The Costs of “Blue Sky”: Environmental Regulation and Employee Income in China

Renrui xiao (xiaorenruim@163.com)
Hunan University

Guangrong Tan
Hunan University

Baocong Huang
Hunan University

Yuanyue Luo
Ningxia University

Research Article

Keywords: environmental regulation, employee income, income inequality

Posted Date: November 30th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1037763/v1

Abstract

Strict environmental regulations may change the behavioral decisions of firms. Based on the exogenous impact of the Chinese Central Government's inclusion of environmental performance in the assessment targets of municipal officials in 2007, this study uses the difference-in-difference method to explore the impact of environmental regulations on employee income. We find that (1) environmental regulations will significantly reduce the average wage level of employees in polluting industries and have no significant impact on nonpolluting industries. (2) This effect is more pronounced in eastern China, where environmental regulations are more stringent, and in areas where political promotion incentives are stronger. (3) Mechanistic analysis finds that environmental regulations will affect employee income by increasing costs and constraining financing. (4) More importantly, we find that the decline in the average wage level of firms is mainly due to the decline in the average wage level of ordinary employees, and the average wage level of management has not decreased significantly, which means that environmental regulations have expanded social income inequality. Our findings contribute to a comprehensive understanding of the effectiveness of the implementation of environmental regulatory policies and economic cost issues.

1. Introduction

Striking a balance between economic development and environmental protection is a common concern of many countries and governments (Okereke and McDaniels 2012; Tang et al. 2020). China, as the world's largest developing country, is the same. While achieving great economic development, it also faces severe environmental problems (Zhang et al. 2019; Zhou et al. 2020). According to the Bulletin of the State of the Environment of China 2015, 78% of prefecture-level cities across the country have severely exceeded air pollution standards. Every year, 350,000 to 400,000 Chinese minors die due to air pollution (World Bank 2007). To strengthen pollution control, the Chinese government has implemented a series of environmental regulatory measures for polluting gas emissions, which have played an important role in improving China's environment (Ren et al. 2018; Li et al. 2017; Fan et al. 2019). However, the implementation of these measures will not only cause changes in pollution levels but also have a nonignorable impact on the economic activities of firms. In this regard, a large number of studies have focused on the impact of environmental regulations on firm innovation, investment, productivity, exports, migration, labor demand, and tax avoidance (Bergek and Berggren 2014; Cai et al. 2016; Albrizio et al. 2017; Hering and Poncet 2014; Chen et al. 2018; Liu et al. 2021; Geng et al. 2021; Yu et al. 2021). However, few studies have focused on the impact of environmental regulations on employee income. When a firm faces negative impacts such as environmental regulations, reducing the wage level of employees is one of the important behavioral decisions it may make. Surprisingly, very little is known about this at present.

At the same time, the decline in the labor income share is a common problem faced by many countries in the world, including China (Gollin 2002; Karabarbounis and Neiman 2013). The inequality of social income has become one of the biggest challenges affecting global social stability. Since labor income,

such as wages, is the main source of income for most people, the existing literature has studied the determinants of firm wages and other labor income from multiple perspectives, such as technological progress (Acemoglu 2003), market monopoly (Berkowitz et al. 2016), urban agglomeration (Chen et al. 2021), industrial structure (Acemoglu and Guerrieri 2008), tax incentives (Suárez Serrato and Zidar 2016; Garrett et al. 2020), minimum wage (Card and Krueger 1994), trade liberalization (Amiti and Cameron 2012), imports and exports (Autor et al. 2013; Amiti and Davis 2012), etc. These studies did not consider the perspective of environmental regulation.

This study attempts to fill this important gap by studying China, the world's largest pollutant emitter and developing countries. In the face of increasingly serious environmental pollution problems, the Chinese central government included environmental performance in the assessment indicators of municipal officials in 2007 and began appointing government officials with reference to pollution reduction performance. However, due to differences in local government responses, in the following years, only some local governments included environmental target constraints in their government work reports, which were clearly listed as performance targets for the year, while some local governments did not include them. As a result, compared with other regions, regions where objective environmental constraints are written into government work reports are subject to stricter environmental regulations.

Taking advantage of the exogenous impact of the Chinese central government’s inclusion of environmental performance in the assessment targets of prefecture-level officials in 2007, we compiled the environmental target data disclosed in the government work report of China’s prefecture-level city and constructed a difference-in-difference empirical strategy to explore the impact of environmental regulations on firm employee income. We find that environmental regulations have reduced the average wage level of employees in polluting industries by 3.2%, and this effect only exists in polluting industries, not in nonpolluting industries. This conclusion is established in a series of robustness tests. Heterogeneity analysis finds that this effect is more pronounced in eastern China, where environmental regulations are more stringent, and in areas where political promotion incentives are stronger. Mechanistic analysis shows that the increase in firm costs and the increase in financing constraints are important channels for the decline in firm average wages caused by environmental regulations. Furthermore, we also find that the decline in the average wage level of firms is mainly due to the decline in the average wage level of ordinary employees. The average wage of management has not decreased significantly, and environmental regulations have increased social income inequality.

Our study has contributed to the existing literature in the following three aspects. First, our research attempts to explore the impact of environmental regulation on the income of employees and its internal mechanism for the first time. Relationships provide new perspectives and insights. Through the abovementioned literature review, it can be found that the literature on environmental regulation and firm behavior decision-making mainly focuses on innovation, investment, productivity, export, migration, labor demand, and tax avoidance (Bergek and Berggren 2014; Cai et al. 2016; Albrizio et al. 2017; Hering and Poncet 2014; Chen et al. 2018; Liu et al. 2021; Geng et al. 2021). The discussion on firm labor income mainly focuses on technological progress, market monopoly, urban agglomeration, industrial structure,

tax incentives, minimum wage, trade liberalization, and import and export (Acemoglu 2003; Berkowitz et al. 2016; Chen et al. 2021; Acemoglu and Guerrieri 2008; Garrett et al. 2020; Card and Krueger 1994; Amiti and Cameron 2012; Amiti and Davis 2012). The research in this study is an expansion and supplement to the above two aspects of the literature.

Second, our research has enriched the discussion about the political economy of centralization and the political economy of pollution. From the perspective of the relationship between the central and local governments and promotion incentives, our study combines environmental policies with government work goals and explores the impact of the internal motivation of local governments in implementing environmental regulations on firm employee income, thereby enriching the political economy of centralization (Blanchard and Shleifer 2001; Xu 2011; Heberer and Senz 2011) and the political economy of pollution (Burgess et al. 2012; Kahn et al. 2015; Lipscomb and Mobarak 2016; He et al. 2020)-related research.

Third, our research supplements the spillover effects of environmental regulations. Specifically, we found that the negative impact of environmental regulations on the average wage level of firm employees only exists in polluting firms, not nonpolluting firms, and the decline in the average wage level of firm employees comes from the decline in the average wage level of ordinary employees. The average wage of management has not decreased, and environmental regulatory measures have increased social income inequality. This finding enables us to have a more comprehensive understanding of the negative externalities and economic costs of environmental regulations.

The rest of the study is structured as follows: Section 2 briefly explains the institutional background and theoretical analysis of this study; Section 3 introduces the data and research design; and Section 4 presents the main results, robustness checks and heterogeneous effects. Section 5 discusses the internal mechanism of the impact of environmental regulations on employee income. Section 6 further analyzes who bears the cost of environmental regulations. Section 7 presents our conclusions.

2. Policy Background And Theoretical Analysis

2.1 Policy background

After the reform and opening up of China, to rapidly develop the economy, the Chinese government paid great attention to economic performance in the promotion of local officials politically and adopted a development strategy of relying on heavy industry first. This mode of economic development has obvious characteristics of high and extensive pollution, so the environmental pollution problem has become increasingly serious. The typical result is the sharp increase in the discharge of SO_2 and other major pollutants, which directly leads to an increase in the frequency and intensity of acid rain. According to Geng et al. (2021), between 1996 and 2000, 72% of cities in China experienced acid rain, and the proportion of cities with acid rain frequencies higher than 40% reached 33%. Out of the need for long-term

sustainable economic development, the Chinese government has decided to implement environmental regulations to improve the status quo of environmental pollution.

China’s earliest environmental regulation goals began in the 10th Five-Year Plan (2000-2005), but due to the lack of reasonable and effective decomposition and assessment methods for environmental protection-related quantitative indicators, the planning goals lack strong constraints, and emission reduction targets for major pollutants have not been achieved (Shi and Xu 2018). At the beginning of the 11th Five-Year Plan (2006-2010), the central government decided to take stronger measures. Since local officials are the actual implementation subjects of the central environmental goals, the central government has decided to include "pollution reduction assessment" as an important assessment content for officials' political promotion. In December 2006, the central government issued the "Decision on Implementing the Scientific Outlook on Development and Further Enhancing Environmental Protection," which clearly stated that the "pollution reduction assessment" should be used as the basis for the political promotion of local officials. Subsequently, the Ministry of Environmental Protection signed the "11th Five-Year Plan Major Pollutant Total Reduction Target Responsibility Letter” (PRTRL) with provinces, municipalities, autonomous regions, and municipalities directly under the Central Government in 2007 and officially began the pollutant emission reduction assessment for local officials.

Under China's unique model of political centralization and economic decentralization, local governments have tremendous influence and control over the development of the local economy (Jin et al. 2005). Environmental emission reduction targets are incorporated into the assessment method based on economic performance. This change in political assessment methods directly affects the political promotion of local officials and profoundly changes the behavior of local governments. The key to this measure lies in the level-by-level decomposition and assessment of environmental protection goals. The central government signs a PRTRL with provincial governments to decompose and implement the national pollution reduction goals to each province, and then each province decomposes and implements it to each prefecture-level city. The cities are further included in the districts and counties and polluting firms within their jurisdiction and finally checked by the central and provincial governments. The results of the assessment are announced to the public and used as the basis for the political promotion of prefecture-level city officials. This also ensures that local governments are able to implement the environmental regulation policies of the central government. Figs. 1 plots the average SO_2 emissions of prefecture-level cities in China from 2004 to 2012. After the PRTRL in 2007, SO_2 emissions dropped rapidly.

In the government’s daily operation, the government work report, an important planning document for prefecture-level city governments, can fully reflect the focus of the government's work in a given year. Therefore, the pollution reduction targets disclosed in government work reports will inevitably have an important impact on polluting firms in the jurisdiction. After the central and local governments signed the PRTRL, due to differences in the responses of local governments, in the following years, some local governments included environmental target constraints in their government work reports, which were clearly listed as performance targets for the year, while some local governments did not. This difference

in response makes areas where pollution reduction targets are written into government work reports subject to stricter environmental regulations compared to other regions, which also provides a realistic basis for this study to distinguish between the treatment group and the control group.

2.2 Theoretical analysis

2.2.1 Firm cost

Theoretically, environmental regulations can influence the wages of employees in firms through multiple channels. The first is the firm cost channel. On the one hand, environmental control has increased the production cost of firms by requiring firms to adopt high-cost clean energy, increase pollution control equipment, and upgrade or rectify high-pollution production lines (Jaffe et al. 1995; Berman and Bui 2001; Alpay et al. 2002). On the other hand, the collection of pollution fees, such as pollution discharge fees, pollution rights trading, and payment of guarantee deposits, also increases the environmental costs of firms (He et al. 2020). When firms face the negative impact of increased costs, they urgently need to transfer risks (Eisdorfer 2008). Lowering the wages of employees is a feasible approach for firms. Lowering wages can save the firm's cash flow in the short term and reduce the firm's operating costs and operating risks. Based on this, this study expects that environmental regulations will reduce the wages of employees in firms. At the same time, the relevant research on the negative impact of firms and the income of employees also provides support for the theoretical logic of this study. For example, the study by Dauth et al. (2014) in Germany found that the increase in costs brought about by import competition significantly reduced the average wage level of firms. Felix and Hines (2009) and Fuest et al. (2018) found that when faced with rising costs caused by rising income tax rates, firms will pass on the tax burden by directly reducing wages. All this evidence shows that reducing the wage level of employees is indeed a common method for firms to resist external uncertainties and possible negative shocks. Therefore, environmental regulations will cause a decline in the wages of employees in firms.

2.2.2 Financing constraints

In addition to the firm cost mechanism, environmental regulations may also affect the wages of firm employees through financing restraint mechanisms. After the signing of the PRTRL in 2007, The People's Bank of China, the China Banking Regulatory Commission, and other relevant departments issued a number of documents to restrict banks and other financial institutions from lending to firms in high-energy-consuming and high-polluting industries, such as the "Notice on Earnestly Implementing National Macro-Control Policies and Strictly Preventing Banking Risks" and the "Notice on Deeply Implementing National Macro-Control Measures and Effectively Strengthening Credit Management,", etc. In addition, the China Banking Regulatory Commission organized a special inspection and notification meeting on loans to polluting firms, requesting the recovery of loans to firms that did not meet the standards for energy consumption and pollution. The implementation of these measures has further deteriorated the financing environment of polluting firms and increased the financing constraints faced by firms. Existing studies have also confirmed that polluting firms do have higher financing constraints than nonpolluting firms (Hong and Kacperczyk 2009), and environmental regulations will increase the financing constraints faced

by polluting firms by sending signals to the capital market (Geng et al. al. 2021). According to financing theory, the preferred choice for firms to finance is to use their own funds first and then use debt financing (Myers and Majluf 1984). When a firm's external financing is blocked, it can only rely on internal financing to provide financial support. As one of the important means of a firm's internal financing, reducing the wages of firm employees can ease financing constraints by increasing the firm's cash flow. Therefore, environmental regulations will also reduce the wage level of firm employees by increasing financing constraints.

3. Data And Empirical Strategy

3.1 Data

The data we use are the environmental regulation target data of China's 225 prefecture-level cities and the data of A-share listed firms from 2004 to 2014. The reason for selecting the sample interval from 2004 to 2014 is that they are located at the ends of China's 10th Five-Year Plan and 12th Five-Year Plan, and they happen to include the year (2007) when the PRTRL was signed. The government environmental regulation target data come from the government work reports of each prefecture-level city over the years, collected from the official website of the local prefecture-level city government, and manually sorted by the environmental regulation targets of the local government. In the process of collection and sorting, we deleted the prefecture-level cities in the two special provinces of Xinjiang and Tibet. We deleted the prefecture-level cities with more serious deficiencies in government work reports. In the end, we collected environmental regulation target data for 225 (77%) prefecture-level cities in China.

The data of A-share listed firms come from the China Stock Market & Accounting Research Database (CSMAR). This database is one of the most authoritative corporate databases in China and provides very detailed corporate financial data. In the process of data sorting, we screened and processed the original data as follows: First, we excluded financial industry firms such as banks and insurance firms and firms with severely missing values for key variables. ST/PT firms are also excluded because their financial conditions are abnormal. Second, to prevent the influence of outliers, we carried out [1%, 99%] tailing treatment for the main financial variables. After the above treatment, a total of 2,387 A-share listed firms were obtained. Finally, after matching the two datasets, our sample contains 17,850 observations from 2,387 listed firms in 225 cities in China from 2004 to 2014.

3.2 Models

The signing of the PRTRL in 2007 provided a quasi-natural experimental environment for investigating the impact of environmental regulations. After the central and local governments signed the PRTRL, due to differences in the responses of local governments, in the following years, some local governments included pollution reduction targets and constraints in their government work reports, which were clearly listed as performance targets for the year. Some governments did not include it. This difference in response makes areas where pollution reduction targets are included in government work reports subject to stricter environmental regulations compared to other areas, which provides a realistic basis for this

study to distinguish between the treatment group and the control group. To this end, we will use prefecture-level city firms that clearly stated pollution reduction targets in the government work report as the treatment group and use prefecture-level city firms that have not clearly stated pollution reduction targets in the government work report as the control group.

According to the above analysis, we use the difference-in-difference model to identify the impact of environmental regulations on employee income. The empirical equation is set as follows:

$$lnwage_{it} = \beta_0 + \beta_1 ER_i \times Post_t + X_{it}B + \gamma_i + \eta_t + \epsilon_{it} \qquad (1)$$

where *i* represents the firm and *t* represents the year. $lnwage_{it}$ is the dependent variable, which represents the employee's income of firm *i* in year *t*. *ER* is a dummyvariable, indicating whether the firm is subject to environmental regulations. For example, if the pollution reduction target is clearly stated in the government work report of the city where the firm is located, the value is 1 and 0 otherwise; *Post* is the period dummy variable, the value was 0 before 2007 and 1 after 2007. *X* is the control variable in this study, which is mainly an index that can affect the income level of employees at the firm level. is a fixed effect at the firm level, which is used to control the factors that do not change with time at the firm level. is a time fixed effect, which is used to control the macroeconomic factors that may change over time. is an error term. In the regressions, the standard errors are clustered by firm.

3.3 Variables

The dependent variable in this study is the average wage of firm employees, where the average wage is the actual wage, including wages paid to employees, bonuses, allowances and subsidies, pension insurance, unemployment insurance, supplementary pension insurance, housing provident funds and payments to employees and housing difficulties subsidies etc. We use the wages paid to the employees and the cash paid for the employees divided by the number of employees in the firm.

The core explanatory variable is environmental regulation. This indicator determines whether it is subject to environmental regulations based on the government work reports of the city where the firm is located in 2007 after the signing of the PRTRL. If a clear pollution reduction target is proposed in a certain year, the value is 1; otherwise, it is 0.

The control variables in this study are variables that affect the wages of employees at the firm level, including (1) firm age. The survival time of a firm in the market will affect the firm’s employee welfare, including employee wages. This study uses the natural logarithm of the difference between the current year and the year when the firm opened. (2) Firm debt ratio. The debt situation of a firm is an important factor affecting the salary and remuneration of a firm. This study uses the ratio of the total debt to the total assets of the firm to express the debt ratio. (3) Firm scale. Generally, the larger the size of a firm is, the stronger its physical and human capital, the stronger its market competitiveness, and its ability to increase employees' wages. This study uses the natural logarithm of the firm's total assets to measure

the scale. (4) Profitability. The profitability of a firm directly determines the average wage of the firm. This study uses the firm's return on assets to measure profitability. (5) Capital intensity. This variable is measured by the logarithm of the ratio of the annual average balance of net fixed assets to the annual average number of employees. (6) Firm asset structure. This variable is expressed by dividing the sum of net fixed assets and inventories by total assets. (7) Number of employees in the firm. The number of employees in a firm is an important factor affecting the average wage of a firm. This study controls this to ensure that changes in the firm’s wage are indeed brought about by environmental regulations, rather than changes in the number of employees in the firm or other factors that may affect the number of employees in the firm. We use the natural logarithm of the number of employees in the firm. Table 1 shows the summary statistics for the main variables.

Table 1 Summary Statistics

Variable	Obs.	Mean	S.D.	Min	Max
lnwage	17850	11.073	0.729	9.296	13.523
ER×Post	17850	0.263	0.440	0	1
lnage	17850	2.645	0.477	0.693	3.258
lev	17850	0.454	0.213	0.045	0.908
size	17850	21.666	1.273	14.937	28.509
roa	17850	0.039	0.056	-0.194	0.204
lncapital	17850	12.434	1.150	9.539	15.855
lnL	17850	7.454	1.330	3.664	10.902
tang	17850	0.418	0.185	0.033	0.833

Notes: All monetary values are in real terms. For definitions of these variables, see Table A1 in the Appendix.

4. Empirical Results And Analyses

4.1 Baseline results

Table 2 shows the baseline results of the impact of environmental regulations on the income of employees. Column (1) is the regression result of the full sample, in which the control variables, firm fixed effects and year fixed effects are controlled. The results show that the coefficient of the environmental regulation variable (ER×Post) is -0.017, which is significant at the 5% level, which means that compared with the control group, environmental regulation reduces the average wage of the employees in the treatment group by 1.7%. According to the previous analysis, those that are truly affected by environmental regulations should be polluting industry firms in prefecture-level cities that set clear pollution reduction targets, and nonpolluting industry firms will hardly be affected. To this end, according to the "Announcement on the Implementation of Special Emission Limits for Air Pollution" issued by the Ministry of Ecology and Environment of the People's Republic of China and the study of He et al. (2020), we divided the full sample into polluting industry firms and nonpolluting industry firms (see Table A2) to further explore the impact of environmental regulations on the income of employees. The results are

shown in Columns (2) and (3) in Table 2. Environmental regulations have significantly reduced the average wage of polluting firms, and they have no significant impact on nonpolluting firms. Compared with firms in the polluting industry in the control group, environmental regulations have reduced the average wage of firms in the polluting industry in the treatment group by 3.2%.

Table 2 Effects of environmental regulation on employee income: baseline results

Dependent Variable	lnwage		
	All industries	Polluting industries	Nonpolluting industries
	(1)	(2)	(3)
ER×Post	-0.017**	-0.032**	-0.012
	(0.008)	(0.014)	(0.009)
lnage	0.164***	0.265***	0.138***
	(0.034)	(0.065)	(0.039)
lev	0.039	-0.198**	0.125**
	(0.049)	(0.095)	(0.056)
size	0.302***	0.230***	0.314***
	(0.018)	(0.035)	(0.021)
roa	0.464***	0.515***	0.427***
	(0.091)	(0.163)	(0.110)
lncapital	0.108***	0.114***	0.113***
	(0.011)	(0.029)	(0.012)
lnL	-0.494***	-0.435***	-0.504***
	(0.017)	(0.036)	(0.019)
tang	-0.082	-0.054	-0.116*
	(0.051)	(0.085)	(0.059)
Firm fixed effects	Y	Y	Y
Year fixed effects	Y	Y	Y
Observations	17850	4338	13512
R-squared	0.699	0.728	0.693

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%.

4.2 Robustness checks

To ensure the robustness of the benchmark regression results, we conducted a series of tests. The first is the test of parallel trend assumption. An important assumption for the difference-in-difference estimation is that if there is no environmental regulation, the average wages of employees in the treatment group

and the control group have a strict common trend. To verify the common trend of the treatment group and the control group, we extend Model (1) to the following event study equation for testing:

$$lnwage_{it} = \alpha + \beta_k \sum_{k=-3}^{3} D_{t_{i0}}^{k} + \xi X_{it} + \eta_t + \gamma_i + \epsilon_{it} \qquad (2)$$

where t_{i0} represents the year in which firm *i* began to be affected by environmental regulationsand *k* is the difference between the current year and t_{i0}. During the operation, we merge all periods of more than 4 years before the implementation of environmental regulations into the 4th year before implementation. All periods of more than 5 years after the implementation of environmental regulations are merged into the 5th year after implementation. The 4th year before implementation was selected as the base period.

Therefore, the actual values of *k*are -3, -2, -1, 0, 1, 2, 3, 4, and 5. $D_{t_{i0}}^{k}$ is a series of "event time" dummy variables; the value is 1 when firm *i* is affected by the environmental regulations in the *k*th year and 0 otherwise.

The estimated results are shown in Figs. 2. The x-axis label -3 represents the third year before the implementation of environmental regulations, and the rest can be deduced by analogy. The red dashed line represents the 95% confidence interval. From the results, before the implementation of environmental regulations, the change trends of the treatment group and the control group are the same, there is no significant trend difference, and the parallel trend assumption is satisfied. After the implementation of environmental regulations, environmental regulations have a significant negative impact on the average wage of employees in polluting industries, while firms in nonpolluting industries have not been affected by environmental regulations, and this effect has a certain degree of sustainability in the short term.

Second, we ruled out the impact of some policies in the same period. Specifically, before the signing of the PRTRL, the Chinese government began to implement the Two Control Zone (TCZ) policy for acid rain and SO_2 in 1998 to alleviate the trend of aggravation of air pollution. However, due to actual implementation reasons, the TCZ policy only had its intended effect after 2005 (Chen et al. 2018). To eliminate the impact of the TCZ policy, in Panel A in Table 3, we control for the interaction of the year dummy variable before and after the TCZ policy and the firm dummy variables for whether the firm is located in the TCZ areas. Second, to address environmental pollution, the Chinese government issued and implemented the Air Pollution Prevention and Control Action Plan (APPCAP) in 2013. For this reason, in Panel B of Table 3, we have deleted the samples of 2013 and 2014. Finally, in 2011, the Chinese government began to try to use the market mechanism represented by the carbon emissions trading (CET) policy to promote environmental protection in seven provinces and cities. In Panel C in Table 3, we control for the interaction of the year dummy variable before and after the CET policy and the firm dummy variables for whether the firm is located in the CET areas. All the results show that the environmental policies of the same period will not affect our estimates, and our conclusions are still valid.

Table 3 Testing for concurrent policies

Dependent Variable	lnwage	
	Polluting industries	Nonpolluting industries
	(1)	(2)
Panel A: "Two Control Zone" policy		
ER×Post	-0.031**	-0.011
	(0.014)	(0.009)
TCZ×Post2005	-0.058	-0.068*
	(0.051)	(0.038)
Observations	4338	13512
R-squared	0.728	0.693
Panel B: Air Pollution Prevention and Control Action Plan		
ER×Post	-0.038**	0.002
	(0.017)	(0.010)
Observations	3271	9951
R-squared	0.709	0.665
Panel C: Carbon Emissions Trading policy		
ER×Post	-0.026*	-0.010
	(0.014)	(0.009)
CET×Post2011	-0.075**	-0.045***
	(0.034)	(0.017)
Observations	4338	13512
R-squared	0.729	0.693
Control variables	Y	Y
Firm fixed effects	Y	Y
Year fixed effects	Y	Y

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%.

Third, the impact of the financial crisis. In the sample interval of this study, the outbreak of the global financial crisis in 2008-2009 had a huge impact on the production and operation of firms. To cope with the impact of the financial crisis, firms are very likely to reduce costs by reducing the average wage of employees, which leads to the findings of this study not being entirely made by environmental regulations. In Panel A in Table 4, we have removed the samples of 2008 and 2009. We find that the conclusions of this study have not been affected by the global financial crisis and are basically consistent with the findings of the baseline results.

Fourth, firms enter or exit the market. In the above analysis, this study mainly uses noncontinuous samples of firms for empirical testing, and there may be a gap between the wages of employees before the firm enters or exits the market and the normal operating firm, which may affect the estimation results of this study. To eliminate the impact of the behavior of firms entering or exiting the market, this study only retains the samples of firms that exist continuously in the sample interval and uses balanced panel data for empirical analysis. The results are shown in Panel B in Table 4. The conclusions of this study have not changed significantly.

Table 4 Other robustness checks

Dependent Variable	lnwage	
	Polluting industries	Nonpolluting industries
	(1)	(2)
Panel A: The global financial crisis		
ER×Post	-0.028*	-0.012
	(0.016)	(0.010)
Observations	3664	11518
R-squared	0.744	0.707
Panel B: Enter or exit the market		
ER×Post	-0.040**	-0.009
	(0.019)	(0.012)
Observations	2861	8232
R-squared	0.738	0.708
Panel C: Firms' relocation		
ER×Post	-0.030**	-0.013
	(0.014)	(0.009)
Observations	4273	13256
R-squared	0.728	0.690
Control variables	Y	Y
Firm fixed effects	Y	Y
Year fixed effects	Y	Y

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%.

Fifth, firms' relocation. Existing studies have shown that when facing strict environmental regulations, firms will evade supervision by relocating to areas with relatively loose environmental regulations (Chen et al. 2018; Zhao et al. 2020). After the signing of the PRTRL in 2007, only some prefecture-level cities issued clear environmental regulation goals, and some prefecture-level cities did not implement environmental regulations. This makes it possible for firms to relocate to avoid the impact of environmental regulations. After the introduction of the environmental regulation targets of each city, a total of 32 firms in the sample of this study have undergone relocation. Correspondingly, we exclude

these firms and re-estimate the impact of environmental regulations on the income of employees. The results are shown in Panel C in Table 4. Environmental regulations have indeed reduced the average wage of employees in polluting firms, while the average wage level of employees in nonpolluting firms has not been significantly affected.

4.3 Heterogeneous effects

From the perspective of the policy design of the PRTRL, the effect of environmental regulations on the income of employees depends on the actual implementation of the prefecture-level city government. In this section, we mainly discuss the heterogeneity of the impact of environmental regulations on firm employee income in different regions and different levels of political promotion incentives. First, the pollution reduction targets of various regions in China during the 11th Five-Year Plan period are very different. Pollution in the eastern region is significantly higher than that of the central and western regions, approximately twice as much as the central and western regions (Geng et al. 2021). In the actual implementation process, the enforcement of environmental regulations in the eastern region is also significantly stricter than that in the central and western regions (Shi and Xu 2018). Therefore, this study predicts that after the implementation of environmental regulations, the average wage of firm employees in the eastern region will drop more significantly. The regression results by region are shown in Panel Table 5. Compared with polluting firms in the central and western regions, the negative impact of environmental regulations on the average wage of polluting firms in the eastern region is more obvious. This effect only exists in polluting firms, and the average wage of employees in nonpolluting firms has not been affected by environmental regulations. This also provides strong evidence for the previous analysis of this study.

Table 5 Effects of environmental regulation on employee income: Heterogeneous effects

Dependent Variable	lnwage	
	Polluting industries	Nonpolluting industries
	(1)	(2)
Panel A: Eastern versus central and western regions		
ER×Post - eastern regions	-0.033*	-0.011
	(0.017)	(0.010)
Observations	2628	9991
R-squared	0.720	0.688
ER×Post - central and western regions	-0.026	0.013
	(0.022)	(0.018)
Observations	1710	3521
R-squared	0.747	0.720
Panel B: Strong versus weak political incentives		
ER×Post - strong incentive	-0.036**	-0.016
	(0.016)	(0.011)
Observations	3191	8694
R-squared	0.737	0.691
ER×Post - weak incentive	0.008	0.025
	(0.029)	(0.019)
Observations	1147	4818
R-squared	0.708	0.699
Control variables	Y	Y
Firm fixed effects	Y	Y
Year fixed effects	Y	Y

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%.

Second, we also investigated the important role of political promotion incentives in the impact of environmental regulations on the income of employees. As a result of the signing of the PRTRL in 2007, pollution reduction has been included in the assessment of the political promotion of local officials, and local government officials with obvious political promotion incentives will more actively and conscientiously implement the environmental regulation goals of the central government to seek political position promotion. Existing research shows that when China’s prefecture-level city leaders (the highest-ranked political leader in a prefecture-level city) are over 57 years old, they will be successively selected for "second-line" jobs such as the National People's Congress and the Chinese People's Political Consultative Conference, and the chances of political promotion will be greatly reduced (Wang 2016). Following the example of He et al. (2020), we divide the whole sample into a "strong political promotion incentive group" and a "weak political promotion incentive group" based on the example of the 57-year-old age of the secretary of the municipal party committee, and discuss that the impact of environmental

regulations on the income of employees is heterogeneous in the degree of political promotion incentives for different officials. Panel B in Table 5 shows that compared with regions with weak political promotion incentives, the negative impact of environmental regulations on the average wage of polluting firms in regions with strong political promotion incentives is more pronounced. At the same time, whether it is a strong political promotion incentive area or a weak political promotion incentive area, environmental regulations have no significant impact on the average wage of nonpolluting employees.

5. Mechanism Analysis

Our theoretical analysis shows that environmental regulations will reduce employee income by increasing costs and raising financing constraints. In this section, we present our verification.

5.1 Increasing cost

In Table 6, we discuss the impact of environmental regulations on firm costs. We use the difference between the total cost and the wages paid by the firm to the employees and the cash paid for the employees to measure the cost of the firm. The advantage of this is that it can observe the direct impact of environmental regulations on other costs in addition to the cost of firm wages. In addition, we controlled the natural logarithm of the firm's wage cost to prevent indirect changes in other costs caused by changes in the firm’s wage cost. The results show that environmental regulations have increased the cost of polluting firms, and the regression coefficient is significant at the 5% level. Compared with polluting firms in the control group, environmental regulations have increased the cost of polluting firms in the treatment group by 4.4%. For nonpolluting firms, the impact of environmental regulations on their costs is not obvious. The above results show that environmental regulations have indeed increased the cost of polluting firms and have a negative impact on the average wage of polluting firms’ employees.

Table 6
Mechanism analysis: Increasing cost

Dependent Variable	lncost	
	Polluting industries	Nonpolluting industries
	(1)	(2)
ER×Post	0.044**	0.023
	(0.022)	(0.017)
Control variables	Y	Y
Firm fixed effects	Y	Y
Year fixed effects	Y	Y
Observations	4341	13331
R-squared	0.671	0.567

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%. Control variables are factors that affect firm costs, including firm wage costs, asset structure, sales expense ratio and financial expense ratio.

5.2 Improving financing constraints

Improving financing constraints is another important channel. Drawing on the research of Hadlock and Pierce (2010), we use the SA index to measure firms' financing constraints. Since the impact of firms' financing constraints on employee income is not as direct as firm costs, we use the mediation effect model for analysis. In Column (1) of Table 7, the regression coefficient of environmental regulations on the financing constraints of polluting firms is significantly positive at the level of 1%, indicating that environmental regulations have indeed increased the level of financing constraints faced by polluting firms. In Column (2), we put the environmental regulation variable and the SA index variable into the regression at the same time. We find that both are significantly negative and that the coefficient of the environmental regulation variable is lower than the coefficient of the baseline regression result. This shows that environmental regulations have indeed reduced the average wage of polluting firms' employees by increasing financing constraints. Similarly, the results in Columns (3) and (4) show that environmental regulations have not increased the level of financing constraints faced by nonpolluting firms. These results also mean that environmental regulations have indeed reduced the average wage of firms by increasing financing constraints.

Table 7
Mechanism analysis: Improving financing constraints

	Polluting industries		Nonpolluting industries	
Dependent Variable	SA Index	lnwage	SA Index	lnwage
	(1)	(2)	(3)	(4)
ER×Post	0.012***	-0.029**	0.004	-0.013
	(0.004)	(0.014)	(0.002)	(0.009)
SA Index		-0.273*		0.138
		(0.154)		(0.105)
Control variables	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Observations	4338	4338	13513	13512
R-squared	0.992	0.729	0.990	0.693

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%.

6. Further Analysis: Who Truly Bears The Costs?

Our research proves that environmental regulations will lower the average wage of employees. However, a more concerning issue is who among the firms has experienced a decline in wages, that is, who truly bears the cost of environmental regulations. To further analyze this issue, referring to the ideas of Card et al. (2016) and Kline et al. (2019), we calculated the average wage of firm management and ordinary employees separately and then examined the impact of environmental regulations on the average wage of firm management and ordinary employees. Specifically, we calculated the average wage of management based on the total annual wage of directors, supervisors, and senior management disclosed in the annual report of the listed firm divided by the size of the management. Among them, the management scale refers to the "total number of directors, supervisors and senior executives" minus the "number of independent directors" and "the number of unpaid directors, supervisors and senior executives". At the same time, we use "wages paid by the firm to the employees and the cash paid for the employees" in the cash flow statement minus "total annual wage of directors, supervisors and senior management" to indicate the total wage of ordinary employees and then divide by the number of ordinary employees to obtain the average wage of ordinary employees. The number of ordinary employees is the total number of employees after deducting all management and the number of unpaid directors, supervisors, and senior executives.

The results of Columns (1) and (2) in Table 8 show that the impact of environmental regulations on the average wage of polluting firm management is not significant and that the impact on the average wage of ordinary employees is significantly negative at the 5% level. This shows that environmental regulations have only reduced the average wage of ordinary employees in polluting firms but have not reduced the average wage of management in polluting firms. On average, the average wage of ordinary employees has dropped by 3.1%. The results in Columns (3) and (4) show that environmental regulations have no significant impact on the average wage of management and ordinary employees of nonpolluting firms. This result means that ordinary employees of polluting enterprises are one of the primary bearers of the cost of environmental regulations. Taking into account the social impact of the decline in the average wages of ordinary employees, environmental regulations have further expanded the inequality of social income.

Table 8
Who bears the cost?

	Polluting industries		**Nonpolluting industries**	
Dependent Variable	lnmw	lncw	lnmw	lncw
	(1)	(2)	(3)	(4)
ER×Post	-0.017	-0.031**	-0.012	-0.014
	(0.023)	(0.016)	(0.011)	(0.010)
Control variables	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y
Observations	4158	4171	12874	12886
R-squared	0.559	0.712	0.612	0.707

Notes: Standard errors are clustered at the firm level. * Indicates a significance level of 10%, ** indicates a significance level of 5%, and *** indicates a significance level of 1%. In addition to the control variables in the baseline regression, considering that management income is directly related to the company's market value, we also control the company's book-to-market value ratio.

7. Conclusions

Where environmental regulations are generally implemented, the spillover effects of environmental regulations have also received increasing attention. This study uses the quasi-natural experiment of the Chinese central government to incorporate environmental performance into the assessment targets of municipal officials in 2007 and the panel data of listed firms to explore the impact of environmental regulations on firm employee income. We found that (1) environmental regulations reduced the average

wage of employees in polluting firms by 3.2%, while the average wage of employees in nonpolluting firms was not affected. This result still exists after excluding the policies of the same period, financial crisis, firm entry, exit from the market or relocation. (2) The impact of environmental regulations on the average wage of polluting firms is more pronounced in eastern China, where environmental regulations are more stringent, and in areas with stronger political promotion incentives. (3) Firm costs and financing constraints are important channels through which environmental regulations affect firm employee income. When environmental regulations lead to an increase in firm costs and financing constraints, firms will reduce the average wage of their employees. (4) Our research further finds that the decline in firm employee income is mainly reflected in the decline in ordinary employee income, and management income shows no obvious impact. In other words, environmental regulations have expanded social income inequality.

The conclusions of this study have two findings as follows: (1) Many countries in the world have environmental regulatory measures. As environmental pollution problems are becoming increasingly serious, more stringent environmental regulations may be implemented in the future. When evaluating these environmental regulations, we should not only consider the improvement of the ecological environment but also pay attention to the negative impact of environmental regulation on firms, especially the negative impact on the income of employees in polluting firms. In the process of top-level design of environmental regulations, the benefits and costs of environmental regulations should be fully considered. (2) According to our research conclusions, government departments can consider introducing some supporting policies to reduce firm costs and financing constraints to alleviate the adverse effects of environmental regulations on the income of firm employees, such as providing special government subsidies, tax incentives, loan interest concessions, and expansion of bank credit. At the same time, in the long run, firms should be encouraged to use cleaner energy and green equipment to achieve a win-win situation between the improvement of the ecological environment and the green and healthy development of firms.

Declarations

Author contribution Renrui Xiao conceived and designed the study and analyzed the results. Guangrong Tan provided the data, wrote the paper. Baocong Huangprovided the data, wrote the paper and analyzed the results. Yuanyue Luo provided the data and wrote the paper. All authors read and approved the final manuscript.

Availability of data and materials The data and materials used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funds This work was supported by the National Social Science Fund of China (No. 20FJYB051) and the Philosophy and Social Science Foundation of Hunan Province (No. 18ZWB23).

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

References

1. Acemoglu D (2003) Labor- and capital-augmenting technical change. J Eur Econ Assoc 1: 1–37
2. Acemoglu D, Guerrieri V (2008) Capital deepening and nonbalanced economic growth. J Polit Econ 116: 467–498
3. Albrizio S, Kozluk T, Zipperer V (2017) Environmental policies and productivity growth: evidence across industries and firms. J Environ Econ Manag 81: 209-226
4. Alpay E, Kerkvliet J, Buccola S (2002) Productivity growth and environmental regulation in mexican and US food manufacturing. Am J Agric Econ 84: 887-901
5. Amiti M, Cameron L (2012) Trade liberalization and the wage skill premium: Evidence from Indonesia. J Int Econ 87: 277-287
6. Amiti M, Davis DR (2012) Trade, firms, and wages: Theory and evidence. Rev Econ Stud 79: 1 -36
7. Autor DH, Dorn D, Hanson GH (2013) The China syndrome: Local labor market effects of import competition in the United States. Am Econ Rev 103: 2121-2168
8. Bergek A, Berggren C (2014) The impact of environmental policy instruments on innovation: a review of energy and automotive industry studies. Ecol Econ 106: 112–123
9. Berkowitz D, Ma H, Nishioka S (2016) Capital-labor substitution, institutions and labor Shares. University of Pittsburgh working paper No. 5981
10. Berman E, Bui LTM (2001) Environmental regulation and productivity. Rev Econ Stat 83: 498-510
11. Blanchard O, Andrei S (2001) Federalism with and without political centralization: China versus Russia. IMF Econ Rev 48: 171
12. Burgess R, Matthew H, Benjamin A, Olken P, Stefanie S (2012) The political cconomy of deforestation in the tropics. Q J Econ 127: 1707-1754
13. Cai X, Lu Y, Wu M, Yu L (2016) Does environmental regulation drive away inbound foreign direct investment? Evidence from a quasi-natural experiment in China. J Dev Econ 123: 73-85
14. Card D, Cardoso AR, Kline P (2016) Bargaining, sorting, and the gender wage gap: Quantifying the impact of firms on the relative pay of women. Q J Econ 131: 633-686
15. Card D, Krueger AB (1994) Minimum wages and employment: A case study of the fast-food industry in New Jersey and Pennsylvania. Am Econ Rev 84: 772-793
16. Chen YJ, Li P, Lu Y (2018) Career concerns and multitasking local bureaucrats: Evidence of a target-based performance evaluation system in China. J Dev Econ 133: 84-101
17. Chen Z, Kahn ME, Liu Y, Wang Z (2018) The consequences of spatially differentiated water pollution regulation in China. J Environ Econ Manag 88: 468-485

18. Dauth W, Findeisen S, Suedekum J (2014) The rise of the east and the far east: German labor markets and trade integration. J Eur Econ Assoc 12: 1643-1675
19. Eisdorfer A (2008) Empirical evidence of risk shifting in financially distressed firms. J Financ 63: 609-637
20. Fan H, Graff Zivin JS, Kou Z, Liu X, Wang H (2019) Going green in China: firms' responses to stricter environmental regulation. National Bureau of Economic Research working paper 26540
21. Felix RA, Hines JR (2009) Corporate taxes and union wages in the United States. National Bureau of Economic Research working paper No.w15263
22. Fuest C, Peichl A, Siegloch S (2018) Do higher corporate taxes reduce wages? Micro evidence from Germany. Am Econ Rev 108: 393-418
23. Garrett DG, Ohrn E, Suárez Serrato JC (2020) Tax policy and local labor market behavior. American Economic Review: Insights 2: 83-100
24. Geng Y, Liu W, Li K, Chen H (2021) Environmental regulation and corporate tax avoidance: A quasi-natural experiment based on the eleventh Five-Year Plan in China. Energy Econ 99:105312
25. Gollin D (2002) Getting income shares right. J Polit Econ 110: 458-474
26. Hadlock CJ, Pierce JR (2010) New evidence on measuring financial constraints: moving beyond the KZ index. Rev Financ Stud 23: 1909-1940.
27. He G, Wang S, Zhang B (2020) Watering down environmental regulation in China. Q J Econ 135: 2135-2185
28. Heberer T, Senz A (2011) Streamlining local behavior through communication, incentives and control: A case study of local environmental policies in China. Journal of Current Chinese Affairs 40: 77-112
29. Hering L, Poncet S (2014) Environmental policy and exports: evidence from Chinese cities. J Environ Econ Manag 68: 296-318.
30. Hong H, Kacperczyk M (2009) The price of sin: the effects of social norms on markets. J Financ Econ 9: 15-36
31. Yu H, Liao L, Qu S, Fang D, Luo L, Xiong G (2021) Environmental regulation and corporate tax avoidance:A quasi-natural experiments study based on China's new environmental protection law. J Environ Manage 296: 113160
32. Jaffe AB, Peterson SR, Portney PR, Stavins RN (1995) Environmental regulation and the competitiveness of US manufacturing: What does the evidence tell Us? J Econ Lit 33: 132-163
33. Jin H, Qian Y, Weingast B (2005) Regional decentralization and fiscal incentives: Federalism, Chinese style. J Public Econ 89: 1719-1742
34. Kahn ME, Li P, Zhao D (2015) Water pollution progress at borders: The role of changes in China's political promotion incentives. Am Econ J Econ Policy 7: 223-242
35. Karabarbounis L, Neiman B (2013) The global decline of the labor share. Q J Econ 129: 61-103
36. Kline P, Petkova N, Williams H, Zidar O (2019) Who profits from patents? Rent-sharing at innovative firms. Q J Econ 134: 1343-1404

37. Li C, McLinden C, Fioletov V, Krotkov N, Carn S, Joiner J, Streets D, He H, Ren X, Li Z, Dickerson RR (2017) India is overtaking China as the world's largest emitter of anthropogenic sulfur dioxide. Sci Rep 7: 14304
38. Lipscomb M, Mobarak AM (2016) Decentralization and pollution spillovers: Evidence from the re-drawing of county borders in Brazil. Review of Economic Studies 84: 464-502
39. Liu M, Tan R, Zhang B (2021) The costs of "blue sky": Environmental regulation, technology upgrading, and labor demand in China. J Dev Econ 150:102610
40. Myers SC, Majluf NS (1984) Corporate financing and investment decisions when firms have information that investors do not have. J financ econ 13:187-221
41. Okereke C, McDaniels D (2012) To what extent are EU steel companies susceptible to competitive loss due to climate policy. Energy Policy 46: 203-215
42. Ren S, Li X, Yuan B, Li D, Chen X (2018) The effects of three types of environmental regulation on eco-efficiency: A cross-region analysis in China. J Clean Prod 173: 245-255
43. Shi X, Xu Z (2018) Environmental regulation and firm exports: evidence from the eleventh five-year plan in China. J Environ Econ Manag 89: 187–200
44. Suárez Serrato JC, Zidar O (2016) Who benefits from state corporate tax cuts? A local labor markets approach with heterogeneous firms. Am Econ Rev 106:2582-2624
45. Tang H, Liu J, Wu J (2020) The impact of command-and-control environmental regulation on enterprise total factor productivity: A quasi-natural experiment based on China's "Two Control Zone" policy. J Clean Prod 254:120011
46. Wang S (2016) Fiscal competition and coordination: Evidence from China. Department of Agricultural and Resource Economics, UC Berkeley working paper
47. World Bank (2007) Cost of pollution in China, economic estimates of physical damages. The World Bank Washington DC
48. Xu C (2011) The fundamental institutions of China's reforms and development. J Econ Lit 49: 1076–1151
49. Zhang Q, Yu Z, Kong D (2019) The real effect of legal institutions: environmental courts and firm environmental protection expenditure. J Environ Econ Manag 98: 102254
50. Zhao X, Liu C, Sun C, Yang M (2020) Does stringent environmental regulation lead to a carbon haven effect? Evidence from carbon-intensive industries in China. Energy Econ 86: 104631
51. Zhou M, Wang B, Chen Z (2020) Has the anti-corruption campaign decreased air pollution in China? Energy Econ 91: 104878

Figures

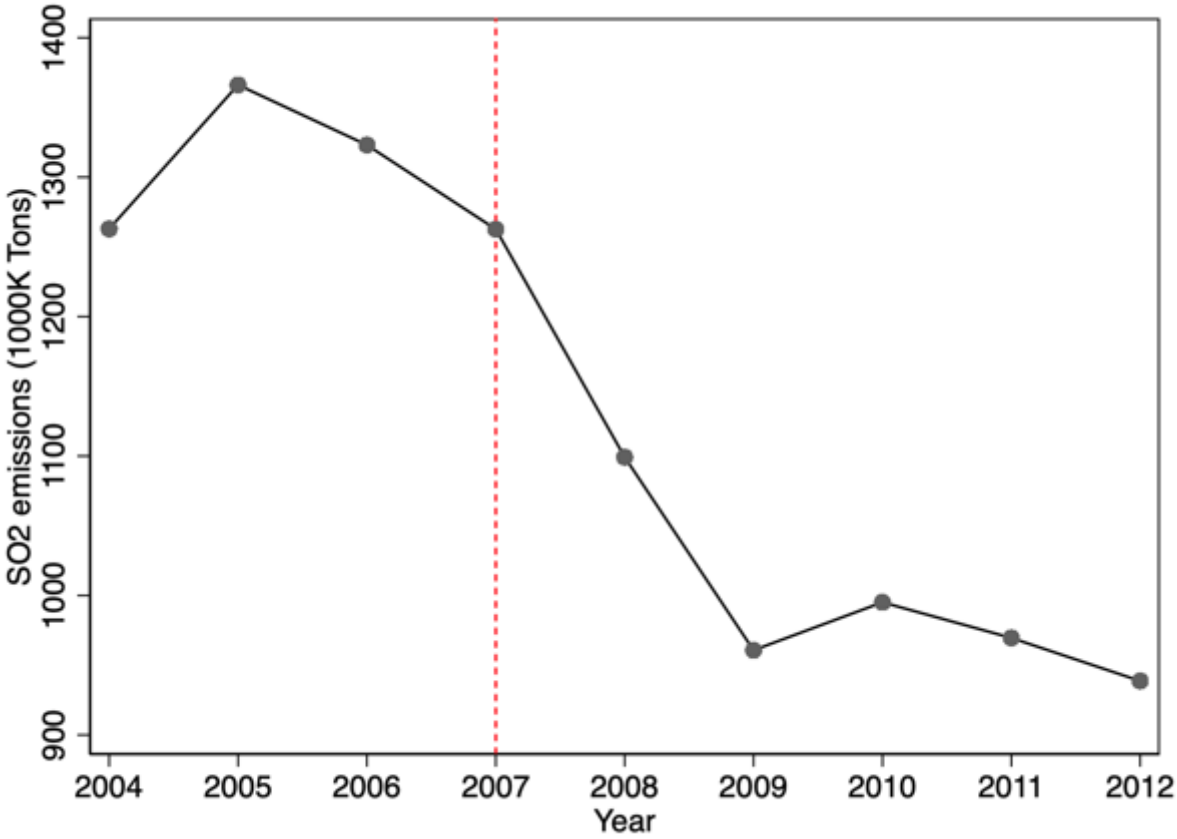
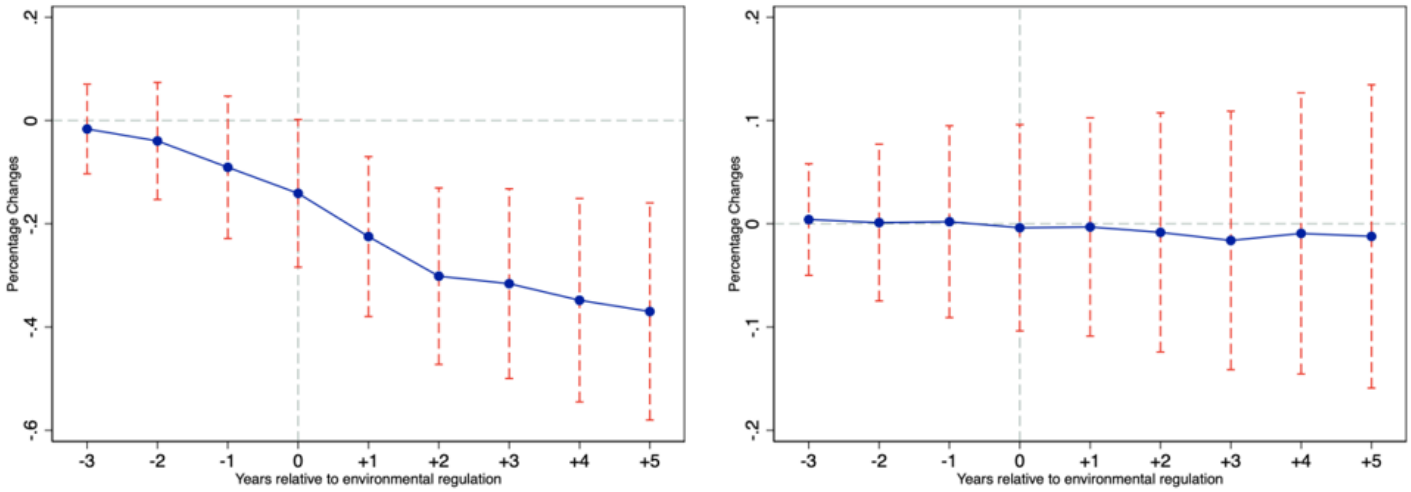


Figure 1

Prefecture-level City SO2 Emissions from 2004 to 2012



Panel A: Polluting industries

Panel B: Nonpolluting industries

Figure 2

Testing for the parallel trend assumption

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Appendix.docx