of variation, as I am able to test the difference in the effect of regulations on companies with a single operating plant against those with multiple locations. We would expect to see that a change of environmental regulation in a state would affect firms producing in pollution intensive industries, but these effects should be lower for firms which have plants in multiple states and therefore may be able to switch production when local environmental enforcement increases.

Results are shown in table one. The structural break regressions demonstrate that the increases in environmental enforcement since 1997 have had a negative effect on productivity. This effect is particularly strong for firms in industries which use highly polluted product inputs intensively. Firm closures have a negative effect on productivity. This effect is amplified for firms which have plants in multiple states. While this may initially seem to be a surprising result, this effect may be explained through firms switching production to secondary plants.

Closure of firms which refuse to comply with environmental regulations has two effects. First, it creates uncertainty in the supply chain, affecting all firms using those inputs and potentially creating production stoppages in local downstream firms. However, firms which have plants in multiple states may react to an increase in enforcement intensity and the related increases in raw material costs by switching production of their highly polluting input intensive industries to plants in nearby states. This suggests that the firm has increased production at a higher cost plant (because the plant was not chosen prior to the regulations), and the productivity of the firm will decrease. This is the effect that we see in the data.

Citations for default of environmental regulations have a positive effect on firm productivity in the state in which they occur and no effect for firms with plants in multiple states. There are several potential explanations for this result. The first is the "Porter hypothesis" which suggests that firms react to environmental regulations by increasing innovation, thereby causing a net gain in productivity from an increase in regulatory intensity. This explanation is difficult to model as it is unclear that such profitable innovations could not take place in the absence of increased regulation.

An alternative explanation would suggest that the change in regulatory stringency imposes a fixed cost on the firm for each year in which they produce a given pollution intensive product. These fixed costs may come in the form of bribery of local officials, pollution abatement equipment, or lobbying costs. The increase in fixed costs associated with increased enforcement intensity would restrict the entrance in a product market to firms with relatively high productivity draws, thereby creating an increase in productivity in the firms which use pollution intensive inputs as evidenced by the data.

Exporting behavior is commonly of interest to policy makers. Many argue that low local regulations may cause an area to become a pollution haven, suggesting that pollution intensive industries will relocate to the area and increase exports to the more stringent countries. I use an indicator which takes the value of one for all years in which the firm exported products. Following the Melitz model (2003), we expect to see that high productivity firms are more likely to export. Therefore, I control for the log of OLS productivity in estimating the effect of an increase in regulatory enforcement. The effect of changes in regulatory enforcement on exporting behavior is estimated based on the model below:

(2). $Indicator\_\exp orter_{ft} = \alpha_f + \beta \log prod\_ols_{ft} + \lambda\ enforcement\_index_{ist} + \gamma yeardum_t$

Results are shown in table 2. I find the only effect of changing environmental enforcement on the propensity of a firm to export to be a positive effect from increasing enforcement through default citations which is not carried through to firms with plants in multiple states. This suggests that citations for lack of environmental compliance are not driving companies from producing and exporting from states which are relatively strict in the enforcement of environmental regulations.

In addition, I consider the effects of increased regulatory enforcement on firm exit. Increased fixed costs resulting from the cost of compliance would suggest that exit should increase with an increase in regulatory intensity and that lower productivity firms would be the first to exit. The estimation strategy for firm exit is shown in equation (3) below, where exit is an indicator variable which takes a value of 1 if the firm exits in the next period.

(3).
$exit_{ft} = \alpha_f + \beta enforcement\_index_{ist} + \lambda \log prodols_{ft} + \varphi \text{int\_} prod\_enforcement_{fist} + \gamma yeardummies_t$

Results are shown in table 3. We find that an increase in the default citation rate does cause an increase in exit by pollution input intensive firms. However, the interaction term shows that more productive firms are less likely to exit the market as a result of increases in default citations. Although closures are not significant, they do follow the opposite signs of the coefficients on default citations. Closures may cause increased uncertainty surrounding the likelihood of enforcement and create some entrenchment among companies which have lower productivity and may perceive lower costs from temporary closure.

i. Robustness of Productivity Results

There are several potential concerns over the robustness of the results. It could be argued that increases in regulation were occurring in areas where there was high productivity growth from new firms, and that these firms drive the empirical results. Alternatively, firms may choose to locate in states in which they expect that the regulatory enforcement will be relatively low, driving down entrance in high enforcement states. In order to test the validity of this claim, I consider whether entrance of pollution intensive firms follows from increases in regulation in table 4. Entrance is an indicator variable which takes the value of one if the year of the observation is the same as the incorporation year of the firm. I find that there is no significant effect from either changes in default rates or closure rates on entrance of firms.

Endogeneity arising from the possibility that firms which would be most negatively affected by increased regulatory enforcement may increase lobbying in order to reduce regulations in their areas is an additional potential issue of concern. The bias which would result from this type of endogeneity would increase the magnitude of the coefficient, creating the suggestion of a significant result where in fact there was none. Restricting the sample to firms which have plants only in the treatment state, and comparing single state firms to those with additional plants outside of the treatment plant addresses this critique. It is unlikely that lobbying for a particular industry in a given state would address focus regulation changes only on firms which had plants only within the state.

However, in order to fully address the causality issue, it is important to identify an instrumental variable for enforcement intensity by states. Table 5 shows the results from one weak instrument which I have identified; the Herfindahl index for dirty industries in a given state. The index is computed based on the Capitaline data set which has incomplete coverage in several sectors, and therefore I suspect that one reason that the instrument is weak is a high degree of measurement error. The instrumental variables estimation shows that the enforcement variables maintain their signs, but are much smaller and are no longer significant.

The Herfindahl index for dirty industries could provide a useful instrument in that the index demonstrates market concentration. In states in which dirty industries are highly concentrated, default citations may decrease as large firms which control the industry are able to negotiate directly with the state government, but closures may increase as the state government may be more likely to close small players which compete with a strong large firm with lobbying influence.

An additional potential instrument for enforcement is the market share of state owned firms in dirty industries. State government officials are less likely to enforce regulations against state owned enterprises, therefore as the percent of sales by state owned companies in dirty industries increased, we would expect to see lower levels of environmental enforcement. The gaps in coverage in my current data set make this instrument an extremely weak one, but I am working on filling some of these gaps.

Finally, regulatory enforcement is particularly strong in areas in which local populations are likely to be affected by pollution from dirty industries. In addition, industries which are connected to the state controlled sewage network are more likely to be monitored as the level of pollution which they emit will affect the operation of the treatment plants. I would like to use variation in the extension of the sewage networks and local population density as an instrument. This instrument would require more disaggregated data, however, as it would require that the data list cited firms. This disaggregated data is available in part for the state of Kerala, but the sample which I have at this point is not yet large enough for estimation. In addition, I would also need several maps of the extension of sewer networks in India.

An additional instrument which I have considered using is the proportion of water which large cities in the states draw from the rivers. Much of the pollution by manufacturing companies flows into local rivers. States which draw large percentages of their water for consumption from the rivers are more likely to heavily enforce environmental regulations, as they find that treating the water for consumption purposes is increases in cost with the amount of pollution in the water. I am still in the process of collecting data for this instrument.

b. Changes in Product Mix in Response to Environmental Regulations

The theoretical basis for this paper is derived from Bernard, Redding, and Schott (2003) (BRS). Firms which are already producing high pollution products are considered to have paid the fixed cost of entry into the market, but not the fixed product cost which must be paid each period in order to produce a particular product. Changes in environmental enforcement increase both the fixed cost of entry and the product specific fixed cost. The variable cost of producing a product with pollution intensive inputs is also affected by changes in regulatory enforcement.

Following the BRS model, we expect to see that with an increase in fixed costs of producing a given product, the number of firms producing that product decrease, and the relative productivity of the marginal firm producing the product therefore increases. In addition, as variable costs increase, profitability of production of a given product decreases, and the product is dropped by more firms. According to BRS, changes in the number of firms producing each product could occur through firms adding or dropping the product.

I test the above implications of the BRS model in tables six through eight. In each case, I compare the product mix reactions of firms which have plants only in one state to those which have plants in multiple states.

The effects of changing regulatory enforcement through changes in variable costs are estimated using raw materials data for each firm. Raw materials are included in the data set for a subset of the firms (these are not separable into plants or products in which they are used). In years in which a firm uses raw materials which fall under the categorization of the 17 highly polluting industries, an indicator for dirty raw materials takes the value of one. This data is then merged to the product level data for the firm. The dependent variable is an indicator for the year in which a product is dropped from the product mix. Years in which a product is temporarily not produced are not included as dropped years. The estimation strategy is shown in equation (4).

(4). $$Dropped_{fp} = \alpha_{fp} + \lambda \log prod_{ft} + \beta \ \mathrm{int\_}enforcement_{ist}\_dirtyraw_{ft} + \gamma yeardummy_t$$

Firm-product fixed effects and year dummies are included in all specifications. Standard errors are clustered by industry, state, year.

Results are shown in table 6. We find that as predicted by the BRS model, firms with high productivity are less likely to drop a product, but that firms using dirty raw materials are more likely to drop a product if enforcement increases.

In order to identify the effects of differences in firm productivities on the propensity to drop a dirty product, I identified products which fell within the 17 highly polluting products categories, and interacted these with each enforcement and productivity term. The difference in coefficients between the term and the interacted term should demonstrate the effect of enforcement on pollution intensive products. I estimate the following model:

(5).

$$Dropped_{fp} = \alpha_{fp} + \lambda \log prod_{ft} + \beta_1 enforcement + \beta_2 \text{int\_} enforcement_{ist} \_dirtyproduct_{ft} + \gamma yeardummy_t$$
$$+ \rho_1 \text{int\_} enforcement_{ist} \_ productivity_{ft} + \rho_2 \text{int\_} enforcement_{ist} \_dirty \_ product_{ft} \_ productivity_{ft}$$

I use an F statistic to test the difference between each term and the interaction term, and compare the difference in coefficients between firms with plants in only one state to those with plants in multiple states. I find that enforcement through firm closure makes it more likely that products will be dropped, but less likely that dirty products will be dropped. This somewhat surprising result suggests that increases in regulations may cause increases in fixed costs of entry for dirty products, increasing the profitability to firms already producing. The overall increase in dropped products is likely an effect of an increase in raw material costs arising from the regulatory enforcement.

More productive firms are more likely to drop dirty products with an increase in regulatory enforcement. This is to be expected, as the fixed period cost increases with regulatory enforcement and productivity in other product sectors may overwhelm the benefits to high productivity firms of continuing to pay the costs of producing in the dirty product market. While the F-statistics demonstrate that the differences in coefficients are significant for firms with plants in a single state, significant differences are not found for firms with plants in multiple states.

Table 8 shows the results for added products. In contrast to the BRS model, I find that the results are not significant for added products. There is no clear reason from the model that the results would hold only for dropped products, but this may be an avenue for future research.

Conclusion and Next Steps

Enforcement of environmental regulations has a negative effect on productivity overall, but this effect can be parsed into several components. Enforcement through citation and fining of firms for defaults in environmental compliance is much less detrimental to firm productivity than closure of firms which fail to comply with regulations. Export propensity does not appear to be affected by changes in environmental enforcement, suggesting that empirical support for the pollution haven hypothesis may be lacking.

Decomposing the effect of enhanced enforcement of environmental regulations by considering the product mix of the firm demonstrates that firms tend to drop products with dirty raw materials as enforcement increases; this effect is relatively strong and significant, suggesting that changes in variable costs have strong effects on the propensity of a firm to produce a product. High productivity firms are more likely to switch out of production of pollution intensive inputs with increased enforcement as suggested by the Bernard, Redding, Schott (2003) model.

There are further levels of variation which I may be able to use to identify the effects of enforcement. Companies which are located close to the border of a state with more lax environmental enforcement should be less affected by strict local environmental regulations as they are able to source supplies from the neighboring state. In addition, companies operating in special economic zones may benefit from reduced cost pollution abatement through cooperation with the other companies in the zone. Companies which are located near highly populated areas are also more closely regulated than those in rural areas. In addition, companies which connect to state sewer systems are more closely monitored for their pollution emissions than are companies which treat their own water.

Table 1: Productivity Effects of Environmental Enforcement

	Log OLS Productivity					
	Plants in Treatment State			Plants in Multiple States		
Lagged input output weighted default rate	1.476***			0.739		
	(0.418)			(0.774)		
Lagged input output weighted closure rate		-1.344*			-1.529***	
		(0.756)			(0.568)	
Structural Break for environmental Regs in 1997 weighted by IO Coef			-1.245***			-1.245***
			(0.140)			(0.136)
Observations	12173	12173	18766	5545	5547	8840
Number of firmid	2497	2497	3014	885	886	984
R-squared	0.01	0.00	0.02	0.01	0.01	0.02

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All regressions have firm and year fixed effects. Standard errors are clustered by industry, state, year. Estimates are done in two stages. OLS productivity is estimated from deflated output minus energy, with capital aggregated from individual components deflated by the relevant index, salaries deflated by average industry wage are used as a proxy for labor, and materials are deflated by input-output coefficient weighted wholesale price indices. Productivity is calculated separately each year for each of the 21 NIC-2 (ISIC-2)digit manufacturing industries.

	Log LP Productivity					
	Plants in Treatment State			Plants in Multiple States		
Lagged input output weighted default rate	1.095***			0.621		
	(0.411)			(0.739)		
Lagged input output weighted closure rate		-0.943			-1.156**	
		(0.695)			(0.578)	
Structural Break for environmental Regs in 1997 weighted by IO Coef			-0.864***			-0.869***
			(0.136)			(0.125)
Observations	12173	12173	18766	5545	5547	8840
Number of firmid	2497	2497	3014	885	886	984
R-squared	0.01	0.01	0.02	0.01	0.01	0.02

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
All regressions have firm and year fixed effects. Standard errors are clustered by industry, state, year. Estimates are done in two stages. LP productivity is estimated from deflated output minus energy, with capital aggregated from individual components deflated by the relevant index, salaries deflated by average industry wage are used as a proxy for labor, and materials are deflated by input-output coefficient weighted wholesale price indices. Energy is used as the LP proxy for innovation. Productivity is calculated separately each year for each of the 21 NIC-2 (ISIC-2)digit manufacturing industries.

Table 2: Effect of Environmental Enforcement on the Propensity to Export

	Indicator for Firm Exporting					
	Plants in Treatment State			Plants in Multiple States		
Lagged input output weighted default rate	0.735**			0.380		
	(0.300)			(0.392)		
Lagged input output weighted closure rate		0.596			0.692	
		(0.438)			(0.460)	
Structural Break for environmental Regs in 1997 weighted by IO Coef			0.143			0.178
			(0.104)			(0.111)
Log of OLS Productivity	0.009	0.009	0.021***	-0.004	-0.004	-0.010
	(0.008)	(0.008)	(0.007)	(0.013)	(0.013)	(0.012)
Observations	11635	11633	18305	5394	5394	9293
Number of firmid	2321	2321	2803	849	849	944
R-squared	0.00	0.00	0.01	0.00	0.00	0.02

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Estimates computed using the linear probability model. All regressions include firm and year fixed effects. Dependent variable is an indicator which takes a value of 1 if a firm is an exporter in a given year. All regressions include firm and year fixed effects. Standard errors are clustered by industry, state and year.

Table 3: Effect of Environmental Enforcement on Exit

	Exit Next Period			
Log of OLS Productivity			-0.021***	-0.016***
			(0.007)	(0.006)
Input Output Weighted Percent Default		0.675*		0.671*
		(0.372)		(0.383)
Interaction between OLS Productivity and input output weighted Percent Default				-1.302*
				(0.673)
Input Output Weighted Percent Closed	-0.418		-0.362	
	(0.683)		(0.700)	
Interaction between OLS Productivity and input output weighted Percent Closed			0.905	
			(0.678)	
Age	0.153***	0.153***	0.152***	0.153***
	(0.057)	(0.057)	(0.057)	(0.057)
Observations	11325	11325	11097	11097
Number of firmid	2575	2578	2520	2523
R-squared	0.06	0.06	0.07	0.07

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Linear Probability regressions, all specifications have state-year dummies and firm fixed effects. Errors are clustered by industry, state, year.

Table 4: Robustness--effect of environmental regulation on Entrance

	Entrance	
Input Output Weighted Percent Closed	-0.054	
	(0.051)	
Input Output Weighted Percent Default		0.003
		(0.031)
Observations	18009	18008
Number of firmid	3443	3443
R-squared	0.00	0.00

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Linear Probability model. Dependent variable is an indicator which takes the value 1 if a firm is in its first year of production. All regressions include firm and year fixed effects. Standard errors are clustered by industry, state and year.

Table 5: Robustness: Instrumental Variable Estimation

	Levinson-Petrin Prod	
Lagged IO Weighted Defaults	0.263	
	(12.570)	
Lagged IO Weighted Closures		-0.034
		(10.072)
Observations	11854	11852
Number of firmid	2178	2176
R-squared	0.01	0.01

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

	Lagged Defaults	Lagged Closures
IO Weighted Herf Index for Dirty Industries	-0.145***	.1807***
	(0.031)	(0.019)
	12402	12402
	2549	2549
	0.09	0.03

All regressions have firm fixed effects and year dummies.

Table 6: Product mix response to Changes in Variable Costs

	Indicator for Dropped Product									
	All Firms		Plants in Treatment State				Plants in Multiple States			
Log OLS Productivity	-0.004**		-0.008**	-0.008**			-0.003	-0.003		
	(0.002)		(0.004)	(0.004)			(0.004)	(0.004)		
Log Levinson-Petrin Productivity		-0.005***			-0.009***	-0.009**			-0.005	-0.005
		(0.002)			(0.004)	(0.004)			(0.004)	(0.004)
Firm Closures interacted with indicator for use of dirty raw materials				0.192***		0.194***		0.061*		0.061*
				(0.070)		(0.070)		(0.033)		(0.033)
Firm Defaults interacted with indicator for use of dirty raw materials			0.176***		0.177***		-0.034		-0.035	
			(0.060)		(0.060)		(0.036)		(0.036)	
Observations	125942	125942	43449	43404	43449	43404	36424	36386	36424	36386
Number of firm_product	14533	14533	7584	7584	7584	7584	5099	5099	5099	5099
R-squared	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

All regressions include firm-product fixed effects and year dummies. Standard errors are clustered by industry, state year. Manufacturing companies from NIC 15-36 included. (NIC classification is closely related to ISIC codes).

Table 7: Examination of Firms Dropping Products in Response to Environmental Enforcement

	Dropped Product Indicator							
	Firms with Plants Only in Treatment State				Firms with Plants in Multiple States			
Log OLS Productivity	-0.012***	-0.005			0.001	-0.002		
	(0.004)	(0.004)			(0.004)	(0.005)		
Log Levinson Petrin Productivity			-0.010***	-0.007**			-0.004	-0.002
			(0.004)	(0.003)			(0.004)	(0.004)
Default Rate	-0.008		-0.029		-0.016		0.037	
	(0.023)		(0.068)		(0.020)		(0.051)	
Dirty Product Indicator Interacted with Default Rate	0.051		-0.196		0.032		0.202	
	(0.036)		(0.119)		(0.038)		(0.128)	
Closure Rate		0.096***		0.170		0.047		0.117
		(0.033)		(0.104)		(0.029)		(0.072)
Dirty Product Indicator Interacted with Closure Rate		-0.054		-0.327**		0.089		0.184
		(0.074)		(0.144)		(0.055)		(0.203)
Default Rate Interacted with log OLS productivity	0.060				-0.079*			
	(0.037)				(0.043)			
Default Rate Interacted with log OLS productivity for Dirty Products	0.107*				-0.182			
	(0.058)				(0.134)			
Closure Rate Interacted with log OLS productivity		-0.051				-0.008		
		(0.051)				(0.044)		
Closure Rate Interacted with log OLS productivity for Dirty Products		0.141**				-0.043		
		(0.071)				(0.158)		
Default Rate Interacted with log LP productivity			0.012				-0.027	
			(0.032)				(0.020)	
Default Rate Interacted with log LP productivity for Dirty Products			0.117*				-0.074	
			(0.061)				(0.055)	
Closure Rate Interacted with log LP productivity				-0.035				-0.031
				(0.046)				(0.030)
Closure Rate Interacted with log LP productivity for Dirty Products				0.130*				-0.046
				(0.071)				(0.095)
Observations	43449	43404	43449	43404	36424	36386	36424	36386
Number of firm_product	7584	7584	7584	7584	5099	5099	5099	5099
R-squared	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

F Statistic:

Test that Coefficient for full sample on Default rate= Coefficient for Dirty Products for Default Rate	1.36		1.8		1.06		1.95	
	0.2431		0.1795		0.3039		0.1625	
Test that Coefficient for full sample on Closure rate= Coefficient for Dirty Products for Closure Rate		2.66		6.41		0.33		0.12
		0.1031		0.0114		0.56611		0.7312
Test that Coefficient for full sample on Interaction of Default rate with OLS productivity= Coefficient for Dirty Products for Interaction of Default Rate with OLS Productivity	0.57				0.74			
	0.4488				0.3897			
Test that Coefficient for full sample on Interaction of Closure rate with OLS productivity= Coefficient for Dirty Products for Interaction of Closure Rate with OLS Productivity		4.79				0.06		
		0.0288				0.8087		
Test that Coefficient for full sample on Interaction of Default rate with LP productivity= Coefficient for Dirty Products for Interaction of Default Rate with LP Productivity			3.13				0.87	
			0.0772				0.3504	
Test that Coefficient for full sample on Interaction of Closure rate with LP productivity= Coefficient for Dirty Products for Interaction of Closure Rate with LP Productivity				3.47				0.03
				0.0629				0.8685

Table 8: Examination of Changes in Propensity to Add Products in response to Environmental Regulations

	Added Product							
	Firms with Plants Only in Treatment State				Firms with Plants in Multiple States			
Log OLS Productivity	0.002	0.002			-0.000	-0.001		
	(0.002)	(0.003)			(0.002)	(0.002)		
Log Levinson Petrin Productivity			0.003	0.002			-0.002	-0.001
			(0.002)	(0.002)			(0.002)	(0.002)
Default Rate	-0.001		0.019		-0.008		0.039	
	(0.014)		(0.039)		(0.012)		(0.028)	
Dirty Product Indicator Interacted with Default Rate	0.007		0.001		-0.032		0.017	
	(0.032)		(0.061)		(0.020)		(0.047)	
Closure Rate		0.013		0.018		-0.026		0.028
		(0.021)		(0.058)		(0.018)		(0.038)
Dirty Product Indicator Interacted with Closure Rate		-0.022		-0.027		0.038		-0.084
		(0.045)		(0.074)		(0.039)		(0.106)
Default Rate Interacted with log OLS productivity	-0.005				-0.055***			
	(0.017)				(0.020)			
Default Rate Interacted with log OLS productivity for Dirty Products	0.000				-0.022			
	(0.027)				(0.049)			
Closure Rate Interacted with log OLS productivity		0.004				-0.022		
		(0.025)				(0.020)		
Closure Rate Interacted with log OLS productivity for Dirty Products		-0.008				0.002		
		(0.025)				(0.046)		
Default Rate Interacted with log LP productivity				-0.002				-0.025
				(0.024)				(0.016)
Default Rate Interacted with log LP productivity for Dirty Products				0.003				0.058
				(0.025)				(0.044)
Closure Rate Interacted with log LP productivity			-0.010				-0.023**	
			(0.017)				(0.010)	
Closure Rate Interacted with log LP productivity for Dirty Products			0.003				-0.021	
			(0.024)				(0.020)	
Observations	41706	41661	41706	41661	35896	35858	35896	35858
Number of firm_product	7514	7514	7514	7514	5088	5088	5088	5088
R-squared	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

F Statistic:

Test that Coefficient for full sample on Default rate= Coefficient for Dirty Products for Default Rate	0.04		0.05		0.82		0.12	
	0.8489		0.8261		0.3667		0.7346	
Test that Coefficient for full sample on Closure rate= Coefficient for Dirty Products for Closure Rate		0.38		0.14		2.34		0.86
		0.5377		0.7067		0.1263		0.353
Test that Coefficient for full sample on Interaction of Default rate with OLS productivity= Coefficient for Dirty Products for Interaction of Default Rate with OLS Productivity	0.02				0.31			
	0.8956				0.5806			
Test that Coefficient for full sample on Interaction of Closure rate with OLS productivity= Coefficient for Dirty Products for Interaction of Closure Rate with OLS Productivity		0.08				0.18		
		0.7822				0.6714		
Test that Coefficient for full sample on Interaction of Default rate with LP productivity= Coefficient for Dirty Products for Interaction of Default Rate with LP Productivity			0.12				0	
			0.726				0.9461	
Test that Coefficient for full sample on Interaction of Closure rate with LP productivity= Coefficient for Dirty Products for Interaction of Closure Rate with LP Productivity				0.01				2.69
				0.9121				0.1011