Fine Me If You Can:
Fixed Asset Intensity and Enforcement of Environmental Regulations in China

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Abstract: Why do some firms face more environmental regulatory actions than others? We present a theory focusing on firm fixed asset intensity. High fixed asset intensity makes a firm less mobile. A less mobile firm cannot present a credible exit threat, making it more susceptible to stringent enforcement. Analysis of key-monitored firms in Jiangsu province, China of 2012-2014 shows that higher fixed asset intensity is associated with more pollution levies and a higher chance of receiving a punitive action. This result holds in a battery of robustness checks and an instrumental variable analysis. Further, our 2018 online survey of Chinese firm managers shows that those from high fixed asset intensity firms indeed consider their firms less mobile and they pay more environment-related operating costs. Finally, data from 2004 Chinese Firm-Level Industrial Survey demonstrates that fixed asset intensity is positively associated with pollution levies in a national sample of 201,926 manufacturing firms.

Running title: fixed asset and environmental regulation

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1. INTRODUCTION

The emerging environmental crisis in China has attracted much attention from both practitioners and academics (Economy 2011). Environmental challenges pose considerable threats to China's long-term development (Tilt 2013). In addition to the detrimental effect on its own environment, the environmental crisis in China has profound global implications. With its increasing economic size and energy consumption, China is now the largest emitter of carbon dioxide, accounting for 27 percent of global emissions in 2012 according to the Carbon Dioxide Information Analysis Center (CDIAC).

Industrial production and transportation are the most important sources of pollution for industrializing countries such as China. The former is often the greatest polluter of air and water. Past studies have shown that effective enforcement of environmental regulations improves environmental quality (LaPlante and Rilstone 1996; Almer and Goeschl 2010; Dasgupta et al. 2001a). However, regulatory enforcement has rarely been an apolitical process. This paper aims to better understand how local governments in China enforce environmental regulations at the firm level. We argue that a higher level of fixed asset intensity makes a firm less mobile, which in turn makes it less able to present a credible exit threat if a local government targets the firm with stringent enforcement. Our theoretical focus on fixed asset intensity differs from past studies that often emphasize firm ownership and firm financial situation (Wang et al. 2003; Wang and Wheeler 2005; Chen et al. 2014).

We also depart from past studies on Chinese firm-level environmental regulatory enforcement that virtually always focus on pollution levies, while overlooking other increasingly important regulatory instruments such as punitive actions (Wang et al. 2003; Wang and Wheeler 2005; Chen et al. 2014; Maung et al. 2016). In our main analysis, we examine two categories of firm-level regulatory actions – pollution levies (also referred to as pollution fees) and punitive actions (e.g., fines, suspension of production, and rectification) – for 318 nationally key-monitored manufacturing firms in Jiangsu province of China from 2012 to 2014. Our main analysis shows that a higher level of fixed asset intensity is associated with a higher amount of pollution levies paid and a higher chance of receiving a punitive regulatory action. The result holds in several robustness checks and when we use instrumental variables to deal with potential endogeneity issues associated with firm-level fixed asset intensity variables.

We further explore the causal mechanism and external validity of these findings. We administered an online survey in October 2018 to 534 firm managers in China. We show that managers from firms with higher fixed asset intensity indeed perceive their firms to be less mobile; their firms also pay more in environment-related operating costs including monitoring, auditing, pollution fees, and fines. Using the 2004 Chinese Firm-Level Industrial Survey (CFIS), we show that fixed asset intensity is positively associated with firm pollution levies in a national sample of 201,926 manufacturing firms.

This paper contributes to the literature on the enforcement of environmental regulations by presenting a theoretical angle that focuses on the asset mobility mechanism associated with fixed asset intensity. Connecting fixed asset intensity and immobility to environmental regulations is not new. In the Pollution Haven literature, for instance, Ederington et al. (2005) propose and test the argument that some industries are less geographically mobile, therefore less sensitive to cross-country differences in environmental regulatory stringency. Cole et al. (2010) use data on Japanese trade patterns and find that the pollution haven effects are more discernible when an industry's geographical immobility is accounted for. These studies share a common assumption that the level of regulatory stringency is uniform within jurisdictions; firms then make relocation decisions based on factors including their mobility. Our theory brings in the agency of local regulators and focuses on their interests and incentives. We argue that within a jurisdiction, even though the *de jure* regulatory stringency (i.e., regulations on paper) is the same, local regulators impose different levels of *de facto* stringency (i.e., the enforcement of regulations) across firms as a function of firm asset mobility.

The empirical contribution of this paper is the use of multiple sources of data, including the collection and analyses of data that constitutes a more comprehensive portfolio of environmental regulatory instruments. In a developing country context, firm-level regulatory action data has been extremely difficult to compile. This is a major reason why empirical studies on the enforcement of environmental regulations have heavily focused on developed countries (Wang and Wheeler 2005). Most, if not all, of the far fewer studies on developing countries concentrate on pollution levies, partly because data on other regulatory instruments such as punitive actions were not available until recently. In the Chinese case, they only became usable after we engaged in extensive coding of online texts in various formats.

The next section presents our theoretical argument. The following two sections discuss data, the main empirical results, robustness checks, and an instrumental variable analysis. The next section provides further evidence for the asset mobility mechanism and tests the external validity of our main findings. We conclude and discuss future research at the end.

2. THEORY

Political economy studies on asset mobility are now legion. For instance, the capital mobility thesis has been explored extensively in cross-country studies of tax competition, welfare state retrenchment, and policy convergence (Simmons and Elkins 2004). The main intuition is that capital is more likely to move toward economies that are business friendly. By adhering to this pattern of movement, mobile capital rewards (by entering) and punishes (by exiting) certain countries (Mosley 2003). The same logic applies to capital mobility within countries. For instance, Malesky (2008) and Wang (2015) show that high-mobility firms in Vietnam and China were able to bargain for favorable treatment or even institutional changes. Liu and Zhao (2017) find that high capital mobility was able to weaken the effect of government initiatives aimed at increasing fiscal capacity in Chinese counties.

Recent studies on the pollution haven hypothesis show that some firms do move – that is, follow through on the exit threat – when local governments apply more stringent environmental regulations. For instance, Dean et al. (2009) find that foreign direct investments in highly polluting industries funded through Hong Kong, Macao, and Taiwan are attracted by weak environmental standards in mainland China. Cai et al. (2016) show that water-polluting firms in China are more inclined to locate or to expand production in downstream counties where the enforcement of environmental regulations is more lenient. Zhu et al. (2014) find that Chinese pollution-intensive firms have relocated from the coastal province of Zhejiang to inland China, where enforcement of environmental regulation is laxer. In some cases, firms have even moved more than once: pulp and paper manufacturers moved from Shanghai to Jiangsu in the 1980s and from Jiangsu to Anhui or Jiangxi in 2005 (Kong et al. 2010).[1]

Almost all existing cross-national and subnational studies on the pollution haven hypothesis focus on firms and their decisions to relocate to jurisdictions with less strict

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[1] For more recent studies on the pollution haven hypothesis in China, see Zheng and Shi (2017), Yang et al. (2019), and Dou and Han (2019).

regulatory regimes, with the underlying assumption that the level of regulatory stringency is uniform within jurisdictions. However, this assumption ignores the agency of the regulators. Within a jurisdiction, even though regulatory stringency is the same on paper, the enforcement is far from being uniform across firms.[2] Indeed, an extensive literature analyzes the politics of monitoring and enforcement of environmental regulations in developed countries. A rich literature in American politics shows that factors such as local community characteristics and facility ownership affect government enforcement decisions. For example, Konisky and Reenock (2013) and Konisky and Teodoro (2016) find that American regulatory agencies are much less likely to target facilities of public ownership and located in minority communities.

Outside the US or the OECD context, however, far fewer studies have been done. Among developing countries, China has received probably the greatest scholarly attention (Blackman et al. 2018). But even for this most-studied developing country, we still know little about the politics of environmental regulation enforcement. The few existing studies focus almost exclusively on the impact of firm ownership – state ownership in particular – and a firm's financial situation (Wang et al. 2003; Wang and Wheeler 2005; Chen et al. 2014; Maung et al. 2016): firms with state ownership are treated more favorably because of political connections; local governments treat firms in dire financial situations more cautiously because they worry about the risks of bankruptcy caused by heavy regulation, which would hurt local economy.

Our theoretical focus on fixed asset intensity departs from these past studies. We advance an argument connecting fixed asset intensity to firm-level regulatory enforcement. Firms with a higher share of fixed assets (e.g., buildings and equipment) are less mobile. This is because relative to non-fixed assets such as accounts receivable and intangible assets, fixed assets incur much greater costs of either replacement or transportation. This makes firms with more fixed assets vulnerable to government regulation. In other words, such firms have less bargaining power against the government because they cannot credibly threaten to exit.

The focus on firm mobility as a function of fixed asset intensity is partly motivated by a major incentive structure change for Chinese local officials since the mid-2000s. Chinese cadre evaluation system promotes those who deliver high priority targets. Before mid-2000s, local leaders were mainly motivated to develop local economy because upper-level governments made promotion decisions by evaluating the relative economic growth of jurisdictions (Maskin et al. 2000). To generate better economic growth, local governments often sacrificed the environment by tolerating noncompliance to lower firms' production costs. By early 2000s, severe environmental degradation has made the central government acutely aware of such a built-in "environmentally unfriendly" incentive in the cadre evaluation system. The central government then implemented various policies to address environmental issues.[3] The most fundamental change though, many believe, is that pollution reduction was added as a high priority target for

[2] Enforcement intensity also varies across localities within a jurisdiction. For instance, He et al. (Forthcoming) show that because water monitoring stations can only capture pollution from upstream, local officials have a spatial discontinuity in enforcing tighter regulations on firms that locate immediately upstream of monitoring stations. See also Kahn et al. (2015).

[3] For instance, in 2013, the State Council approved the Action Plan for Air Pollution Prevention and Control, which outlines specific PM2.5 air pollution targets for local governments.

local officials: at the national level, environmental performance became a major component for cadre promotion decisions since the 11^{th} Five-year Plan (2006-2010).[4]

In China, the central government sets the environmental policy objectives. In response to objectives set by the central government, provincial governments design their own enforcement plans and allocate regulatory burdens to prefectural cities and counties. City and county leaders' performance evaluations now include how well they have implemented the delegated pollution reduction plans. As a function of such a change in cadre evaluation since the 11^{th} Five-year Plan, local officials are currently driven by multiple important imperatives. They are expected to generate economic growth, which has been and still is the most important indicator for career advancement (Heberer and Senz 2011). At the same time, they must meet environmental targets, the failure of which will constitute a veto (*yipiao foujue*) at the annual evaluation. Unfortunately, these two imperatives can be at odds with each other as GDP growth has often been achieved at the expense of the environment in China.

In theory, improving environmental quality does not have to impede economic growth. The Porter hypothesis posits that strict environmental regulations can induce efficiency and encourage innovations that help improve productivity (Porter and van der Linde 1995). However, some empirical evaluations suggest that stricter regulations only led to modest long-term gains in productivity (Ambec et al. 2013). Moreover, local leaders in China have a short time horizon: e.g., the average tenure of a prefecture party secretary between 2001 and 2010 is a mere 2.5 years (Cao, Kostka, and Xu 2019). This not only lowers their incentive in imposing strict environmental regulation but also in making medium- and long-term green investments given that such investments often take a long time to bear fruit. During such a short period of time, how can a local leader achieve higher economic growth and more pollution reduction compared to his/her peers? One way of achieving this, we argue, is by targeting firms with different levels of enforcement stringency: firm mobility is a key factor in local governments' calculation.

More specifically, to reduce local pollution, stringent environmental regulations need to be implemented for manufacturing firms: numerous past studies have proven the effectiveness of environmental regulations (LaPlante and Rilstone 1996; Almer and Goeschl 2010). However, stringent regulations increase production costs for firms. For instance, for a small paper factory in China that on average discharges 327,800 tons of wastewater yearly, the cost of reducing 90% suspended solids is $452,364 in 1994 (Dasgupta et al. 2001b). Affected firms will seek to relocate to regions with laxer regulations. Stricter environmental regulations will hurt economic growth if firms relocate to other localities. The good news for local governments is the fact that firms, even those within the same industry, vary in their ability to relocate.

Therefore, knowing that firms have varying capacities to exercise this exit strategy, as a rational actor, a local government should design an enforcement strategy that maximize its objective function that balances economic growth with environmental protection. On the one hand, such a strategy involves a more lenient enforcement of environmental regulations on mobile firms so that they would stay, and local economic growth can be sustained. On the other hand, stricter enforcement would be imposed on less-mobile firms: without a credible exit threat,

[4] For instance, in 2005, the Decision from the State Council on Implementing the Scientific Concept of Development and Strengthening Environmental Protection emphasizes "incorporating environmental protection into the contents of the assessment of leading cadres, and taking this assessment of environmental protection as one of the basis for cadre evaluation and promotion."

these firms would have to improve their environmental performance in response to a more stringent enforcement of environmental regulations so that local pollution can be reduced. In sum, we expect:

Hypothesis: firms with higher fixed asset intensity are more likely to be targeted by more stringent enforcement of environmental regulations from local governments.

3. DATA

Sample of Firms in Main Analysis

Our main analysis uses firm-level regulatory actions for 318 national key monitored polluting manufacturing firms in Jiangsu, 2012–2014.[5] We choose to focus on nationally key monitored manufacturing firms instead all manufacturing firms for our main analysis because of data availability of our dependent variables: for instance, provincial EED's websites only provide pollution levy data for key monitored firms. We choose Jiangsu province because Jiangsu is a province with a very diverse portfolio of manufacturing, which allows us to take advantage of a greater degree of variation in our key independent variable – firm fixed asset intensity. Out of the 31 manufacturing industries included in the CFIS, 25 are included in our Jiangsu sample of 318 key monitored firms.[6]

In China, the central government keeps a list of key polluting firms heavily monitored by the environmental agencies. These key polluting firms are large enough to be included in the CFIS, which includes information for all state-owned enterprises and all non-state-owned enterprises whose sales are above 20 million RMB annually.[7] Key monitored polluting firms account for 65 percent of the total industrial water and air pollution in China.[8] Taking key monitored air polluting firms in 2007 as an example, 80,000 firms surveyed nationwide in 2005 were ranked in order of SO_2, soot, and dust. For each pollutant, environmental agencies total the emissions, starting from the largest emitting firm, then the second largest, and so forth until the aggregate amount accounts for 65 percent of the total emissions of the pollutant in China. Firms

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[5] Key monitored polluting firms also include non-manufacturing firms such as water treatment plants (whose capacity is equal to or larger than 10,000 tons per day) and power plants. We choose not to include water treatment plants because they are not manufacturing firms that pursue maximization of profits: they are designed to deal with pollution. We exclude power plants because they are not manufacturing firms: they are in the energy sector which is considered a strategically key sector and is subject to a different set of regulations.

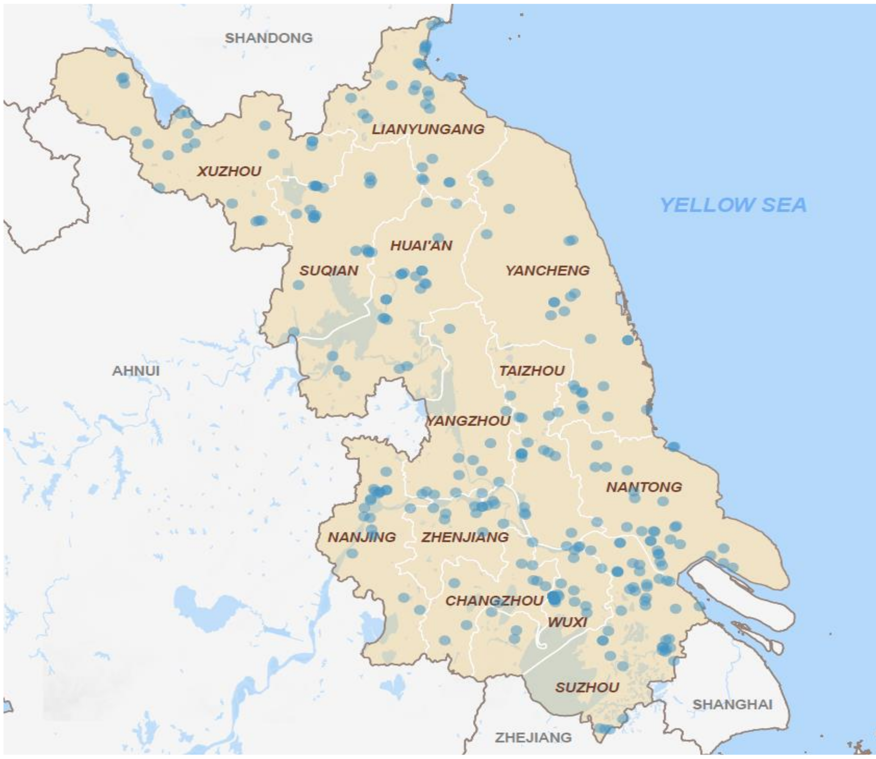
[6] The other two provinces with a similar level of diverse manufacturing are Guangdong and Zhejiang. We do not choose Zhejiang because the first year for which pollution levy data is available for Zhejiang is 2013: this is the last year for which we have data on firm characteristics from the CFIS. In other words, there is only one year overlapped (2013) between the pollution levy data and the firm characteristic data. We do not choose to focus on Guangdong because Guangdong has a much smaller number of key monitored firms than Jiangsu: e.g., in 2012, the number of key monitored firms in Guangdong is only 59.8% of that of Jiangsu.

[7] The total production of these firms accounts for 90 percent of Chinese industrial production.

[8] Local bureaus of environmental protection implement the selection of firms; provincial regulators verify and publish the final list. Online Appendix C has a more detailed discussion on the process for selecting key monitored firms.

whose emissions are counted in the aforementioned 65 percent are considered national-level key monitored air-polluting firms.[9] The final list includes those that appear at least once on the three pollutant lists (SO_2, soot, dust).[10] Figure 1 shows the locations of the 318 key monitored firms included in our study: these key monitored firms cover all regions of the province. Figure A-1 of the appendix displays their industry breakdown.

Figure 1: Distribution of key monitored manufacturing firms, Jiangsu, 2012-2014.



[9] Water-polluting firms are selected following the same set of procedures.
[10] The list changes annually as a function of firms' annual emissions.

Firm-Level Regulatory Actions

The study of government applying environmental regulations to firms is not new. In American context, there is a well-established literature, partly thanks to publicly available high-quality regulation action data such as those released by the United States Environmental Protection Agency (EPA). Since such a centralized database simply does not exist in China, we compiled our data on regulatory actions from multiple sources.

For pollution levies, we obtain data at the firm-year level from the website of the Department of Environmental Protection of Jiangsu province. This variable is measured in thousand RMB, in logarithm. Figure A-2(a) of the online appendix shows its density distributions. Pollution levies, in theory, are environmental taxes levied based on the amount of pollution. However, there are problems associated with this pollution levy system (Jiang and Mckibbin 2002). First, the average level of pollution levy is often too low to create a real incentive for firms to improve their environmental performance. Second, if a firm emits multiple pollutants, it only pays for its worst-performing pollutant. Third, before 2007, about 80 percent of pollution levies went back to firms for environmental projects and/or equipment purchases in the form of state loans and subsidies. Pollution levies paid by firms are also tax exempt. Finally, local governments often offer exemptions.

For punitive actions, the best source for raw data is from the Institute of Public and Environmental Affairs (IPE), a non-profit environmental research organization registered and based in Beijing. Its website has over a million records of firm-level environmental regulatory actions that it has collected from various government websites and news reports.[11] The empirical challenge for scholarly research is that these records are in Chinese texts of various formats (e.g., txt, PDF, and even various image formats).[12] Indeed, the coding of firm-level punitive actions based on Chinese texts was the most time-consuming part of our data collection efforts.

It is unlikely that IPE would miss incidents regarding firms included in our analysis because they are nationally key monitored firms. The period (2012-2014) for this study was characterized by a strong social attention and media scrutiny on environmental issues. The Environmental Information Disclosure Measures came into force in 2008. It forces governmental authorities at all levels and major industrial polluters to disclose environmental information to the public. Provincial-level Environmental Protection Bureaus must disclose information on environmental laws and regulations, environmental quality, environmental management and supervision, and environmental accidents and emergency responses. Nationally key monitored firms must disclose information on the concentration and volume of each pollutant discharged and their environmental facilities in operation (Zhang et al. 2016).

Punitive actions often include suspension of production, fines, and rectification. As a first step, and due to the small number of firms that received any punitive actions during 2012–2014 – a mere 9.35 percent of all firm-years – we code a dummy variable (*punitive action*) that equals 1 if a firm received any punitive action in a year and 0 otherwise. Punitive actions have become more prevalent in recent years in China. Command-and-control regulations such as punitive actions, when strictly enforced, are more likely to bring about pollution reduction (Harrington

[11] http://www.ipe.org.cn/IndustryRecord/Regulatory.aspx?keycode=343j9f9ri329293r3rixxx, last accessed May 22, 2018.

[12] Appendix D has an example of a record of firm-level environmental regulatory action.

and Morgenstern 2004).[13] In China, the central requirement to meet binding pollution reduction targets increases the local incentive to use punitive actions. Figure A-2(b) of the online appendix shows the distribution of this variable.

Key Explanatory Variables

We use the CFIS data to create two firm-year-level fixed asset intensity variables: one defined as fixed asset as a percentage annual output (logged) and the other fixed asset as a percentage annual sales (logged). Firm output and sales are highly correlated (at about 0.99), therefore, some of our robustness checks presented in the main text only use one of the two variables.

After presenting our main results and robustness checks, we use instrumental variables to account for potential endogeneity issues associated with firm-year-level fixed asset intensity variables. Our instruments measure industry-year level fixed asset intensity based on firms from all Chinese provinces. The idea is that industry characteristics – including fixed asset intensity – are largely determined exogenously by technology. Specifically, for a given industry-year, we take the median of firm-year fixed asset to output ratios ($fixed\ asset\ per\ output\ _{median}^{industry}$) and the median of firm-year fixed asset to sales ratios ($fixed\ asset\ per\ sale\ _{median}^{industry}$), for all firms in this industry-year included in the CFIS. The distributions of fixed asset intensity measures at the firm-year level are right skewed. For such skewed distributions, it is better to use median measures to capture the central tendency in the data.[14]

Control Variables

We control for a battery of firm-level characteristics including ownership (state-owned (SOE), collectively owned, HMT owned (Hong Kong, Macao, and Taiwan), foreign owned, and privately owned), profit rate, output (logged, 1000 RMB), income tax paid (logged, 1000 RMB), age (logged), and wage contribution.

Firm ownership has been one theoretical focus of past studies, the argument often being that SOEs are treated more favorably because of their political connections (Wang et al. 2003; Wang and Wheeler 2005). Some past studies also find that local governments treat firms in dire financial situations more cautiously because they worry about the risks of bankruptcy caused by heavy regulation (Wang et al. 2003). We therefore include firm profit rate, which is a firm's profit to total output ratio.

We include firm output to control for firm size. Firm income tax might affect government decisions because those making more fiscal contributions might enjoy greater bargaining power with the government. We use the age of a firm as a proxy for technological advancement, assuming older firms often use less efficient technology and machinery. Firms that provide more employment to the local economy might be protected by local government. Ideally, we should use a firm's employment as a percentage of local employment. But the firm employee variable from the CFIS has too many missing values. Instead, we use *firm wage contribution (%)*, which

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[13] Market incentive-based policies, if properly implemented, should produce better environmental outcomes as they continually motivate firms to reduce emissions in search of lower costs.

[14] The mean is more likely to be skewed by a few outlier observations. Therefore, median measures are our preferred measures even though we obtain similar results using mean measures in our instrumental variable analysis; results available upon request from authors.

is a firm's total wage as a percentage of the total wage paid in a prefecture-year.[15] Table 1 presents the summary statistics. Table A-1 of the online appendix has the correlation statistics.

Table 1: Descriptive Statistics.

Variable Names	N	Mean	SD	Min	Max
punitive action	727	0.0935	0.2914	0	1
pollution levy (log 1000RMB)	692	5.2472	2.6919	-2.3026	11.1548
state-owned enterprise (SOE)	727	0.1623	0.3690	0	1
collectively owned	727	0.0220	0.1468	0	1
privately owned	727	0.5103	0.5002	0	1
HMT owned	727	0.1238	0.3296	0	1
foreign owned	727	0.1816	0.3858	0	1
firm total output (log 1000RMB)	727	6.5702	1.8051	3.0182	11.8818
firm income tax (log 1000RMB)	719	-0.4495	4.1036	-6.9078	6.8362
firm age (log)	727	2.6683	0.6406	1.0986	5.0039
firm wage contribution (%)	727	0.4128	1.0258	0.0007	13.3484
firm profit rate	727	0.0514	0.0914	-0.5654	0.6628
environmental violation	727	0.1472	0.3545	0	1
fixed assets as % of output (log)	727	3.2957	1.0714	-2.3026	6.7830
fixed assets as % of sale (log)	727	3.3045	1.0803	-2.3026	6.6921
fixed asset per output $_{\text{industry median}}$	727	0.1385	0.0264	0.0681	0.2327
fixed asset per sale $_{\text{industry median}}$	727	0.1418	0.0276	0.0685	0.2327

Control for Pollution Baseline

Is it possible that firms with more fixed assets simply emit more pollution and therefore are subject to more government regulatory actions? One strategy therefore is to control for a baseline of firm-level pollution. However, simply adding firm emissions is both problematic and practically difficult. First, emissions can be a function of regulatory actions: if firm adjusts its pollution after receiving a fine, regulatory actions then affect firm-level pollution, introducing a reverse causality. Second, one firm can emit various pollutants. The Jiangsu data records 21 pollutant indicators (11 water-related and 10 air-related). Some firms emit only one pollutant, while others emit a few: e.g., only five firms reported the emission of copper. It is hard to combine all indicators into a single pollution baseline. Finally, these pollutant variables have many missing values.

Not controlling for a pollution baseline creates an omitted variable bias only when the baseline correlates with the key explanatory variable. Table 2 presents the correlation coefficients between measures of fixed asset intensity and six major firm-level pollutant indicators.[16] None of the six firm-level pollutant indicators correlates with fixed asset measures: the only correlations that are larger than 0.10 in absolute value are those between NH per output and firm fixed asset; but these are negative correlations. Therefore, we can be less concerned about such an omitted variable bias.

That being said, we do control for pollution level by including a dummy variable indicating whether there was any instance of emitted pollution exceeding the government-set levels for a

[15] Data on the total wage in a prefecture-year is from Chinese City Statistics.

[16] These include three water-related pollutants: COD (chemical oxygen demand), NH (ammonia), and TP (total phosphorus); and three air-related pollutants: NO_x (nitrogen dioxide and nitric oxide), SO_2 (sulfur dioxide), and soot.

firm in a given year. This *environmental violation* variable serves as a proxy for the baseline of a firm's environmental performance.[17]

Table 2: correlations between firm-level pollutants and measures of fixed asset intensity.

	COD per output	NH per output	TP per output	NO_x per output	SO_2 per output	Soot per output
Fixed assets as % of output (log)	−0.004	−0.143	−0.025	0.047	0.035	0.053
Fixed assets as % of sales (log)	−0.003	−0.133	−0.016	0.047	0.034	0.052

Note: pollutant measures are standardized by a firm's total output.

4. EMPIRICAL FINDINGS

Main Results

We use OLS regressions to model a firm's pollution levies (logged 1000RMB) and punitive action (1/0): the latter is a binary measure; therefore, we essentially use linear probability models for punitive action. All model specifications include prefecture, industry, and year fixed effects.[18] Other than the environmental violation variable, all right-hand side variables are lagged by a year to alleviate potential reverse causalities. We cluster standard errors at the prefecture level.[19]

Table 3 present the main results: we include two model specifications for each dependent variable. Column (1) and (2) present the results for pollution levies. Here, both firm fixed asset intensity variables are positively associated with pollution levies. Not only are the positive effects statistically significant, but they are also substantively important. Both the pollution levies and firm fixed asset variables are logged so that the coefficient can be interpreted as elasticities. Using the coefficient in Column (1) as an example, one percent increase in fixed asset intensity is associated with 0.399 percent increase in pollution levies.

Turning to the control variables, we find that collectively owned firms are associated with more pollution levies, compared to private firms, the baseline ownership category. In our data, firm ownership does not correlate with firm-level pollution: for instance, collective ownership's correlations with NO_x, SO_2, soot, NH, and COD are 0.13, 0.14, -0.09, -0.08, and -0.1. Therefore, it is unlikely that collectively owned firms pay more pollution fees simply because they pollute more. We do not find any significant effect associated with other ownerships, including state ownership. This finding is different from past studies, which often find that local governments protect SOEs via lower pollution levies (Wang et al. 2003; Maung et al. 2016).

Meanwhile, larger (*Firm total output (logged)*) and older (*Firm age (logged)*) firms and firms that paid a higher amount of taxation (*Firm income tax (logged)*) are associated with more pollution levies. A firm's contribution to local employment (*Firm wage contribution (%)*), on the other hand, is unrelated to pollution levies. *Environmental violation* increases pollution levies, which suggests that the baseline of firm environmental performance matters when governments implement environmental regulations.

[17] This variable also does not correlate with firm fixed asset intensity (Table A-1 of appendix).
[18] Jiangsu has 13 prefectures. Firms from 25 industries are included in our analysis.
[19] Clustering at the industry level does not change our main result. Regression results available upon request.

Table 3: Explaining pollution levies and punitive actions, Jiangsu, 2012-2014.

	Dependent variable:			
	Pollution Levies		Punitive Action	
	(1)	(2)	(3)	(4)
Fixed assets as % of output (log)	0.399***		0.014*	
	(0.079)		(0.008)	
Fixed assets as % of sales (log)		0.386***		0.014*
		(0.076)		(0.008)
Firm Ownership (baseline: private)				
State-owned enterprise (SOE)	0.418	0.447	0.120*	0.120*
	(0.270)	(0.274)	(0.065)	(0.065)
Collectively owned	0.627**	0.636**	0.117**	0.117**
	(0.295)	(0.297)	(0.046)	(0.046)
HMT Owned	0.354	0.370	0.021	0.020
	(0.316)	(0.316)	(0.025)	(0.024)
Foreign Owned	0.111	0.132	−0.040*	−0.040*
	(0.294)	(0.293)	(0.022)	(0.022)
Firm profit rate	−0.100	−0.131	0.079	0.083
	(0.634)	(0.630)	(0.172)	(0.171)
Firm total output (logged)	0.374***	0.374***	0.010	0.010
	(0.056)	(0.056)	(0.008)	(0.008)
Firm income tax (logged)	0.043*	0.043*	−0.006	−0.006
	(0.025)	(0.025)	(0.006)	(0.006)
Firm wage contribution (%)	0.017	0.012	−0.004	−0.004
	(0.128)	(0.128)	(0.007)	(0.007)
Firm age (logged)	0.311***	0.318***	0.003	0.003
	(0.114)	(0.115)	(0.018)	(0.018)
Environmental violation	0.297**	0.298**	−0.021	−0.022
	(0.137)	(0.138)	(0.032)	(0.032)
Year fixed effects	√	√	√	√
Prefecture fixed effects	√	√	√	√
Industry fixed effects	√	√	√	√
Clustered s.e. (prefecture)	√	√	√	√
Observations	611	611	719	719
R^2	0.696	0.695	0.140	0.140
Adjusted R^2	0.669	0.668	0.077	0.077

Note: model 1-2 (pollution levies in logged 1000RMB) and model 3-4 (punitive action measured as a binary variable) are estimated by OLS; all right-hand side variables except for environmental violation are lagged by one year. *p<0.1; **p<0.05; ***p<0.01.

Column (3) and (4) in Table 3 present the results that explain government punitive actions. Both of our measures of firm fixed asset intensity are positively associated with the dependent variable. Though the statistical significance level is lower than the case of pollution levies. Regarding the substantive effect, Column (3) and (4) have the same mean coefficient estimate, 0.014, which suggests that a one-unit increase in the fixed asset intensity variable is associated with a 0.014 increase in the probability that a firm receives a punitive action.[20] This is not a small

[20] The fixed assets as % of output (log) variable has a mean of 3.30 and a standard deviation of 1.08 (Table 1): one-unit increase is almost one standard deviation increase.

increase because the average chance a firm receives a punitive action in a year is 0.094 in our data: an increase of 0.014 in probability is an almost 15% increase from this average chance.

Among the control variables, only ownership variables are associated with punitive action. Collectively owned firms and state-owned firms are associated with a higher chance of receiving a punitive action, compared to the baseline category, private firms.[21] Foreign ownership is associated with a lower chance of punitive action, which suggests that foreign firms have been treated better when it comes to punitive actions.

Robustness Checks

Table 4 presents model specifications with fewer control variables. In addition to a firm fixed asset intensity variable, Column (1) and (5) only include ownership variables and a firm profit variable – variables found to affect regulatory decisions from past studies (Wang et al. 2003; Wang and Wheeler 2005). Column (2) and (6) include firm total output (logged) and firm income tax (logged). In Column (3) and (7), firm wage contribution (%) is added to control for a firm's contribution to local employment. Finally, we add firm age in Column (4) and (8): the only difference between these two model specifications and those in Table 3 is the environmental violation variable. Across all model specifications, firm fixed asset intensity is positively associated with the dependent variables. In Table 4 we only use fixed assets as % of sales (log), which is highly correlated with the fixed assets as % of output (log) variable; Table A-2 of the online appendix has regression results when using the latter and the results are similar.

Moreover, the national list of key monitored firms changes annually as a function of firms' annual emissions. As a result, some firms enter/leave the list and therefore our data in different years. Our main analysis is therefore based on a unbalanced panel data. Table 5 shows the results when we limit our analysis to the 168 firms that are included in all three years. We lose around one third of observations compared to regressions in Table 3. Yet we find similar results. Indeed, the magnitudes of the substantive effects are slightly bigger than those in Table 3: e.g., the coefficient in Column (1) of Table 5 suggest that one percent increase in firm fixed asset intensity is associated with 0.436 percent increase in pollution levies.

Finally, we have argued earlier that it is difficult and potentially problematic to control for firm-year level emissions. In this section though, we conduct a robustness check by adding a firm-year total emissions variable. A firm pays for the top three air and top three water pollutants that it emits. In theory, for each pollutant, the government first generates an environmental equivalent by weighing pollutant emissions by an environmental impact factor and then multiplies the equivalent by a fee rate. The sum of fees calculated for these six pollutants serves as the baseline for the total amount of fees a firm pays. For each firm in the sample, we keep the top three air and top three water pollutants and construct the total emissions variable by adding up the emissions of the six pollutants (by weight). Adding this variable excludes key-monitored firms of 2012 because of data unavailability for this year. Moreover, for 2013 and 2014, many missing values exist, which further reduces the number of observations to less than half of the observations in Table 3.

Table 6 presents the results. Column (1)-(4) are pollution levies regressions. Note Column (2)/(4) leaves out the total firm emission variable while using the same sample as in Column

[21] State ownership does not correlate with firm-level pollution: correlations with NO_x, SO_2, soot, NH, and COD are 0.12, 0.11, -0.05, 0.07, and 0.00. It is unlikely that SOEs are more likely to receive a punitive action because they pollute more.

(1)/(3) when we include the total firm emission variable: the goal is to see whether our estimation of the fixed asset intensity variables would change significantly once we control for firm emissions. In Column (1) and (3), both fixed asset intensity variables are still statistically significant; the magnitudes of the coefficient estimates are similar to our main results in Table 3. The emission variable is positive and significant. However, removing this variable in Column (2)/(4) does not change the estimate of the fixed asset intensity variables, which confirms our previous argument that thanks to low correlations between fixed asset intensity and firm emissions, excluding the emission variable does not introduce an omitted variable bias.

Column (5)-(8) are regressions of punitive action. Column (6)/(8) leaves out the total firm emission variable while using the same sample as in Column (5)/(7); the emission variable is not statistically significant. This makes sense because punitive actions are often issued based on violations that do not always correlate with total firm emissions. Many punitive actions are issued based on procedural violations: for example, when a firm built a production line without government approval. The mean coefficient estimates of the fixed asset intensity variables are similar to our main results in Table 3; but they are not statistically significant, because of a much smaller sample size: we now have less than half of the observations compared to our main result regressions in Table 3.

Table 4: Explaining pollution levies and punitive actions, Jiangsu, 2012-2014 – models with fewer control variables.

	Dependent variable:							
	Pollution Levies				Punitive Action			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed assets as % of sales (log)	0.416***	0.384***	0.384***	0.392***	0.013*	0.014*	0.014*	0.014*
	(0.089)	(0.076)	(0.076)	(0.077)	(0.008)	(0.008)	(0.008)	(0.008)
Firm Ownership (baseline: private)								
State-owned enterprise (SOE)	0.986**	0.640**	0.638**	0.474*	0.128*	0.120*	0.119*	0.118*
	(0.383)	(0.311)	(0.311)	(0.278)	(0.065)	(0.066)	(0.066)	(0.066)
Collectively owned	0.988***	0.592**	0.594**	0.639**	0.118**	0.118**	0.117***	0.117**
	(0.229)	(0.259)	(0.261)	(0.311)	(0.049)	(0.046)	(0.045)	(0.046)
HMT Owned	0.597	0.361	0.358	0.357	0.024	0.020	0.021	0.021
	(0.371)	(0.322)	(0.327)	(0.319)	(0.025)	(0.024)	(0.024)	(0.025)
Foreign Owned	0.384	0.115	0.113	0.126	−0.035*	−0.040*	−0.040*	−0.039*
	(0.347)	(0.304)	(0.308)	(0.288)	(0.019)	(0.021)	(0.021)	(0.022)
Firm profit rate	1.570*	−0.121	−0.087	−0.010	0.013	0.080	0.076	0.076
	(0.921)	(0.650)	(0.672)	(0.659)	(0.127)	(0.167)	(0.162)	(0.164)
Firm total output (logged)		0.375***	0.366***	0.368***		0.008	0.010	0.010
		(0.059)	(0.061)	(0.056)		(0.007)	(0.007)	(0.007)
Firm income tax (logged)		0.050**	0.049*	0.038		−0.006	−0.006	−0.006
		(0.025)	(0.027)	(0.024)		(0.007)	(0.007)	(0.006)
Firm wage contribution (%)			0.034	0.019			−0.004	−0.004
			(0.141)	(0.130)			(0.007)	(0.007)
Firm age (logged)				0.330***				0.002
				(0.118)				(0.017)
Year fixed effects	√	√	√	√	√	√	√	√
Prefecture fixed effects	√	√	√	√	√	√	√	√
Industry fixed effects	√	√	√	√	√	√	√	√
Clustered s.e. (prefecture)	√	√	√	√	√	√	√	√
Observations	619	611	611	611	727	719	719	719
R^2	0.629	0.685	0.685	0.693	0.147	0.139	0.139	0.139
Adjusted R^2	0.600	0.660	0.659	0.666	0.092	0.080	0.079	0.078

Note: model 1-4 (pollution levies in logged 1000RMB) and model 5-8 (punitive action measured as a binary variable) are estimated by OLS; all right-hand side variables are lagged by one year. *p<0.1; **p<0.05; ***p<0.01.

Table 5: Explaining pollution levies and punitive actions, Jiangsu, 2012-2014, using only firms that are included in all three years.

	Dependent variable:			
	Pollution Levies		Punitive Action	
	(1)	(2)	(3)	(4)
Fixed assets as % of output (log)	0.436***		0.016*	
	(0.087)		(0.009)	
Fixed assets as % of sales (log)		0.416***		0.018*
		(0.081)		(0.009)
Firm Ownership (baseline: private)				
State-owned enterprise (SOE)	0.481**	0.514**	0.138*	0.138*
	(0.241)	(0.247)	(0.073)	(0.072)
Collectively owned	0.550**	0.560**	0.123**	0.123**
	(0.258)	(0.262)	(0.057)	(0.058)
HMT Owned	0.260	0.277	0.054	0.053
	(0.363)	(0.364)	(0.051)	(0.051)
Foreign Owned	0.042	0.068	−0.013	−0.013
	(0.342)	(0.339)	(0.034)	(0.033)
Firm profit rate	0.633	0.589	0.185	0.193
	(1.122)	(1.115)	(0.163)	(0.163)
Firm total output (logged)	0.406***	0.406***	0.004	0.004
	(0.076)	(0.076)	(0.010)	(0.010)
Firm income tax (logged)	0.007	0.007	−0.012	−0.012
	(0.027)	(0.027)	(0.009)	(0.008)
Environmental violation	0.338	0.339	−0.028	−0.028
	(0.218)	(0.220)	(0.051)	(0.051)
Firm wage contribution (%)	0.037	0.032	0.012	0.012
	(0.137)	(0.138)	(0.014)	(0.013)
Firm age (logged)	0.326**	0.338**	0.002	0.003
	(0.140)	(0.141)	(0.016)	(0.016)
Year fixed effects	√	√	√	√
Prefecture fixed effects	√	√	√	√
Industry fixed effects	√	√	√	√
Clustered s.e. (prefecture)	√	√	√	√
Observations	433	433	509	509
R^2	0.705	0.703	0.170	0.171
Adjusted R^2	0.668	0.666	0.083	0.084

Note: model 1-2 (pollution levies in logged 1000RMB) and model 3-4 (punitive action measured as a binary variable) are estimated by OLS; all right-hand side variables except for environmental violation are lagged by one year. *p<0.1; **p<0.05; ***p<0.01.

Table 6: Jiangsu Sample with Emission Control.

	Dependent Variable:							
	Pollution Levies				Punitive Action			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fixed assets as % of output (log)	0.355**	0.369***			0.009	0.008		
	(0.144)	(0.130)			(0.017)	(0.018)		
Fixed assets as % of sales (log)			0.331**	0.344***			0.012	0.011
			(0.134)	(0.120)			(0.017)	(0.018)
Firm Ownership (baseline: private)								
State-owned enterprise (SOE)	0.184	0.186	0.222	0.226	0.052	0.051	0.051	0.050
	(0.268)	(0.259)	(0.274)	(0.266)	(0.062)	(0.061)	(0.062)	(0.061)
Collectively owned	0.697**	0.580**	0.700**	0.582**	0.129	0.133	0.128	0.132
	(0.297)	(0.269)	(0.287)	(0.262)	(0.165)	(0.157)	(0.166)	(0.158)
HMT Owned	0.087	0.050	0.108	0.072	0.096	0.096	0.095	0.095
	(0.421)	(0.426)	(0.421)	(0.425)	(0.062)	(0.063)	(0.062)	(0.063)
Foreign Owned	−0.083	−0.056	−0.053	−0.025	−0.062*	−0.063*	−0.063*	−0.065*
	(0.317)	(0.322)	(0.321)	(0.326)	(0.034)	(0.033)	(0.034)	(0.033)
Firm profit rate	0.647	0.424	0.588	0.362	0.155	0.162	0.165	0.172
	(1.096)	(1.157)	(1.064)	(1.131)	(0.207)	(0.210)	(0.206)	(0.208)
Firm total output (logged)	0.264**	0.318**	0.259**	0.313**	0.021	0.019	0.021	0.019
	(0.128)	(0.137)	(0.127)	(0.136)	(0.029)	(0.029)	(0.029)	(0.029)
Firm income tax (logged)	0.036	0.036	0.036	0.036	−0.018	−0.018	−0.018	−0.018
	(0.068)	(0.079)	(0.069)	(0.079)	(0.017)	(0.017)	(0.017)	(0.017)
Environmental violation	0.178	0.261	0.177	0.260	0.007	0.004	0.006	0.003
	(0.149)	(0.172)	(0.151)	(0.174)	(0.045)	(0.046)	(0.045)	(0.046)
Firm wage contribution (%)	0.028	0.030	0.023	0.024	−0.006	−0.006	−0.006	−0.006
	(0.139)	(0.143)	(0.140)	(0.145)	(0.011)	(0.011)	(0.011)	(0.011)
Firm age (logged)	0.315*	0.350**	0.326**	0.362**	0.008	0.007	0.009	0.009
	(0.165)	(0.151)	(0.165)	(0.151)	(0.035)	(0.035)	(0.035)	(0.036)
Emissions	0.068***		0.068***		−0.003		−0.003	
	(0.022)		(0.022)		(0.005)		(0.005)	
Year fixed effects	√	√	√	√	√	√	√	√
Prefecture fixed effects	√	√	√	√	√	√	√	√
Industry fixed effects	√	√	√	√	√	√	√	√
Clustered s.e. (prefecture)	√	√	√	√	√	√	√	√
Observations	295	295	295	295	346	346	346	346
R^2	0.652	0.640	0.650	0.638	0.245	0.244	0.245	0.244

Note: model 1-4 (pollution levies in logged 1000RMB) and model 5-8 (punitive action measured as a binary variable) are estimated by OLS; all right-hand side variables except for environmental violation and emissions are lagged by one year. *p<0.1; **p<0.05; ***p<0.01.

Instrumenting Firm-Level Fixed Asset Variables

Using firm-year fixed asset intensity measures in the regression analysis might introduce an endogeneity bias because firms may reduce fixed asset intensity when facing more stringent regulatory actions (Frye 2004; Liu and Zhao 2017). This introduces a downward bias because more regulatory actions lower firms' fixed asset intensity, therefore creating a negative causal effect going from regulatory stringency to fixed asset intensity. The fact that despite such a potential downward bias, we still find a positive relationship between fixed asset intensity and pollution levies/punitive actions increases the credibility of our results.

To address this potential endogeneity issue, we adopt an instrumental variable approach. Our instruments are median values of industry-year level fixed asset intensity based on firms included in the CFIS from all provinces of China. The idea here is that industry level fixed asset intensity is largely determined exogenously by technology and unlikely to be endogenous to local government regulations. In Table 7, we present the results when we instrument a firm-year-level fixed asset intensity variable using one industry-level fixed asset variable and its square term. Using both an industry fixed asset measure and its square term as instruments captures more variation in the fitted values and thus leave less in the first-stage residuals. This is also consistent with Dieterle and Snell (2014) that suggest that using a measure and its square term to instrument for an endogenous regressor can improve instrumentation and model fit if concerns about overidentification can be allayed.[22]

Results from Table 7 confirm what we have found in the main analysis (Table 3). For instance, in the first model specification, we use an industry median variable of fixed asset to output ratios ($fixed\ asset\ per\ output\ _{median}^{industry}$) and its square term as instruments for the firm-year-level fixed asset to output variable. We find that higher fixed asset intensity increases the amount of pollution fees paid by a firm.

We have argued earlier that if more regulatory actions lower firms' fixed asset intensity, we would observe a negative causal effect going from regulatory stringency to fixed asset intensity, which would introduce a downward bias in our OLS estimates. This is confirmed by the coefficient estimates from the instrumented fixed asset intensity variables in Table 7: they are much larger than the OLS estimates in Table 3. Take Column (1) as an example, the one from the instrumental variable analysis is 1.836 while the corresponding OLS estimate in Table 3 is 0.399. In Column (3) and (4) in which we explain punitive actions, we also find that the estimates from the instrumented fixed asset intensity variables are much larger than those OLS estimates in Table 3: e.g., in Column (3), the one from the instrumental variable analysis is 0.175 while the OLS estimate in Table 3 is 0.014.

The diagnostic statisitics from Table 7 support our choice of instruments. Across all model specifications, they pass the weak instruments test, showing that our instruments are not weak instruments. Next, the Wu–Hausman statistic tests the consistency of the OLS estimates. When we reject, it means OLS is not consistent, suggesting endogeneity is present. We can reject the null in all model specifications, suggesting that using firm-level fixed asset variables is indeed likely to suffer from the described endogeneity effect. Finally, since we are using more than one instrument, we also report the Sargan test results. The null for this overidentifying restrictions test is that the extra instrument is valid. In all model specifications, we cannot reject the null, confirming that the extra instrument is indeed valid.

[22] The same instrument strategy has been applied in recent studies including Andersson et al. (2017), Rooney (2019), and Tigre et al. (2017).

Table 7: Explaining pollution levies and punitive actions using instrumental variables, Jiangsu, 2012-2014.

	Dependent variable:			
	Pollution Levies		Punitive Action	
	(1)	(2)	(4)	(5)
Fixed assets as % of output $(\log)^{instrumented}$	1.836^{**}		0.175^{*}	
	(0.866)		(0.100)	
Fixed assets as % of sale $(\log)^{instrumented}$		1.913^{**}		0.176^{*}
		(0.912)		(0.102)
Instruments used:				
1): fixed asset per output $_{\text{median}}^{\text{industry}}$	√		√	
2): (fixed asset per output $_{\text{median}}^{\text{industry}})^2$	√		√	
3): fixed asset per sale $_{\text{median}}^{\text{industry}}$		√		√
4): (fixed asset per sale $_{\text{median}}^{\text{industry}})^2$		√		√
Weak instruments test	2.835	2.686	5.390	5.153
(p-value)	(0.059)	(0.069)	(0.004)	(0.006)
Wu-Hausman test	4.565	5.027	3.289	3.227
(p-value)	(0.033)	(0.025)	(0.070)	(0.072)
Sargan test	0.007	0.001	0.217	0.285
(p-value)	(0.932)	(0.977)	(0.640)	(0.593)
Control variables	√	√	√	√
Year fixed effects	√	√	√	√
Prefecture fixed effects	√	√	√	√
Observations	611	611	719	719

Note: we use 2SLS, with the same set of control variables as in Table 3; we cannot include fixed industry effects because the instrumental variables are measured at the industry level.

5. CAUSAL MECHANISM AND EXTERNAL VALIDITY

Evidence from a National Survey of Managers

To see whether firms with higher fixed assets are indeed less likely to relocate, we designed and fielded a firm-level survey in October 2018 to a total of 534 firms following the sampling procedure outlined in Li and Zeng (2019). Though not drawn from a probability-based sample, our sampled firms, especially those that reported over 20 million RMB in annual sales, are comparable to the population of firms reported in the CFIS in terms of location, ownership, size (by sales), and to some extent industrial breakdown.[23]

In the survey, we asked each manager to estimate his/her firm's fixed asset as a percentage of its annual sales, which allows us to construct a firm-level measure of fixed asset intensity. Table 8 presents the results from two model specifications on the effects of fixed asset intensity. The dependent variable in Column (1) is a binary measure based on the following question: "How difficult is it for your firm to move production to a different city within the province?" Firms reporting any kind of difficulty in relocation are coded as "immobile." The dependent variable in Column (2) is a firm's environmental expense, based on the following question: "What were your firm's operation costs related to environment (monitoring, auditing, pollution fees, fines, etc.) in 2017?"[24]

In both models, we control for firm sales, whether or not the CEO is a member of the National People's Congress (NPC), whether or not the board of the firm has NPC members, the firm's ownership structure (SOE being the baseline category), the number of employees, the productivity of the firm compared to other firms, how difficult it is for the firm to meet environmental standards set by the state, and the location of the firm (coastal, central, or western: western is the baseline category).[25] Finally, we include industry fixed effects.

Table 8 suggests that managers in firms with higher fixed asset intensity indeed consider their firms less likely to relocate their production. Furthermore, these firms incur higher environmental operational expenses including pollution fees and fines. Taken together, these results lend support to the asset mobility mechanism and provide evidence that our findings from Jiangsu's key monitored firms are applicable to the present day and to a more diverse set of firms.

Table 8: Testing the effect of fixed asset using survey data.

	(1) Immobility	(2) Environmental Expense
Fixed Assets as a Percentage of Sales	0.008*	0.007**
	(0.004)	(0.003)
Privately Owned	-0.794***	-0.502**
	(0.268)	(0.219)
HMT Owned [a]	0.0926	-0.614
	(0.579)	(0.391)
Foreign Owned	-0.553	-1.113***
	(0.433)	(0.359)
Collectively Owned	-0.747	-0.055

[23] See online Appendix B for more details.
[24] We use log transformation to smooth the highly skewed distribution of this variable.
[25] See online Appendix B for summary statistics and construction of the variables.

	(0.640)	(0.443)
Joint Venture	-0.546	0.111
	(0.460)	(0.484)
CEO is NPC Member	0.496	0.111
	(0.334)	(0.251)
Board Contains NPC Member	-0.407	0.379
	(0.303)	(0.239)
Firm Sales	-0.017	0.265***
	(0.053)	(0.045)
Number of Employees	-0.149	0.171*
	(0.105)	(0.0995)
Productivity	-0.061	-0.358**
	(0.160)	(0.152)
Difficulty in Meeting Env. Stand.	0.008*	0.007**
	(0.004)	(0.003)
Coastal Provinces [b]	-0.017	0.265***
	(0.053)	(0.045)
Central Provinces	0.496	0.111
	(0.334)	(0.251)
Constant	-0.407	0.379
	(0.303)	(0.239)
Industry fixed effects	√	√
Observations	493	508

Notes: a: HMT Owned refers to Hong Kong, Macao, and Taiwan ownership; b: western province is the baseline category. For ownership variables, the baseline category is state-owned enterprises (SOE). Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Evidence from the 2004 CFIS

To further examine whether our findings are generalizable to firms beyond key monitored firms in Jiangsu, we fit a series of models on pollution levies using all manufacturing firms from the 2004 CFIS.[26] 2004 is the only year for which the CFIS provides information on pollution levies. The 2004 data covers approximately 89.5% of industrial firms in China.[27] Our analysis contains 201,926 manufacturing firms, a sample size large enough to test the external validity of our findings.

In the main analysis, we construct firm-level fixed asset intensity variables by calculating the percentage of fixed assets in total annual output and sales separately. For consistency, we create two measures using CFIS data following the same rule. The only problem is that the 2004 CFIS data does not have a firm output variable. We use firm intermediate input as a replacement because intermediate input determines firm output. Intermediate input refers to goods and services used in the production process to produce other goods or services; it equals the total

[26] We cannot fit punitive action models because the CFIS has no punitive action data.
[27] In 2004, the Chinese government conducted the first national economic census. Nie et al. (2012) obtain this percentage by comparing the sales of all firms in the dataset to the aggregate amount of industrial sales derived from the census.

output less value-added.[28] Moreover, the correlation between intermediate input and total sales is 0.958, similar to the correlation between total output and total sales in the Jiangsu sample.

Table 9: Explaining pollution levies using the CFIS 2004 Sample.

	Dependent Variable: Pollution Levies			
	(1)	(2)	(3)	(4)
Fixed assets as % of intermediate input (log)	0.31***	0.25***		
	(0.01)	(0.01)		
Fixed assets as % of total sales (log)			0.28***	0.31***
			(0.01)	(0.01)
Firm Ownership (baseline: private)				
State-owned enterprise (SOE)	0.20***	0.23***	0.23***	0.22***
	(0.07)	(0.06)	(0.07)	(0.07)
Collectively owned	−0.07*	−0.08*	−0.07*	−0.08*
	(0.04)	(0.04)	(0.04)	(0.04)
HMT Owned	−0.17***	−0.18***	−0.13***	−0.19***
	(0.04)	(0.04)	(0.04)	(0.04)
Foreign Owned	−0.30***	−0.31***	−0.24***	−0.32***
	(0.03)	(0.03)	(0.03)	(0.03)
Firm profit rate	0.26***	−0.43**	0.53***	0.02
	(0.05)	(0.21)	(0.14)	(0.09)
Firm intermediate Input (logged)	0.44***		0.41***	
	(0.02)		(0.02)	
Firm total sales (logged)		0.46***		0.47***
		(0.02)		(0.02)
Firm income tax (logged)	0.03***	0.02***	0.03***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)
Firm wage contribution (%)	13.74***	13.24***	14.91***	13.01***
	(1.49)	(1.45)	(1.60)	(1.44)
Firm age (logged)	0.23***	0.23***	0.24***	0.22***
	(0.01)	(0.01)	(0.01)	(0.01)
Prefecture fixed effect	√	√	√	√
Industry fixed effect	√	√	√	√
Clustered s.e. (prefecture)	√	√	√	√
Observations	201,926	201,926	201,926	2019,26
R^2	0.16	0.16	0.16	0.16

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

The control variables included are identical to those in the main analysis except for firm size and environmental performance variables. Since firm output is not available, we use intermediate input or total sales as proxies of firm size. The CFIS has no data on firm pollution and environmental violation. Therefore, we cannot control for pollution baseline as we did in our main analysis.[29] Finally, we use prefecture and industry fixed effects and cluster the standard errors at the prefecture level.

[28] The definition is from the Bureau of Economic Analysis: https://www.bea.gov/help/faq/185, last accessed August 26, 2020.

[29] Admittedly, this could introduce an omitted variable bias as firms may pay more pollution levies because they pollute more. However, at least based on the sample of key monitored firms

In Table 9, we use fixed asset as a percentage of intermediate input (logged) in Column (1) and (2) and fixed asset as a percentage of total sales (logged) in Column (3) and (4). For each fixed asset intensity measure, we include either intermediate input or total sales to control for firm size. The coefficient estimates associated with fixed asset intensity in all models are similar in terms of significance and magnitude; they indicate that pollution levies positively relate to fixed asset intensity. Comparing to the main results in Table 3, we find that these coefficients are highly similar in magnitude to those from the Jiangsu sample. This similarity suggests that the estimated effect at this magnitude is not restricted to key monitored firms in Jiangsu.

6. CONCLUSION

To explain the variation in firm-level environmental regulatory actions, this paper offers a theoretical angle that focuses on the asset mobility mechanism associated with fixed asset intensity, bringing in the agency of local regulators and their interests and incentives. Specifically, we argue that high fixed asset intensity makes a firm less mobile, which in turn makes it unable to present a credible exit threat when faced with stringent enforcement of environmental regulations. Local governments, therefore, are more likely to target these firms, knowing that they are much less likely to relocate. Our empirical findings from key monitored polluting firms in Jiangsu provides strong and robust evidence of the theory. Higher level of firm fixed asset intensity corresponds to a higher amount of pollution levies paid and a higher chance of receiving a government punitive action.

These results suggest that local governments in Jiangsu behave strategically. They are much less likely to use heavy pollution levies and punitive actions against firms with low fixed asset intensity because such firms do have the ability to move, therefore posing a credible threat of relocating to other jurisdictions. However, pollution fees and punitive regulatory actions such as monetary fines and suspension of production are often necessary and effective tools to change firms' environmental performance. Facing severe environmental issues and consequent pressures from the central government to clean up the environment, local governments are therefore more likely to target firms with high fixed asset intensity.

Using an original firm-level survey and the national sample of the CFIS, we provide evidence that what we find in Jiangsu can be generalized to other parts of the country. Future studies can further corroborate this by extending the analyses to include more provinces and years, especially regarding government punitive actions. Considering that coding punitive actions and matching firm names between various datasets are very time-consuming, one optimal strategy may involve selecting provinces that represent different regions and different levels of economic development in China. Qualitative evidence through interviews with firms and environmental regulators may also help further illuminate the "strategic local government" story.

Finally, understanding the politics of regulatory enforcement can have significant policy implications. The Chinese government has shown great efforts to address environmental and climate crisis by experimenting with various new regulatory instruments. Our empirical findings suggest that policymakers will need to consider the strategic thinking of local governments in designing these policies to ensure their success. For instance, weakening favorite treatments of

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in Jiangsu, there is no correlation between firm pollution and fixed asset intensity (Table 2); this is further confirmed by Table 6 which indicates that adding a firm emission variable does not change the estimates of the fixed asset intensity variables.

mobile firms requires lowering their exit threat. However, this is often beyond the ability of individual subnational jurisdictions as mobile firms can play one jurisdiction against another. A more effective policy design requires coordination between different jurisdictions and monitoring by the central government so that a race to the bottom in *de facto* environmental regulatory stringency can be halted and hopefully reversed.

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