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Local environmental legislation and employment growth: evidence from Chinese manufacturing firms

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Abstract
In China, there exists a huge debate for a long time on whether a double dividend, reducing pollution emissions and boosting employment, can be achieved by intensifying environmental regulations. In this paper, we use two data sets on provincial environmental legislation and Chinese manufacturing firms during 1998–2013, to estimate the impact of provincial environmental legislation on the firms' employment growth with a difference-in-difference (DID) model. Results showed that (1) after the implementation of environmental legislation, the employment growth of regulated manufacturing firms decreases significantly by 3.07%, and this result is robust to alternative tests. (2) Local environmental legislation reduces employment growth mainly via the influencing mechanism of the firm's entry and exit, export, and innovation. (3) The local environmental legislation has heterogeneous impacts on employment growth in different industries and different regions, and the estimated effect is more obvious in high-pollution industries and areas with strong enforcement. (4) Environmental legislation significantly improves job destruction and reduces job creation, resulting in a −3.86% job net increase. Due to the long-term implementation of extensive economic growth mode, China's ecological environment has been deteriorating since the 1990s, and environmental pollution has attracted more and more social attention. Until 2013, the Communist Party of China put forward 'ecological civilization', and building a beautiful new China with harmonious coexistence between man and nature has become an important development strategy. Meanwhile, starting from the implementation of the Two-Control-Zone policy in 1998, China has implemented numerous environmental policies in just ten years. These environmental policies have greatly improved the quality of China's ecological environment, but their economic effects have been controversial. Given the special historical period, this paper helps assess the impact of Chinese environmental policies on employment and provides a more objective policy evaluation and implications for improving existing laws and regulations to achieve higher social welfare. To achieve this goal of balancing the improvement of the ecological environment and high employment level, environmental policies firstly should be flexible to ensure that the environmental standards follow the firm's characteristics and regional characteristics to avoid "one size fits all". Particularly, for regions with poor economic development or having a single industrial structure, the implementation cycle of the environmental policies should be extended to ensure that they have enough time to achieve industrial restructuring and complete the environmental protection goals. Secondly, we find that environmental legislation hurts

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employment growth by limiting export decisions, so the government should use multiple channels to stabilize export when implementing environmental legislation. Thirdly, technological R&D and innovation play an important role in the effect of environmental legislation on firms' employment growth. Therefore, the government should provide a more flexible environment for firms' R&D and innovation with appropriate fiscal policies and technical support.

Keywords Environmental legislation · Employment growth · Employment reallocation · Export decisions · Technological innovation

1 Introduction

Since its reform and opening up, China's economy has maintained a high growth rate for nearly 40 years, which has been hailed as a "growth miracle" by the world (Prasad, 2009; Yao, 2014). Many scholars have examined the causes of China's economic growth, and some of them argue that China has several conditions conducive to economic growth, such as abundant natural resources, a large high-quality, and cheap labor force, an accumulating physical and human capital, and a rapidly growing technological innovation capability (Fan et al., 2012; Wei, 2008). However, some argue that China is not exceptional in these conditions compared to other countries, and is even lower in resource endowment per capita and technological innovation capacity. Thus, the growth of physical and human capital and technological progress is only a result of economic growth, not an intrinsic source, and the deeper determinant behind China's "growth miracle" is the institutional arrangement (Cao, 2012; Li et al., 2000). In fact, since North's seminal contribution (North and Thomas, 1973), more and more economists have begun to focus on the role of institutions in economic growth, especially economic and political institutions (Coccia, 2018a, 2018b, 2018c; Rodrik, 2006). Existing literature has shown that a country's judicial system has a strong influence on the financial markets and its economic growth (Andolfatto, 2002;Claessens & Laeven, 2003; Lepore et al., 2018), and that limiting the power and structure of government also plays a similar role (Agostino et al., 2016; Gründler & Potrafke, 2019; Plümper & Martin, 2003).

As an important manifestation of institutional reform, China's environmental legislation process has been greatly accelerated in recent years. The environmental administration department under the State Council has also formulated more than 130 administrative regulations on environmental protection, including *the Regulations on Nature Reserves* and *the Regulations on Wildlife Protection,* etc., and nearly 2000 national environmental standards, forming a relatively complete environmental legal system. However, the strict environmental policies, aiming at protecting the ecological environment and saving natural resources, may hurt the economy in the short term, especially in employment. To add insult to injury, the employment situation in China has become increasingly dire since the outbreak of COVID-19. In February 2020, China's urban unemployment rate climbed directly from 5.3–6.3%, reaching a new high since 2018. By the end of May, 4.6 million people were newly employed in urban areas, down 22.95% year-on-year, with a particularly significant drop in high-touch service industries and labor-intensive export firms. In this situation, the analysis of the employment effect of environmental regulations is of greater relevance. Theoretically, the impact of environmental regulations on employment is uncertain. Firstly, environmental regulations increase the production costs of firms, leading to a decrease in their profits or even possible withdrawal from the market, which in turn reduces the demand for labor (Shan and Wang, 2019). Secondly, in order to comply with new environmental regulations, firms may use new emission reduction technologies, such as introducing new emission reduction equipment, improving production processes or production skills, and if these emission reduction technologies are labor-intensive, environmental regulations may instead increase employment. Finally, the impact of environmental regulations on employment is related to the market power of the firms. When the market power is large, they can pass on the compliance costs to consumers by adjusting product prices, and their employment is almost unaffected (Morgenstern et al., 2002).

On the other hand, China's legislative process is vastly different from that of western economies. In China, the formulation of laws and regulations is mainly done from top to bottom, that is, the central government will first determine the basic target and general framework of the law, and then the central government's legislative principles need to be implemented through local government legislation. In terms of the legislation related to environmental protection, China is different from western countries in at least two perspectives. First, in China, the central government first sets the overall goal of environmental protection, and then the local governments share the overall goal together. The environmental protection goal of the central government will be shared by all provinces, and the goal proposed by all provinces will be shared by their subordinate districts and counties.[1] Second, for the emission standard of some specific pollutants, China's local government often sets stricter standards than the central government.[2] As a result, the local government's environmental legislation in China usually has a more direct and significant impact on firms' production and business decision. Furthermore, labor unions in China are very different compared with those in western countries. They must support the centralized and unified leadership of the CPC (Communist Party of China) and maintain a high degree of consistency with the CPC Central Committee on its political stance, direction, principles, and path.[3] This dependence may cause China's labor unions to play a different role in protecting workers' interests. To sum up, the difference in environmental legislative procedures and labor unions between China and western economies may lead to different effects of environmental regulation on the labor market. Thus, exploring how environmental regulation affects labor demand in China requires empirical investigation based on regional legislation instead of central policy.

The study makes the following contributions. Firstly, we use two methods to verify the exogeneity of local environmental legislation: (1) considering that pollutant emission is an important cause of environmental legislation, we control the emissions of China's major

[1] For example, on December 15, 2011, the State Council of the People's Republic of China issued *the 12th Five-Year Plan for National Environmental Protection* (2011–2015), which requires the total sulfur dioxide emissions not to exceed 20.864 million tons by 2015, achieving a reduction of 1.814 million tons than 2010. On this basis, 31 provinces (excluding Hong Kong, Macao and Taiwan) will share the reduction of 1.814 million tons sulfur dioxide emissions. According to *the 12th Five-Year Plan for the protection of the ecological environment in Hebei Province*, Hebei province explicitly requires a reduction of at least 95,400 tons on sulfur dioxide emissions from 2011 to 2015.

[2] For example, *the Comprehensive Emission Standards for Atmospheric Pollutants*, formulated by the central government, stipulates that the emission centration of sulfur dioxide from new sources of pollution should not exceed 550 mg/m^3. However, *Shanghai's Comprehensive Emission Standards for Air Pollution* requires that the maximum emission concentration of sulfur dioxide from new sources should not exceed 200 mg/m^3.

[3] For example, Chinese president Xi Jinping held a conference with the new leaders of the All-China Federation of Trade Unions(ACFTU) and delivered an important speech in Beijing, China, Oct. 29, 2018.

pollutants such as wastewater, industrial sulfur dioxide, and solid waste in the baseline regression. (2) Referring to Hering and Poncet (2014) and Liu et al. (2017), we use the airflow coefficient as an instrumental variable for local environmental legislation. The larger the airflow coefficient, the lower the pollutant emissions that can be monitored and thus the lower possibility of implementing environmental legislation, satisfying the correlation requirement of the instrumental variable. In addition, the airflow coefficient is usually determined by the meteorological system and geographical conditions of a region, which satisfies the exogeneity assumption of the instrumental variable. Secondly, due to the differences in timing, intensity, and other details of law enforcement among different regions in China, the impact of environmental legislation on the employment growth of manufacturing firms may vary across regions. Therefore, in this paper, we collect information on the emissions of major pollutants and the number of environmental protection agencies, the number of environmental protection agency staff, and the number of environmental protection cases in different regions in China, and calculate the pollution intensity and the intensity of environmental enforcement in each region, then conduct a regional heterogeneity analysis based on these differences. Thirdly, our paper further studies the potential mechanisms behind the impact of environmental legislation on employment. Revealing the micro mechanism behind the effect of environmental legislation on employment growth help provide important policy implications and suggestions regarding how to balance environmental protection and employment growth. Fourthly, the margins of employment adjustment at the firm level have important distributional implications for the affected labor force (Walker, 2011, 2013). Our paper further decomposes the net employment growth into job creation and job destruction and estimates the effect of environmental legislation on each of them respectively. In addition, we further explore how the regulated firms change their entry and exit decisions due to environmental legislation, offering new insight into the distributional impacts of regulation on the affected labor force.

The remainder of this paper is organized as follows. Section 2 is the literature review. Section 3 provides research hypotheses. Section 4 describes the methodology and data. Section 5 provides the empirical results and discussion. Finally, Sect. 6 concludes and discusses the potential policy implications.

2 Related literature

Theoretically, there are two contrary effects of environmental regulation on labor demand, namely, 'the compliance cost effect' and 'the innovation offset effect'. The compliance cost effect refers to the environmental regulations improve firms' compliance costs, forcing them to change the optimal production decisions, which reduces the competitiveness of firms and threatens workers' jobs. However, some scholars argue that environmental regulation will generate an 'innovation offset effect'. Because carefully crafted environmental regulation can improve technological level, enhance competitiveness, and create new job opportunities (Chishti et al., 2020; Guo et al., 2017; Zhong et al., 2021).

Similar to the theoretical studies, a large number of empirical studies have failed to agree on the employment effect of environmental regulations. Greenstone (2002) points out that the amendments to the Clean Air Act in the United States reduced nearly 600,000 jobs in areas that failed to meet the standard. Kahn and Mansur (2013) find that in certain industries such as credit intermediaries and raw materials metals in the United States, the employment elasticity of energy prices was significantly negative. Raffa and Earnhart

(2019) explore the negative effects of environmental enforcement on the amount of environmental labor employed by facilities regulated under the U.S. Clean Water Act. After that, Raffa and Earnhart (2021) further distinguish "environmental labor" (labor dedicated to regulatory compliance) and "production labor" (labor dedicated to production), and find government environmental interventions do not affect environmental labor, yet negatively affect production labor. Different from the above findings, Berman and Bui (2001) discover that air quality agreements in the United States did not reduce employment but had a slight promotion effect. Hafstead and Williams (2018) analyze the effects of environmental policy on employment using a new general-equilibrium two-sector search model. They find that imposing a pollution tax causes substantial reductions in employment in the regulated industry, but this is offset by increased employment in the unregulated sector, so the net effect on overall employment is small. Zhong et al. (2021) find that with the intensification of environmental regulation, the employment of high-skilled labor will grow while that of low-skilled labor will decline first and then rebound, showcasing a U-shaped curve. In addition, some scholars believe that the relationship between environmental regulation and employment is uncertain. The diversified effects may result from the difference in industry energy intensity (Aldy & Pizer, 2015; Noureen et al., 2022), the difference in labor force proficiency (Sen and Acharyya, 2012; Chishti et al., 2022), or the difference in ecological innovation (Jahanger et al., 2022; Ali, et al., 2022).

In recent years, with environmental problems becoming more and more prominent, more researchers pay attention to China's context from both macro perspectives (Liu et al., 2018) and micro levels (Liu et al., 2017). For example, Liu et al. (2017) find a more stringent wastewater discharge standard decreased the labor demand of the textile printing and dyeing enterprises by approximately 7%. Liu et al. (2018) estimate the impact of pollution reduction on labor demand in China's manufacturing sector, and confirm a 1% reduction in SO2 (COD) emissions causes a reduction in labor demand of approximately 0.018–0.019% (0.012–0.013%). Zhong et al. (2021) verify the employment of high-skilled labor will grow along with the intensification of environmental regulation while that of low-skilled labor will decline first and then rebound, showcasing a U-shaped curve. Guo et al. (2020) prove that the effect of expense-type environmental regulation on provincial employment exhibited as "U" curve form and the effect of investment-type environmental regulation on provincial employment was always positive. Sheng et al. (2019) find that the intensity of environmental regulation has a negative impact on the employment of manufacturing enterprises through both output effects and substitution effects.

Another notable feature is that, with the rapid development of the New and New Trade Theory, many scholars have begun to explore the mode and law of economic operation from the perspective of heterogeneous firms. Greenstone et al. (2012), Martin et al. (2016), Wagner et al. (2014) and Liu et al. (2017) respectively discussed the employment effect of environmental regulation by using the firms' data of the United States, the United Kingdom, France, and China. However, these studies mostly focus on the overall changes in employment due to environmental regulations. As stated by Walker (2013), the employment cost of environmental regulation should not only focus on the total employment level or unemployment rate, but more importantly, the replacement cost of the labor force. When stricter environmental regulations are implemented, the workers of affected firms will be relocated across regions or industries. If an unemployed worker finds a new job in a short time without a significant drop in wages, the lost job will not be considered a "net loss". Conversely, if a worker is unemployed for a long time or loses his or her industry-specific job skills and previous work experience, it should be considered a net loss of human capital. Therefore, when examining the employment effect of environmental regulation, we should pay attention to the direction and structure of employment change in addition to the change of the overall employment level.

As mentioned above, the existing studies do not agree on the employment effect of environmental regulation. Some scholars attribute this to the complexity of environmental regulations and the limits of data availability. In fact, the accurate measurement of the environmental regulation intensity is still questionable. The related studies use the cost of reducing pollution (Levinson, 1996; Keller and Levinson, 2002), the pollution or energy consumption (Naughton, 2014; Cole and Elliot, 2003), the investment in dealing with pollution (Shadbegian & Gray, 2009) and government's environmental regulations (Broner et al., 2012; Javorcik & Wei, 2001) to test the economic influence of environmental regulations. The above environmental regulation indicators reflect the intensity of environmental policies to a certain extent, but the differences between them are also very significant. Another possible reason is that the traditional view, the government's environmental policies are exogenous, may ignore the endogenous character of environmental regulations. Advocates of environmental regulation reform overemphasize theoretical efficiency and fail to consider the uncertainty and the operational strategic behaviors in the process of implementation, which will affect the effectiveness of environmental regulations (Latin, 1984). Therefore, different from the existing literature, this paper takes the provincial environmental legislation in China as a quasi-natural experiment to avoid potential endogeneity. Based on the DID method, our research provides a more accurate estimation on the impact of environmental legislation on employment. In addition, we further explore the potential mechanisms behind the documented effects, including the firm's entry and exit, export, and R&D investment. Our critical and robust analysis provides crucial policy implications.

3 Research hypothesis

The impact of environmental legislation on the labor market is uncertain (Berman & Bui, 2001). On one hand, more stringent environmental regulation leads to higher production costs, which causes enterprises to raise product prices thereby lowering demand for its output (Wang & Feng, 2014), thus reducing demand for inputs, including labor (this is referred to as the output effect). On the other hand, to comply with the new, more stringent regulations, enterprises must hire workers to install and maintain pollution abatement equipment (Liu et al., 2017), or alter their production process to reduce pollution, which may require more or less workers than those required in the previous production process. Thus, after undertaking compliance efforts, enterprises' demand on labor may be different compared with that prior to the regulation (this is referred to as the substitution effect). However, for the environmental legislation of local governments in China, these two effects are quite different. As a typical method of command-and-control environmental regulation, China's environmental legislation provides sewage permit management for pollutant emission, and firms must discharge pollutants in accordance with the requirements in the sewage permit. Local environmental protection departments may punish firms that do not meet the requirements of the emission standards, including fines, rectification, shutdown and closure. For many regulated firms, it is usually difficult to achieve clean transformation by adding emission-reduction equipment or changing the production process (Ouyang et al., 2020; Zhao et al., 2020). Thus the environmental legislation has evolved into a "constraint" to restrict the production and operation of enterprises, resulting in less complementary effect of environmental regulation on employment. This is consistent with the negative impact of environmental regulation on enterprises' employment growth documented in other countries in recent years. For example, Wagner et al. (2014) find a significant 7% reduction in employment of the European Union Emissions Trading Scheme (EU EST) in regulated firms in Phase II. Marin and Vona (2017) indicate an increase in energy price (as proxies of environmental regulation) had a modestly negative impact on employment (−2.6 percent) for French manufacturing establishments. Bailey and Thomas (2017) verify the more-regulated American industries experienced fewer new firm births and slower employment growth in the period 1998–2011. Based on the above analysis, we propose:

Hypothesis 1 The local environmental legislation will hurt the employment growth of Chinese manufacturing firms.

Firm's entry and exit could be an important channel that the environmental legislation affects the labor demand. Theoretically, new environmental laws require enhanced investment in environment-friendly equipment and technology, resulting in a high compliance cost (Jaffe & Palmer, 1997). As a result, environmental legislation could raise the barriers for a new firm to enter (Qiu et al., 2018). In the meantime, firms with low productivity have to exit the market, as they cannot meet the high standards under the new laws (Tombe & Winter, 2015). The existing literature has widely confirmed that environmental legislation has a crucial impact on the firm's entry and exit. Becker and Henderson (2000) discover the Clean Air Act [CAA] and its Amendments from 1970 reduced the birth of plants in non-attainment counties, compared with attainment counties. With the advent of regulation, the net present value for a typical new plant in a non-attainment area could fall by 25–45%. Jefferson et al. (2013) conclude that the stringent requirements of the Two Control Zone (TCZ) policy encouraged the entry of more productive firms and the exit of less productive ones. In China, Yang et al. (2021) also find evidence that stricter environmental regulation increased the probability of exit for firms with lower productivity and reduced the probability of entry for those potential pollution-intense entrants, leading to significant resource reallocation within the industries. As jobs could be provided by new firms and firms that exit the market are associated with job loss, the entry and exit of firms inevitably affect the local labor market. Based on the above analysis, we propose:

Hypothesis 2 Local environmental legislation reduces employment growth via the channel of the firm's entry and exit.

Another important channel that new environmental regulations affect employment growth is export. It has been widely shown that export has a significant impact on the labor market. Export not only increases the demand for labor but also leads to the change of relative demand of heterogeneous labor, and such adjustments further affect the distribution of positions, wages, and so on (Dooley et al., 2003, 2004; Feenstra and Hong, 2010; Hummels et al., 2010; Dauth et al., 2014). According to the New-New Trade Theory, one of the biggest export barriers is the sunk cost (Roberts and Tybout, 1997; Melitz, 2003). Sunk cost is the expenditure of obtaining information about overseas demand, establishing distribution channels and service networks, and promoting new products to enter a new export market, which is irreversible once invested. The sunk cost directly affects firms' export decisions, but also indirectly affects firms' export decisions through spillovers, social networks, and other factors (Sjöholm, 2003; Hussain, et al., 2021). However, environmental regulations force firms to internalize the externality of pollution, leading to higher production cost (Arimura, 2002; Xu, 2016). Due to the increasing production cost, less capital can be invested in searching for overseas markets, building marketing networks, etc., resulting in less export expansion. Mani and Wheeler (1998) discover that high-standard environmental regulation diminished the comparative advantage of the related industry and made difference on trade patterns. Cole et al. (2005) find that pollution abatement cost within an industry was a statistically significant negative determinant of that industry's competitiveness measured by Revealed Symmetric Comparative Advantage (RSCA) and net exports. Based on the above analysis, we propose:

Hypothesis 3 Local environmental legislation reduces employment growth via the channel of export decisions.

Environmental legislation requires firms to meet a higher level of environmental standards, and as a response, firms may update their production processes and invest more in pollution controls. Porter Hypothesis points out that proper environmental regulation could promote innovation and R&D (Porter & Linde, 1995). Due to the potential technological innovation, environmental regulation could improve firms' productivity and competitiveness (Wen, et al., 2021; Dogan et al., 2022), and we define it as the innovation compensation effect. However, it may have a negative impact on the firm's technological innovation because the total amount of capital is fixed in a certain period for a firm and the increase of investment in pollution control will crowd out other R&D investments (Leonard, 2006). As our paper mainly estimates the difference in firms' employment growth in 3 years before and after local environmental legislation, the time is short that firms are difficult to refinance. So the increase of firms' investment in pollution control is likely to crowd out the R&D funds, which may lead to a weak even negative impact on technology innovation. Through an examination of China's clean production standards, Yuan and Xiang (2018) found that environmental regulation significantly increased the profitability of enterprises but did not promote enterprise innovation. Shi et al. (2018) estimated the impact of China's carbon emissions and trading pilot policy on enterprise innovation, and they conclude that this policy significantly inhibits the innovation of both regulated and non-regulated enterprises to reduce enterprise productivity. The decline of technological innovation increases the unit production cost of firms, so the firm's price advantage decreases relative to their competitors. As a result, the market demand for products gradually shrinks and the production scale of firms also decreases, thus reducing the demand for labor and generating employment substitution effect (Fig. 1). Based on the above analysis, we propose:

Hypothesis 4 Local environmental legislation reduces employment growth via the channel of technological innovation.

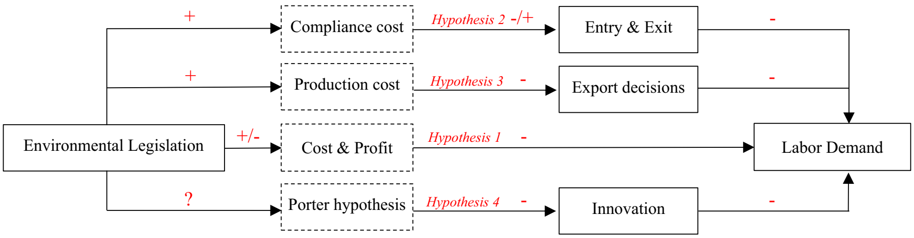

Fig. 1 Influence path The "+", "−" and "?" refer to the variable in the left box having a positive, negative and uncertain impact on the variable in the right box respectively. The "+/−" means that environmental legislation increases a firm's cost, but reduces its profit, and "−/+" means that the increased compliance cost will reduce the probability of entry for those potential entrants, and increase the probability of exit for those regulated firms

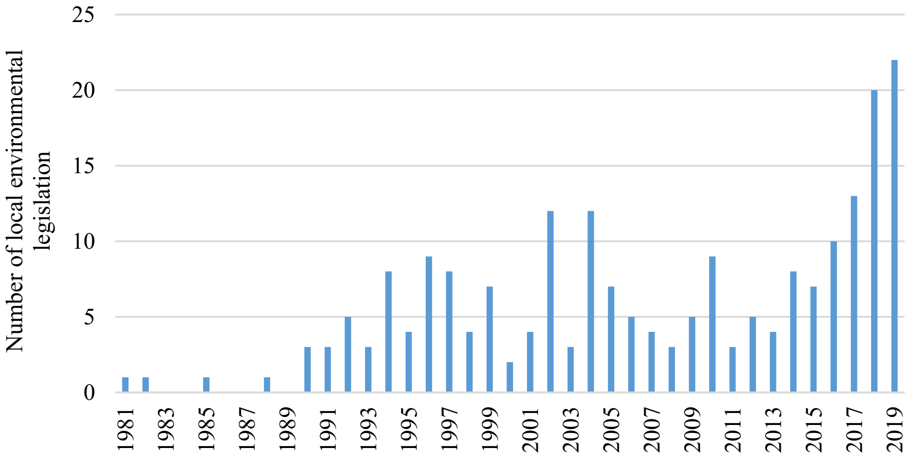

Fig. 2 Annual distribution of China's local environmental legislation

4 Methodology and Data

4.1 Sample and data

- *The data on environmental legislation.*

This data is collected from the official website of provincial Ecology and Environment Bureaus. There are different types of local environmental legislation, including comprehensive environmental legislation (e.g., *Environmental Protection Regulations*, which serves as the basic framework of China's environmental legislation), and individual legislation for specific pollutants, (e.g., *Law of the PRC on Prevention and Control of Water Pollution*, *Law of the PRC on Prevention and Control of Air Pollution*, and *Law of the PRC on Prevention and Control of Environmental Pollution by Solid Wastes*). Figure 2 depicts the number of China's local environmental legislation since the Reform and Opening Up[4] It

[4] In this part, the local environmental legislation mainly includes the Environmental Protection Regulations, Water Pollution Prevention Regulations, Air Pollution Prevention Regulations and Solid Waste Pollution Prevention Regulations.

can be roughly divided into four stages: the initial stage (1981–1989), the development and improvement stage (1990–2004), the relative decline stage (2005–2013), and the sustained and rapid development stage (after 2014). Especially, after the implementation of the *Legislative Law of the People's Republic of China* in 2015, the legislative power of local governments has been enhanced. Before 2015, the power of environmental legislation was only delegated to 31 provinces and 49 specific cities. After 2015, the power of local legislation was extended to all 282 districted cities. Under this circumstance, the number of local environmental legislation has increased rapidly. From 1978 to 2015, the total number of local environmental legislations in China was 144. But in the following five years, the number of legislations reached 72, accounting for half of the total number of previous legislations.

- *The firm-level data.*

This data is obtained from Chinese Industrial Enterprise Data (CIED), and the sample period is from 1998 to 2013. This period was chosen for three reasons: (1) considering the availability of data, the National Bureau of Statistics of China has not published subsequent Chinese Industrial Enterprise Data since 2013. Therefore, the latest data we can obtain for Chinese manufacturing firms is from 2013. (2) The characteristics of China's economic development differed significantly around 2013. China's economy has entered a period of new normal since 2013. Before 2013, China mainly focused on the speed of economic development and the total GDP. After 2013, more attention was paid to quality and efficiency. (3) The conditions of China's environmental protection exist significant differences around 2013. Before 2013, the extensive economic growth mode brought serious environmental pollution problems. However, in 2013, the Communist Party of China put forward "ecological civilization", proposing to build a beautiful China with harmonious coexistence between man and nature, which brings an opportunity for the development of a green and low-carbon economy.

Due to the statistical issues such as abnormal indicators and obvious measurement errors in this set of data, we filter the original data according to the ideas provided by Brandt et al. (2012). We delete the observations with total output less than 5 million; we delete the observations with negative or missing values of total income, employment, fixed assets, total sales, or intermediate input; we delete those firms whose establishment year is earlier than 1949, and delete the firms with age less than 0; we delete the observations with less than 8 employees at the end of the year; we delete the observations of firms with obvious mistakes, such as the sample with total assets less than current assets. Due to the lack of information on the "industrial added value" of firms in 2004, we estimate it according to the accounting principles (industrial added value = total industrial output value-industrial intermediate input + value-added tax).

The information on GDP per capita, urbanization level, green area per capita, the total number of industrial firms, total labor force, and the total urban industrial output value of each region is obtained from the "China Statistical Yearbook". The data regarding regional pollution and environmental information is obtained from the "China Environment Yearbook".

4.2 Variables and statistical description

- *Dependent variable.*

In this paper, employment growth (Job_growth_{pft}; p, f and t represent province, firm and year respectively) is measured by the growth rate of employees in firms over time. Firm's employment growth may originate from two aspects. One is the growth in the number of employees in the existing firms, and the other is the employment growth caused by the firms' entry and exit. Following Davis and Haltiwanger (1992), *Job_growth* is measured as:

$$job\_growth_{pft} = \frac{e_{pft} - e_{pft-1}}{\left(e_{pft} + e_{pft-1}\right)/2} \tag{1}$$

where e represents the employment level, measured as the number of employees of each firm at the end of the year. The employment growth calculated by this method is a monotonic function and the value is between [−2, 2]. The employment growth caused by firm's entry or exit can also be measured in the equation, where − 2 represents the firm's exit and 2 corresponds to the firm's entry.

- *Independent variable.*

Environmental legislation (*Treatment*) and legislative time (*Post*) are the core independent variables of this paper. $Treatment_p$ represents a dummy variable indicating whether province p is in the treatment group or not. If one province has passed environmental legislation, it is treated as the experimental group and the value of *treatment* is 1. Otherwise, *treatment* equals 0. *Post* is a dummy variable indicating whether the year is during the three years after the environmental legislation has been enacted. In the special situation where an environmental law has been revised repeatedly, we deal with it according to the following principle: if the law is revised in the fifth year or even later after it was first passed, it will be regarded as two different laws. And if the law is revised within five years, it will be treated as the same law. And if the dates of enactment and implementation of environmental laws are not in the same year, this paper uses the time of enactment as the time of environmental legislation. And the reason for that is Chinese firms, especially state-owned firms, are very sensitive to government policies and may respond before the policy is formally implemented.

- *Control variables*

The control variables in this paper include both firm-level variables and regional variables: firm's size (*size*), measured as the logarithm of the total output, and firm's age (*age*), measured as the year minus the year of establishment of the firm. We also control dummy variable *SOE* indicating whether the firm is state-owned or not. State-owned firms are affected by government administrative orders and central plans, and they need to fulfill additional "social responsibility", which leads to a slower adjustment in their employment structure when facing external shocks. The export dummy variable (*export*) indicates whether the firm exports or not. Compared with non-export firms, export firms are usually larger in scale and have a relatively larger size of employment. At the same time, the "learning by doing" effect of export can increase the productivity of firms which indirectly affects their employment growth. The total factor productivity (*lntfp*) is also controlled in our analysis. The existing literature mostly uses the OP method (Olley & Pakes, 1996) and the LP method (Levinsohn & Petrin, 2003) to estimate firms' total factor productivity. However, as the key indicators (e.g., industrial added value and intermediate input) are missing in the CIED after 2007, we approximately calculate firms' total factor productivity by $ATFP = \ln Q/L - s \ln K/L$ (Head & Ries, 2003), where Q is approximately replaced by the total industrial output value, K is the total fixed assets, L is the number of employees, *s* represents the contribution of capital in the production function, which is set to 1/3 (Hall & Jones, 1999). Productivity not only affects the overall employment level, but also affects the skill structure and gender structure of employment in a firm. Capital intensity (*lnkl*) is the ratio of the total assets to the number of employees at the end of the year, reflecting the amount of capital allocated to a unit of labor force. Labor-intensive firms have a higher level of employment, but capital-intensive firms may employ more highly skilled labor. Local GDP (*lngdp*) is controlled as regions with a higher degree of economic development can better gather advantageous resources and provide local residents with a large number of employment opportunities and higher wage. In addition, we also control the level of regional urbanization (*urbanization*), measured as the proportion of urban population in the total population of each province.

- *Descriptive statistics of the variables.*

We report the descriptive statistics of the main variables in Table 1 in the appendix. Our sample includes 248,319 firms in the control group and 379,936 firms in the treatment group. In the full sample, the average job growth of Chinese manufacturing firms is 0.03, indicating that an increased trend persists in the labor demand during 1998–2013. The mean value of the firm's age is 17.29, which is lower than that in the western countries. While its standard deviation is 49.35, a relatively large value, indicating that there are significant differences in the establishment time of Chinese manufacturing firms. Some firms are established in the current year, but some long-established brands have even existed for 2000 years. The share of state-owned firms and export firms is 42.4%, and 48.3%, respectively. The mean value of factor intensity is 50.958, meaning the fixed asset investment for each worker is 50,958 yuan. Moreover, the average GDP and urbanization rate in China's prefecture-level cities are 28,598,210 yuan and 53.2%, respectively, showcasing a tremendous increase compared to 2000.

Compared with the control group (the firms in non-legislative regions), the variables in the treatment group (the firms in legislative regions) have significant differences except for *export*. The average employment growth rate, scale, and capital-labor ratio in legislative areas are higher, but the average firm's size and capital-labor ratio are relatively smaller. The proportion of non-state-owned firms in the legislative regions is higher. But compared with non-legislative regions, there is no significant difference in the proportion of export firms. The mean difference of the regional variables *lngdp* and *urbanization* is significant, indicating that GDP per capita level in legislative regions is higher and the urbanization rate is also higher than that of non-legislative regions. It should be noted that although the average employment growth of firms in the legislative regions is lower than that in the non-legislated regions and the difference is significant at the statistical level of 5%. The test of difference in the mean value of each variable is independent. At the same time, the results in Table 1 describe the average change of each variable during the entire sample period without considering the differences before and after the legislative period.

4.3 Methodology and econometric model

This article uses the local environmental legislation events to identify the impact of environmental legislation on the employment growth of Chinese manufacturing firms based on the difference-in-difference model (DID). First, we collect the data on environmental legislations of China's 31 provinces, including the "Environmental Protection Regulations"

Table 1 The variables, and their indicators, measurement, data source and expected impact

Variable	Indicator	Measurement	Data source	Expected impact
Treatment	Environmental legislation	A binary dummy variable (1,0)	CELED	–
Post	Legislative time	A binary dummy variable (1,0)	CELED	–
Size	The firm's scale	The firm's total output	CIED	+
Age	The firm's age	The year minus the year of establishment of the firm	CIED	+
Soe	Whether the firm is state-owned or not	A binary dummy variable (1,0)	CIED	+
Export	Whether the firm exports or not	A binary dummy variable (1,0)	CIED	+
lntfp	The firm's total factor productivity	ATFP = ln Q/L-s ln K/L	CIED	+
lnkl	The firm's factor intensity	The ratio of the total assets to the number of workers	CIED	?
lngdp	The city's GDP	The GDP of the prefecture-level city	CUSY	+
Urbanization	The city's urbanization	The urbanization rate of the prefecture-level city	CUSY	?

The CELED, CIED and CUSY in data source refer to China's Environmental Legislation Events Database, Chinese Industrial Enterprise Database and China Urban Statistical Yearbook, respectively. And the "+", "–" and "?" in the expected impact refer to the variable having a positive, negative and uncertain impact on the employment growth respectively and "Pollution Prevention Regulations". Secondly, the provinces with environmental legislation are regarded as the experimental group, and the unlegislated provinces are regarded as the control group. In order to ensure that the employment growth in the control group follows the same trend as the experimental group before legislation, this paper selects control groups based on the following principles. First, the provinces are treated as the control group only if there is no relevant legislation passed in the 3 years before or after the legislation has been passed. Second, the average annual growth rate of employment in the control group should be similar to that in the experimental group during the 3 years before the legislation has been passed. Finally, it must be noted that due to the number of provinces with legislation is far more than the unlegislated provinces in some years, the control group is not completely available for some special legislative provinces. Furthermore, in order to overcome the interference of regional characteristics that do not vary over time, province fixed effects are controlled. The basic settings of the model are as follows:

$$job\_growth_{pft} = \alpha_1 treatment_p \times post_{pt} + \alpha_2 X_{ft} + \alpha_3 X_{pt} + \delta_p + \delta_f + \delta_t + \mu_{pft} \tag{2}$$

where the dependent variable job_growth_{pft} represents the employment growth of firm *f* in province *p* from year t-1 to t. $Treatment_p$ represents a dummy variable indicating whether province *p* is in the treatment group or not. *Post* is a dummy variable indicating whether the year is during the three years after the environmental legislation has been enacted. The coefficient of *treatment*post* measures the difference in employment growth between the experimental group and the control group after the environmental legislation, and it reflects the average impact of environmental legislation on employment growth at the firm level. The variable X_{ft} represents firms' factors that affect the employment growth of Chinese manufacturing firms, including firm's size (*size*), firm's age (*age*), whether the firm is a state-owned firm or not (*soe*), whether the firm exports or not (*export*), firm's productivity (*lntfp*), firm's capital intensity (*lnkl*). The variable X_{pt} represents regional factors that affect employment growth, including GDP per capita in the province where the firm is located (*lngdp*) and urbanization level (*urbanization*). δ_p, δ_f and δ_t represent regional fixed effects, firms fixed effects and time fixed effects respectively, andμ_{pft} is the random error term.

5 Empirical results and discussion

5.1 Benchmark Regression

Taking the possible sequence correlation and heterogeneous problems into account, we cluster the regression standard deviations at the industry level in the benchmark regression. As shown in Table 2, columns (1)–(3) show the most basic ordinary least squares (OLS) results. Columns (4)–(6) show results using the fixed effects model (FE), which can control for a certain type of omitted variable. Only time fixed effect is controlled in column (2), and region fixed effect is added in column (3). The inclusion of time fixed effect and region fixed effect means that we now control for the general macroeconomic factors which impact all firms over time as well as region-invariant firm-specific characteristics. In columns (4)–(6), we further control for the firm fixed effect to capture the impact of firms' individual characteristics that do not change over time. All the regression results show that, after controlling the firms' individual characteristics and macroeconomic factors, the employment growth of manufacturing firms regulated by environmental legislation (treatment group) is significantly lower than those of unregulated firms (control group). The results show that after the implementation of environmental legislation, the employment

Table 2 Benchmark regression

	(1) *Job_growth* OLS	(2) *Job_growth* OLS	(3) *Job_growth* OLS	(4) *Job_growth* FE	(5) *Job_growth* FE	(6) *Job_growth* FE
Treatment×post	−0.023***	−0.015***	−0.016***	−0.041***	−0.031***	−0.031***
	(−6.151)	(−4.438)	(−5.584)	(−22.580)	(−14.911)	(−14.929)
Size	0.077***	0.072***	0.072***	0.292***	0.286***	0.286***
	(20.496)	(20.682)	(20.767)	(114.081)	(110.704)	(110.653)
Age	−0.0005***	−0.0006***	−0.0006***	−0.0001***	−0.0001***	−0.0001***
	(−7.107)	(−7.578)	(−7.660)	(−4.792)	(−5.179)	(−5.181)
Soe	−0.028***	−0.033***	−0.032***	−0.048***	−0.052***	−0.052***
	(−2.907)	(−3.447)	(−3.354)	−17.901)	(−19.297)	(−19.324)
Export	−0.039***	−0.048***	−0.048***	0.002	−0.013***	−0.013***
	(−4.919)	(−6.976)	(−6.983)	(1.111)	(−5.875)	(−5.880)
lntfp	−0.185***	−0.166***	−0.165***	−0.920***	−0.886***	−0.886***
	(−9.803)	(−8.925)	(−8.904)	(−62.993)	(−60.405)	(−60.382)
lnkl	−0.083***	−0.082***	−0.082***	−0.204***	−0.208***	−0.208***
	(−22.658)	(−22.591)	(−22.945)	(−206.539)	(−187.912)	(−187.892)
lngdp	0.026***	0.008	0.018**	−0.019***	0.064***	0.064***
	(4.209)	(1.307)	(2.326)	(−5.871)	(13.193)	(13.190)
Urbanization	−0.001	0.037*	0.024	0.117***	−0.068*	−0.069*
	(−0.049)	(1.829)	(1.093)	(3.569)	(−1.924)	(−1.926)
Costant	−0.443***	−0.225***	−0.311***	−0.884***	−1.504***	−1.435***
	(−11.194)	(−4.353)	(−5.121)	(−41.732)	(−36.395)	(−20.639)
Time-fixed effect	No	Yes	Yes	No	Yes	Yes
Firm-fixed effect	No	No	No	Yes	Yes	Yes
Region-fixed Effect	No	N0	Yes	No	No	Yes
N	577,408	577,408	577,408	577,408	577,408	577,408
F	213.310	863.960	1031.020	6819.300	4258.450	3918.800
Adj. R^2	0.090	0.105	0.105	0.260	0.265	0.266

The acronyms *N*, F and adj. R^2 refer to sample size, the value of F-test and adjust R-squared, respectively. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

growth of regulated manufacturing firms decreases significantly by 3.07% (columns 2 and 5), which is consistent with the results of Liu et al. (2017), and Hypothesis 1 is validated. The possible reason for this result is that the employment substitution effect of local environmental legislation exceeds the employment complementary effect in China, resulting in a negative impact on labor demand. In fact, the Environmental Protection Regulations formulated by local governments in China, including sewage permits, emission standards, or government fines, closure, and bankruptcy imposed on non-compliant firms, have become strict constraints. The production cost raises because of the internalization of environmental protection, leading to a shrinking production scale, and thus it is difficult to maintain sustained employment growth for the regulated firms (Liu et al., 2021). On the other hand, under the constraints of the new performance appraisal index, China's local officials have to pay more attention to environmental governance and investment and implement strict

Table 3 Impact mechanism test based on firm entry and exit

	(1) Probit	(2) Logit	(3) Probit	(4) Logit
	Entry	*Entry*	*Exit*	*Exit*
Treatment×post	−0.185***	−0.311***	0.403***	0.829***
	(−3.999)	(−3.673)	(12.637)	(11.830)
Control variable	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes
Firms-fixed effect	Yes	Yes	Yes	Yes
N	639,331	639,331	602,131	602,131

The acronyms *N* refers to sample size. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

environmental supervision for the purpose of promotion (Chang et al., 2021), and thus the potential penalties for the non-compliant firms have become the "Sword of Damocles".

5.2 Mechanism tests

- *Test the channel of firm's entry and exit*

To test the effect of firm's entry and exit, we define firm's entry and exit state as follows: if one firm does not exist in period T-1 or before, but begins to exist in period T, it is defined as the firm's entry (*entry* = 1, otherwise it is 0); If the firm exists in period T-1 and before, and disappears from period T, it is defined as firm's exit (*exit* = 1, otherwise 0). We use Probit and Logit models to estimate how local environmental legislation affects firm's entry and exit, respectively. As shown in Table 3, China's environmental legislation reduces the probability of new firms entering the market by 1% (column 1), and increases the probability of surviving firms exiting the market by 2.84% (column 3), which is similar to the results of Yang et al. (2021), and thus lower labor demand, supporting Hypothesis 2. Environmental legislation requires higher environmental standards and increases the productivity threshold for firms to enter the market, which means only those high-productivity firms that meet the emission requirements will choose to enter the market (Qiu et al., 2018). At the same time, some low-productivity firms may exit the market because they fail to meet new emission standards and production technology requirements (Tombe & Winter, 2015). In the short term, less entry and more exit in the market resulting from the environmental legislation has a negative impact on the labor market.

- *Test the channel of firm's export decision*

The increase in "compliance cost" caused by environmental legislation squeezes out the expenses of exploring foreign markets and reduces the probability of export. Therefore, environmental legislation may reduce the employment growth of firms via the reduction in export (Hu et al., 2021). To test this effect, we define a binary dummy variable *export* as follows: if one firm exports, *export* = 1, otherwise it is 0. Then we respectively use the Logit

Table 4 Impact mechanism test based on export

	(1) Logit	(2) Logit	(3) Xtlogit	(4) Xtlogit
Treatment×post	−0.089***	−0.056***	−0.127***	−0.105***
	(−8.877)	(−4.934)	(−6.601)	(−5.042)
Control variable	No	Yes	No	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes
Firms-fixed effect	No	No	Yes	Yes
N	628,251	626,237	304,406	302,866
aDj. R^2	0.091	0.176		

The dependent variable *Export* is a dummy variable, which equals 1 if one firm exports, and 0 otherwise. The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

model and the Xtlogit model to test the impact of environmental legislation on firms' export decisions. As shown in Table 4, after controlling the time fixed effect, the firms fixed effect and the region fixed effect, we find the coefficient of *treatment×post* is significantly negative, indicating that local environmental legislation significantly reduces the export probability (6.08%) of Chinese manufacturing firms, which is consistent with the results of Shi and Xu (2018), and Hypothesis 3 is validated. As shown in Melitz (2003), firms had to pay fixed costs to enter the export market. Stricter environmental policies reduced the ability of non-exporters to pay these costs, so it is more difficult for them to access the export markets.

- *Test the channel of technological Innovation*

Porter Hypothesis points out that appropriate environmental policies can promote technological innovation of the regulated firms, improve firms' productivity and competitiveness, offsetting the "compliance cost" brought by environmental policies to some extent (Liu et al., 2021), and produce an innovation compensation effect. However, environmental policies may have a negative impact on firm's technological innovation because the total amount of capital is fixed in a certain period for a firm and the increase of investment in pollution control will crowd out other R&D investments. On this basis, technological innovation may reduce the unit production cost and product price of firms and increase the market demand for products. The resulting expansion of production scale may increase the demand for labor. On the other hand, the increase in productivity may also lead to the decline of labor demand per unit of output, which may have a negative impact on the employment growth. In order to test whether environmental legislation reduces firms' employment growth through the mechanism of technological innovation, this paper uses " the output value of new products" (innovation1) and " the research and development expenses" (innovation2) from CIED as indicators of technological innovation.

Table 5 reports the test on how environmental legislation affects the technological innovation of manufacturing firms, and the results show that local environmental legislation significantly reduces firms' innovation capacity by about 30% (columns 1and 2), either measured by the output value of new products or the research and development expenses.

Table 5 Impact mechanism test based on innovation

	(1) *Innovation1*	(2) *Innovation1*	(3) *Innovation2*	(4) *Innovation2*
Treatment_post	− 0.298***	− 0.312***	− 0.015	− 0.065
	(− 12.045)	(− 10.599)	(− 0.267)	(− 1.177)
Control variable	No	Yes	No	Yes
Time-fixed effect	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes
Firms-fixed effect	Yes	Yes	Yes	Yes
N	385,965	385,217	194,195	194,091
Adj. R^2	0.586	0.598	0.785	0.786

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization.t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

This shows that the crowding effect of environmental legislation is very obvious, and the "Porter Hypothesis" is not established, which is similar to the results of Konisky (2007). To meet the requirements of environmental regulation, firms need to invest in pollution control. However, this type of investment squeezes out investment in green technology innovation and increases the cost burden of firms (Lv et al., 2021).

5.3 Heterogeneity test

- *Firms' ownership and factor intensity*

Hering and Poncet (2014) found that the ability of state-owned firms to absorb additional environmental costs and bargain with policy executors was far greater than that of non-state-owned firms, and state-owned firms could reduce the sensitivity of government environmental policies by virtue of capital advantages and administrative connections. In order to test the ownership differences of the employment effect of local environmental legislation, this paper divides the enterprise samples into state-owned firms and non-state-owned firms. The first step is to carry out sub sample regression and then constructs the triple interaction of SOE and *treatment*×*post* for triple differential regression. Similarly, in order to test the employment effect of environmental regulation in different factor intensive firms, we divide firms into labor intensive (KL = 0) and capital intensive (KL = 1) according to the capital labor ratio. The results in column (1) to (3) of Table 2 in appendix show that compared with non-state-owned firms, environmental legislation has a relatively small inhibitory effect on employment adjustment of state-owned firms. This result is consistent with the view of Hering and Poncet (2014), and the administrative connection between state-owned firms and the government does reduce their sensitivity to environmental policies. The results in column (4) to (6) show that compared with labor intensive firms, environmental legislation has less inhibitory effect on employment adjustment of capital intensive firms. The reason is that, under the pressure of environmental protection, the declined profit and scale of labor intensive firms may lead them sack some employees. In contrast, to meet the requirements of environmental policies, the capital intensive firms may adopt new emission reduction technologies, such as adding new emission reduction equipment, improving work links or production processes. These new equipment and processes will increase labor demand, which can offset the unemployment caused by the rising compliance costs to a certain extent.

- *Industrial pollution intensity*

Environmental legislation aims at dealing with pollution and protecting environment. However, for the same regulation, heavy-pollution industries are greatly affected by legislation, while light-pollution industries are less affected. Therefore, the impact of environmental legislation on employment growth may vary across industries with different pollution level. In order to solve this problem, this paper first calculates the pollution intensity (*pollut*) of each industry, then constructs the interaction terms for pollution concentration with treatment variable and period variable respectively, and finally adds it into the benchmark model for triple DID estimation. In order to ensure the robustness of the regression results, in addition to retaining the numerical variable of industry pollution intensity, this paper also constructs dummy variables of industries with high or low pollution intensity based on the mean value of pollution intensity and divides the samples into two groups. Since there are many methods to calculate industrial pollution intensity and they are not unified and authoritative, this paper uses three methods to measure industrial pollution intensity. First, the emissions of industrial solid waste, waste gas and waste water per unit output value are treated the standardized emissions, then the emissions of these wastes are simply averaged to obtain the pollution degree index of the industry i in the year t. Finally, the average pollution degree of industry i is obtained by averaging the pollution degree from 1998 to 2013, which is the index of industry pollution intensity. Second, *EPI* index is constructed as a proxy index of industrial pollution intensity by $EPI = \sqrt{E \times P}$, where E refers to the pollutant emission of per unit of industrial output value in the industry i and the calculation method is similar to method 1, and P refers to the proportion of pollutant emission from industry i in the total pollutant emission of all industries. Third, the coal consumption per unit of industrial output value is used as the proxy index of industrial pollution intensity.

The corresponding regression results are reported in Table 3 in appendix. It can be seen that when the industrial pollution intensity is considered, environmental legislation still significantly reduces the employment growth of manufacturing firms. The coefficient of the triple interaction term is significantly negative. It indicates that compared with the industries with low pollution intensity, the inhibiting effect of environmental legislation on employment growth is more obvious in the industries with high pollution intensity.

5.4 Bullet Regional enforcement intensity

The effect of environmental legislation depends on the degree of law enforcement, and the different intensity of enforcement has different impacts on the employment growth. In order to test how the effect of environmental legislation on employment growth varies with law's enforcement intensity, we use the number of environmental protection cases, the number of employees in the environmental protection departments and the number of institutions in the environmental protection system as the proxy variables of regional law enforcement intensity (*case*), respectively. It is used to construct interaction terms with treatment variable and period variable respectively. And these interaction terms are added into the benchmark model for triple DID estimation. As shown in Table 4 in appendix, after controlling the intensity of regional environmental law enforcement, the coefficient of *Treatment* × *Post* is still significantly negative; indicating that environmental legislation significantly reduces the employment growth. The coefficient of the triple interaction term is negative, indicating that the restraining effect of environmental regulation on employment growth is more obvious in the areas with high enforcement intensity compared with the areas with weak enforcement intensity, which is consistent with the results of Zheng et al. (2022). In fact, the greater intensity of environmental law enforcement will bring about higher violation cost faced by companies. The possibility of illegal behavior such as illegal discharge will be reduced. Therefore, enterprises will possibly comply with environmental regulation.

5.5 Robustness tests

- *Exogeneity test of environmental legislation.*

The premise of the empirical analysis using DID is that policy shocks are exogenous, that is, for a special province, whether the environmental legislation is implemented or not is random. However, in fact, environmental legislation may be influenced by the local pollution status and the level of economic development. For example, if one province has a higher level of long-term environmental pollution, the more likely it is to implement environmental legislation. To verify whether local environmental legislation is exogenous, this paper does the following two tests. Firstly, considering that one important factor influencing local environmental legislation is the pollution status of each province, we add the emissions of wastewater, industrial sulfur dioxide and solid waste in Eq. (1) to mitigate the endogeneity of environmental legislation. Secondly, we perform a two-stage least squares regression using the air mobility coefficient as an instrumental variable for local environmental legislation. This instrumental variable is a common practice in the field of environmental economics in recent years (Hering & Poncet, 2014; Liu et al., 2017). The larger the air flow coefficient, the lower the pollutant emissions that can be monitored and therefore the lower probability of implementing environmental legislation, satisfying the instrumental variable correlation requirement. Moreover, air flow coefficient is usually determined by the meteorological system and geographical conditions of a region, satisfying the instrumental variable exogeneity assumption.

In this paper, wind speed information at 10 m height and boundary layer height (used to measure mixed layer height with 75×75 grids) is collected from the European Centre for Medium Weather Forecasting (ECMWF) ERA dataset. Then we process the data as follows: (1) Matching the EAR database with China's prefecture-level cities based on the latitude and longitude; (2) Taking the product of wind speed and boundary layer height for each cell as the air flow coefficient (*afc*); (3) Averaging the air flow coefficient of prefecture-level cities to obtain the province-level air flow coefficients. In this paper, the air flow coefficients used in the regressions are the average coefficients for each province from 2000 to 2013.

Table 5 in appendix reports the results of the exogeneity tests of local environmental legislation. Columns (1) and (2) control the emissions of three major pollutants in each province, including industrial sulfur dioxide (dioxide), solid waste (*solid_waste*) and wastewater (*water_waste*). After controlling for these major pollutants, the coefficient of $treatment \times post$ is still significantly negative, which is consistent with the baseline regression. Columns (3)–(6) show the results of 2SLS after using the air flow coefficient as an instrumental variable. Among them. Columns (3) and (4) are the results of the first stage, and both F-values are greater than 10, which can reject the hypothesis of a weak instrumental variable; the coefficient of $aic \times post$ is significantly negative, indicating that the probability of implementing environmental legislation is lower in areas with larger air movement

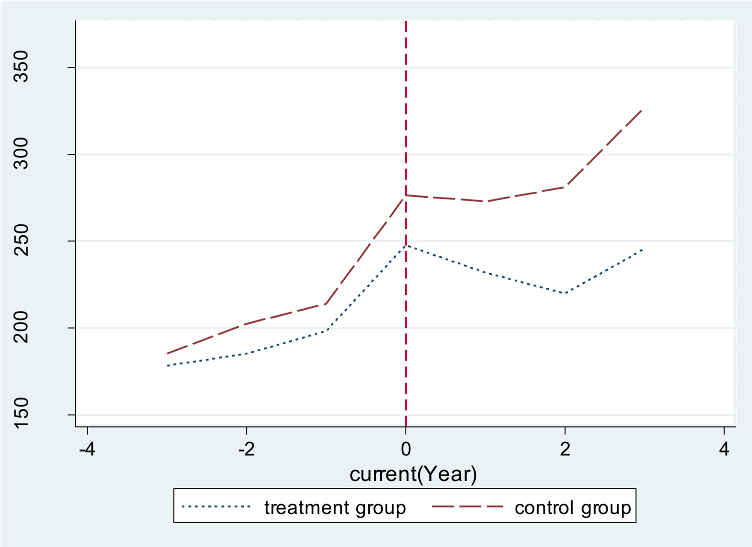

Fig. 3 Employment growth before and after environmental legislation. The x-axis is the time of legislation, "current" denotes the year of legislation, "1" and "− 1" denote the year after and the year before legislation, respectively; the y-axis represents the number of workers (unit: 10,000 people), expressed in terms of the total employed population of firms at the end of the year

coefficient, which is also consistent with our expectation. Columns (5) and (6) show the results of the second stage. The coefficient of *treatment*×*post* is still significantly negative, indicating that the conclusion local environmental legislation reduces employment growth of Chinese manufacturing firms is robust. The above analysis suggests that China's environmental legislation policy is exogenous and thus using the DID method is feasible.

- *Parallel Trend Test*

An important prerequisite for using the DID model is to satisfy the parallel trend hypothesis. In this paper, it is required that the employment of the control group and the treatment group follow the same trend before the implementation of environmental legislation. As shown in Fig. 3, we first use the graphic method to depict the employment growths of the control group and the experimental group before and after the implementation of the legislation. It is found that before the implementation of the environmental legislation, the employment curves of the control group and the treatment group are basically parallel. But after the implementation of the legislation, the employment curves of the control group and the treatment group are gradually different. This result indicates that the employment growths of the control group and the treatment group selected in our research are basically the same before the environmental legislation, and the employment growths gradually show differences after the legislation, which satisfies the parallel trend hypothesis. In addition, this paper also uses two other methods to test parallel trend hypothesis (Table 6 in Appendix). First, the whole sample period is divided into two periods before and after legislation according to Cai et al. (2016), and time dummy variables *bef* and *aft* are set correspondingly. We also construct time dummy variable *B_n* (n = 1,2,3) for n years before the legislation and dummy variable *A_n* (n = 1,2,3) for n years after the legislation respectively

Table 6 Other robustness tests

	(1) Multi-phase to two-phases	(2) PSM-DID	(3) Eliminating state owned firms	(4) Eliminate extreme values	(5) 1998–2007 Enterprise sample	(6) 2008–2013 Enterprise sample	(7) Controlling the average wage of firms	(8) Control province- time effect
Treatment × *post*	−0.009**	−0.018***	−0.022***	−0.003**	−0.013***	−0.027***	−0.016***	−0.058***
	(−2.356)	(−6.616)	(−7.203)	(−2.508)	(−6.194)	(−4.839)	(−6.405)	(−8.735)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province-time effect	No	No	No	No	No	No	No	Yes
N	100,623	577,408	448,230	324,440	382,799	194,609	382,380	577,408
Adj. R^2	0.091	0.123	0.122	0.201	0.042	0.212	0.046	0.253

The acronyms N and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. t values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively following Hering and Poncet (2014). And the interaction items between these time dummy variables and the dummy variable of environmental legislation *treatment* are added to the basic regression, respectively. The regression results of the above two methods all show that before legislation, the coefficient between the time dummy variable and treatment dummy variable is not significant, but it is significantly negative after legislation. It further shows that before the implementation of environmental legislation, there is no significant difference in the trend of employment growth between the control group and the treatment group, satisfying the hypothesis of parallel trend.

- *Other robustness tests*

In this section, we further show the robustness of the above-documented results. First, we use the two-phase DID method instead of the multi-phases DID method in column (1). Column (2) shows the estimates based on the PSM-DID method. In columns (3) and (4), the state-owned firms and the observations with extreme values are eliminated, respectively. Columns (5) and (6) show the estimated results for the sub-samples with the period 1998 to 2007 and 2007 to 2013, respectively, we further control the firm's average wages in column (7). In the last column, the province-time fixed effect is added. As shown in Table 6, the coefficients of the interaction term are all consistently significantly negative, indicating that the estimation results of benchmark regression in this paper are robust.

5.6 The decomposition of job growth

To better understand the margins of employment adjustment, we further decompose a firm's employment growth into two separate components: one measuring the growth rate from expanding establishments (i.e. the *job creation rate*) and the other measuring the rate at which contracting establishments are shrinking (i.e. the *job destruction rate*). Then we define a new indicator *net employment growth*, which equals the difference between the *job destruction rate* and the *job creation rate*. As shown in Davis et al. (1996), Moser et al. (2010) and Bosch and Esteban-Pretel (2012), these three indicators can be measured as follows: $job\_creation_{pft} = \max\ (\Delta jobs_{pft}, 0)$, $job\_destruction_{pft} = \max\ (-\ \Delta jobs_{pft}, 0)$, and $job\_net = job\_creation_{pft}$- $job\_destruction_{pft}$. And $jobs_{pft}$ is the logarithm of the number of employees of firm *f* in year *t*.

The results of benchmark regression show the local environmental legislation significantly reduces employment growth of Chinese manufacturing firms. It can be inferred that there are three possible scenarios: (1) local environmental legislation increases job destruction while reducing job creation. (2) local environmental legislation increases job destruction and job creation, but the effect of job destruction is greater than that of job creation. (3) local environmental legislation reduces job destruction and job creation, but the job destruction effect is smaller than the job creation effect. In order to test these conjectures and further characterize the employment redistribution effect, we regress *job creation*, *job destruction* and *net employment growth* on local environmental legislation by OLS model and fixed effect model respectively. The corresponding results are reported in Table 7. It can be seen that after controlling the time fixed effect, firm fixed effect and region fixed effect, local environmental legislation significantly improves the job destruction of Chinese manufacturing firms (columns (1) and (4)) and reduces the job creation (columns (2) and (5)). But the combination of the above two effects leads to a significant negative net employment growth effect, and the point estimate from our preferred specification

Table 7 Further analysis based on job creation and job destruction

	(1) *Job_destruction* OLS	(2) *Job_creation* OLS	(3) *Job_net* OLS	(4) *Job_destruction* FE	(5) *Job_creation* FE	(6) *Job_net* FE
Treatment×post	0.017***	−0.021***	−0.038***	0.017***	−0.021***	−0.038***
	(5.147)	(−6.885)	(−8.250)	(11.153)	(−13.224)	(−15.901)
Size	−0.221***	0.124***	0.345***	−0.221***	0.124***	0.345***
	(−46.819)	(24.404)	(41.940)	(−103.128)	(71.017)	(105.551)
Age	0.0001***	−0.0001***	−0.000***	0.0001***	−0.0001***	−0.0001***
	(5.631)	(−2.848)	(−4.452)	(5.806)	(−3.030)	(−4.979)
Soe	0.023***	−0.041***	−0.064***	0.023***	−0.041***	−0.064***
	(5.977)	(−10.091)	(−8.841)	(10.527)	(−19.464)	(−19.377)
Export	0.016***	0.004	−0.013**	0.016***	0.004*	−0.013***
	(4.615)	(0.925)	(-2.440)	(9.087)	(1.793)	(−4.458)
lntfp	0.659***	−0.454***	−1.113***	0.659***	−0.454***	−1.113***
	(28.725)	(−13.230)	(−23.819)	(55.991)	(-49.844)	(-59.741)
lnkl	0.162***	−0.090***	−0.252***	0.162***	−0.090***	−0.253***
	(37.601)	(-30.22)	(-64.785)	(136.473)	(−106.076)	(−173.538)
lngdp	−0.103***	−0.055***	0.048***	−0.103***	−0.055***	0.048***
	(−10.797)	(−4.851)	(3.631)	(−27.322)	(−12.468)	(8.178)
Urbanization	0.246***	0.237***	−0.008	0.246***	0.237***	−0.008
	(6.317)	(3.352)	(−0.107)	(9.121)	(8.605)	(−0.206)
Constant	1.566***	0.123	−1.443***	1.566***	0.123	−1.443***
	(13.557)	(1.251)	(−9.767)	(32.663)	(1.564)	(−16.019)
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firm-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	577,333	577,333	577,333	577,333	577,333	577,333
adj. R^2	0.304	0.192	0.241	0.302	0.181	0.269

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

(column (6)) suggests that the net employment growth of firms affected by environmental legislation is 3.86% lower than those not affected (column (3) and (6)), which is consistent with the results of Walker (2010).When the local government implements certain environmental legislation, firms usually rent or buy pollution control equipment and use more environmentally friendly input to meet the new requirements. As a result, the firm's cost of production increases. Inevitably, the rapid rise of production costs in a short period will lead to the decline of the competitive advantage of firms, resulting in the reduction of the production scale and the demand for labor (Greenstone, 2002). On the other hand, environmental legislation requires firms to increase investment in environmental protection. With the improvement of production equipment, the rate of return on capital factors also increases. According to Deschenes (2014), when the rate of return on capital factors increases, firms will reduce capital factor input and increase labor factor input with the substitution effect between capital factor and labor factor. In addition, the "Porter Hypothesis" (Porter & Linde, 1995) points out that well-designed environmental regulations force firms to increase investment in innovation. Moreover, the improved technology can reduce the marginal cost of production, increase the output scale of the firm, and finally increase the demand for labor. Interestingly, our results suggest that most of the employment adjustment is occurring through decreases in the job creation rate (i.e. the rate at which plants with positive employment growth shed jobs), suggesting there may be significant costs to the affected workforce from these plant level reductions in employment.

6 Conclusions and policy implications

6.1 Conclusions

Since the Reform and Opening Up in 1978, China's economy has maintained around an average 10% annual GDP growth rate during the process of urbanization and industrialization. China's economic growth is widely viewed as the extensive economic growth mode at the cost of environmental pollution under the loose environmental regulations, leading to the trade-off between "green water and green mountains" and "gold and silver mountains". Serious environmental issues could affect individuals' health and normal life (Ji et al., 2022), and it will also hinder the country's economic development in the long run (Yang et al., 2020). In such a situation, the implementation of stricter environmental regulations is of great significance to improve the quality of the ecological environment and promote the sustainable development of China's economy. What's even more special is that, after 2012, China's economy shifted from high-speed growth to a medium–high rate of growth. In this special period, policymakers and the general public are interested in the potential impact of environmental regulation on output and employment. Due to its role as a major source of pollutants and in providing an essential input to other sectors, impacts on the manufacturing sector are of particular importance.

In this paper, we estimate the employment effects of local environmental legislation on Chinese manufacturing firms, using a robust DID framework including time fixed effect, firm fixed effect, and region fixed effect to control for the potential endogeneity of environmental legislation. The results show that local environmental legislation significantly reduces the employment growth of Chinese manufacturing firms, and the impact is relatively small, on the order of 3.07%, which is very close to the results of Liu et al. (2017). However, this finding differs greatly from some existing studies on the economic effects of institutional reform, which state that institutional reforms, such as the protection of intellectual property rights, the establishment of financial market and the clarity of ownership, provide the necessary incentives to accumulate human and physical capital and improve the resource allocation efficiency, and thus can boost economic growth and labor demand (Alquist et al., 2022; Coccia, 2019; Lepore et al., 2018). One possible explanation for this difference is that China's environmental legislation mainly emphasizes the sharing of obligations. That is, in order to achieve the goal of environmental protection, each firm must emit pollutants within the given standards. The environmental protection departments will give severe penalties to these firms that fail to meet the standards. In contrast, many other institutional reforms emphasize the protection of rights, such as property rights and ownership. This protection based on exclusivity brings additional benefits to firms and will have a positive impact on their profits, output, employment, etc.

Reduced form estimates alone are uninformative about how these employment impacts are achieved. The results of mechanism tests find that one possible channel is firm's entry and exit. Environmental legislation raises the barriers to entry, resulting in fewer new firms entering the market (Qiu et al., 2018). At the same time, higher environmental requirements may lead those firms that exceed the stipulated standards to exit from the market (Tombe & Winter, 2015). Fewer entries and more exits significantly reduce employment growth for firms. Another possible channel is firm's export decision. The New-New Trade Theory has demonstrated that export expansion can significantly increase labor demand (Dooley et al., 2004). However, we find that China's environmental legislation increases the compliance cost of firms, leading to less capital can be invested in searching for overseas markets, building marketing networks, etc., thus resulting in a lower export probability. The last possible channel is technological innovation. China's environmental legislation does not produce an innovation compensation effect, and more investment in pollution control crowds out the investment in technology R&D (Leonard, 2006), resulting in a lack of technological innovation capacity. This deficiency cannot ensure that firms form a comparative advantage over their competitors in terms of profits, output, and productivity, which in turn negatively affects the employment growth of firms.

We also find heterogeneous impacts of the environmental legislation by type of firm's ownership, factor Intensity, sub-industry and sub-region, with greater negative effects on employment in domestic non-state-owned firms, labor-intensive firms, firms which belong to the high pollution-intensive industry and firms which face stronger environmental enforcement. Furthermore, we decompose the *employment growth* to understand the degree to which changes in regulatory stringency over time from China's environmental legislation have contributed to costly job transitions to the affected workforce. The results show that environmental legislation significantly improves job destruction and reduces job creation, resulting in a − 3.86% job net increase. So Chinese manufacturing firms primarily respond to regulatory pressure by destroying jobs rather than reducing their hiring rates, which is consistent with the results of Walker (2013). However, it is not entirely clear how to monetarize these effects. While the jobs might disappear, the workers certainly do not, and thus the true costs should be characterized by the adjustment costs associated with reallocating the workforce.

6.2 Policy implications

China's 14th Five-Year Plan sets a higher goal for environmental governance in 2021–2025. Requiring synergistically control the emissions of PM2.5 and ozone, and PM2.5 concentration drops by 10% in prefecture-level cities; Comprehensively renovating the emissions of volatile organic compound, and the total emissions of nitrogen oxides and volatile organic compounds fall by more than 10% respectively; Protecting and constructing "the beautiful rivers and lakes", and chemical oxygen demand and ammonia nitrogen emissions fall by 8% respectively. Moreover, at the 75th General Debate of the UN General Assembly, President Xi Jinping stated that "China will scale up its Intended Nationally Determined Contributions by adopting more vigorous policies and measures. We aim to have CO2 emissions peak before 2030 and achieve carbon neutrality before 2060." In such a context, the formulation and implementation of stricter environmental regulations will become an important policy orientation in the process of China's future economic and social development (Ali et al., 2021). And our paper shows that the government's environmental policies may have negative effects on the labor market in the short term while improving the ecological environment quality. Therefore, the government's environmental policy should consider its economic, social, and environmental benefits in an integrated manner.

Effective environmental legislations should balance the improvement on ecological environment and high employment level, and the corresponding policy recommendations are summarized as follows:

Firstly, environmental regulations raise the compliance cost of firms and may adversely affect their profits, production, employment, etc., but it cannot be said that firms should avoid the government's environmental policies. Instead, firms should establish ecological awareness and environmental responsibility. In particular, some heavy pollution manufacturing firms should see the crux of their own problems, and strive to create a variety of conditions to eliminate the adverse impacts on the environment. At the same time, we should take a variety of means to reduce the environmental burden of firms. For example, the government can provide special funds or low-interest loans to help manufacturing firms upgrade their equipment and production technology. For those non-compliant polluting firms, especially some small and medium-sized firms, give them a longer period of time to rectify, and ensure that the closure, shutdown, and other severe punitive measures are not used easily and frequently.

Secondly, China's environmental legislation has heterogeneous impacts on the labor demand by type of firm's ownership, sub-industry and sub-region. Therefore, environmental policies should be flexible to ensure that the environmental standards are in accordance with the firm's characteristic and regional characteristics to avoid "one size fits all". And flexible environment policies can not only achieve the purpose of reducing firms with high energy consumption, high pollution and low efficiency, but also avoid being too strict that firms choose to exit the market directly rather than invest in technological innovation. Meanwhile, for some regions with poor economic development or having a single industrial structure, the implementation cycle of the environmental policies should be extended to ensure that they have enough time to achieve industrial restructuring and complete the environmental protection goals. The government should also compensate them through relevant policies, such as reducing local taxes, increasing capital investment, or introducing external support to assist them to complete some highly necessary environmental protection planning projects.

Thirdly, this paper finds that environmental legislation increases the export cost of firms, and inhibits their export expansion, resulting in lower employment growth. Therefore, multiple channels should be used to stabilize export quantity and improve export quality when implementing environmental legislation. For example, the joint of "government-bank-enterprise" should be further strengthened, and the government provides a platform to enhance the financing efficiency and accuracy, and thus reduce the financing cost of firms. And the firms should make full use of export tax rebates, export credit insurance and other preferential systems to reduce the financial pressure. In addition, firms should make good use of the free trade agreements signed between China and other countries, as well as the China Import and Export Fair, the China International Import Expo, the China Beijing International Fair for Trade in Services and other international exhibitions to strengthen communication with overseas customers, and thus can reduce the searching cost in overseas markets.

Finally, this paper finds that technological R&D and innovation serve as an important channel that explains the impact of environmental legislation on firms' employment growth. Therefore, the government should provide a more flexible environment for firm's R&D and innovation with appropriate fiscal policies and technical support. For example, the government can build various forms of industry-university-research cooperation platforms and strengthen the public service system to achieve a reasonable allocation of scientific and technological innovation resources. Government also can take active measures to reduce fees and taxes and give special preferential treatment to R&D investment. In addition, the government can improve the legal system for technological innovation to motivate more investment in R&D. In sum, local environmental legislation, aimed at improving ecological and environmental quality, may have a negative impact on social welfare, while. Therefore, the government should take effective measures to limit the potential negative impacts, and balance "clear waters and green mountains" and "mountains of gold and silver".

6.3 Limitations of the study

Our research complements existing studies that focus more or less exclusively on developed economies, but there are still some limitations. Firstly, due to data availability, this paper mainly uses the database of Chinese industrial enterprises during 1998–2013. Since 2013, the National Bureau of Statistics of China has stopped publishing this data. Therefore, it is difficult to know the latest production and operation status and financial status of Chinese industrial enterprises. In particular, after 2013, China experienced many major external shocks, such as the U.S.-China trade dispute that started in 2017 and the outbreak of COVID-19. These external shocks directly affect the production and operation of industrial enterprises and the implementation of environmental policies, and thus it is doubtful whether the findings of this paper can be directly generalizable to the present. Secondly, according to the wage determination theory of labor economics, the most important factor that determines the individual wages and employment status of the labor force is the level of human capital, including age, gender, marital status, education level, etc. Unfortunately, the statistical indicators of the Chinese industrial enterprise database are the basic information of enterprises, enterprise financial status, and enterprise production and sales status, and do not include the specific personal information of workers. Therefore, the employment growth in this paper is the overall changes after considering new and departed employees, and it is difficult to know which labor force benefited from environmental legislation (gained new jobs) and which labor force suffered (lost jobs). In the future, if we can combine the Chinese industrial enterprise database with the data from individual labor force surveys, we can examine the effect of environmental legislation on the demand for different types of workers (e.g., experienced and non-experienced workers, skilled and unskilled, highly educated and less educated) to identify which workers are more affected by environmental legislation. Third, in a developing country like China, which usually lacks a complete enforcement monitoring mechanism, the effect of environmental legislation may ultimately depend on the environmental enforcement intensity. Although this paper describes the environmental enforcement intensity in Sect. 4.5.4 from several perspectives, such as the number of environmental cases, the number of enforcement agencies and the number of employees in environmental agencies, these indicators are mostly indirect and vague. Key information about local government environmental enforcement is still missing, such as the amount of pollutants reduced, which enterprises are the main sources of the reduced pollutants, how much the administrative penalties imposed are, and who are the main departure targets. If we control for these factors in the previous regression equation, we can get a more accurate impact of environmental legislation on the employment growth of Chinese manufacturing firms.

Appendix

See Tables 8, 9, 10, 11, 12 and 13.

Table 8 Descriptive statistics of variables

	Control group				Treatment group				Full sample				
	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max	Mean	Standard deviation	min	Max	Difference in mean
Job_growth	0.031	0.375	−2	2	0.028	0.406	−2	2	0.03	0.394	−2	2	0.003**
Size	10.646	1.461	0	19.023	10.738	1.484	0	19.851	10.702	1.475	0	19.851	−0.092***
Age	17.733	49.307	0	2000	17.011	49.371	0	2002	17.296	49.347	0	2002	0.722***
Soe	0.239	0.426	0	1	0.234	0.423	0	1	0.236	0.424	0	1	0.005***
Export	0.371	0.483	0	1	0.37	0.483	0	1	0.371	0.483	0	1	0.001
lntfp	1.367	0.283	−4.792	2.353	1.362	0.298	−6.714	2.456	1.364	0.292	−6.714	2.456	0.005***
lnkl	3.882	1.266	−5.861	14.13	3.964	1.396	-6.404	14.514	3.931	1.347	−6.404	14.514	−0.082***
lngdp	9.969	0.731	8.325	11.458	10.001	0.803	7.768	11.514	9.989	0.775	7.768	11.514	−0.033***
Urbanization	0.52	0.151	0.23	0.896	0.541	0.182	0.175	0.896	0.532	0.171	0.175	0.896	−0.021***
Sample size	248,319				379,936				628,255				

***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

Table 9 Heterogeneity test based on the difference in firms' ownership and factor intensity

	(1) State-owned enterprise	(2) Non state owned firms	(3) Triple difference	(4) Labor-intensive	(5) Capital-intensive	(6) Triple difference
Treatment × *post*	− 0.012***	− 0.023***	− 0.026***	− 0.012***	− 0.017***	− 0.017***
	(− 3.716)	(− 6.489)	(− 7.548)	(− 4.862)	(− 7.363)	(− 6.598)
Triple cross term			0.075***			0.025***
			(5.908)			(4.803)
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	129,178	448,230	577,408	295,972	281,436	577,408
adj. R^2	0.078	0.121	0.109	0.038	0.064	0.046

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

Table 10 Heterogeneity test based on difference in industrial pollution intensity

	(1)	(2)	(3)	(4)	(5)	(6)
	Industrial pollution density		Industrial pollution density *scale		Coal consumption per unit of output	
	Numerical variable	Dummy variable	Numerical variable	Dummy variable	Numerical variable	Dummy variable
Treatment×post	−0.026***	−0.026***	−0.027***	−0.022***	−0.021***	−0.023***
	(−19.113)	(−5.871)	(−19.311)	(−4.482)	(−6.670)	(−4.941)
Treat×post×pollut	−0.035**	−0.022***	−0.009***	−0.016*	−0.002***	−0.017**
	(−2.520)	(-2.914)	(-2.583)	(−1.997)	(−2.932)	(−2.328)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	577,259	577,527	577,259	577,259	577,259	577,527
adj. R2	0.111	0.063	0.111	0.068	0.111	0.061

Notes: The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

Table 11 Heterogeneity test based on difference in regional enforcement intensity

	(1)	(2)	(3)	(4)	(5)	(6)
	Environmental cases		Number of employees in environmental enforcement departments		Number of institutions in the environmental protection system	
	Numerical variables	Dummy variable	Numerical variables	Dummy variable	Numerical variables	Dummy variable
Treatment × *post*	−0.133***	−0.005**	−0.183***	−0.011***	−0.060***	−0.005**
	(−10.44)	(−2.229)	(−9.98)	(−4.455)	(−5.118)	(−2.486)
Treat × *post* × *case*	−0.018***	−0.015**	−0.022***	−0.022***	−0.011***	−0.021***
	(-9.959)	(−2.454)	(−9.731)	(−3.581)	(-5.560)	(-3.277)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	573,345	577,408	577,408	577,408	569,245	577,408
adj. R^2	0.112	0.072	0.111	0.067	0.112	0.072

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

Table 12 Exogeneity test of local environmental legislation

	(1) *Job_growth*	(2) *Job_growth*	(3) *Treatment_post*	(4) *Treatment_post*	(5) *Job_growth*	(6) *Job_growth*
Treatment×post	−0.017***	−0.017***			−0.055***	−0.055***
	(−5.964)	(−5.768)			(−18.980)	(−18.944)
Aic×post			−0.085***	−0.085***		
			(-400.430)	(-400.580)		
Dioxide	0.045***	0.044***			0.060***	0.060***
	(4.780)	(4.651)			(13.280)	(13.207)
Solid_waste	−0.019**	−0.022***			0.0001	−0.0007
	(−2.519)	(−2.748)			(0.030)	(−0.151)
Water_waste	−0.091***	−0.092***			−0.064***	−0.064***
	(−12.152)	(−12.157)			(−16.160)	(−16.176)
Control variable	Yes	Yes	No	No	Yes	Yes
Time-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Firms-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Region-fixed effect	No	Yes	No	Yes	No	Yes
N	540,231	540,231	494,634	494,634	531,275	494,634
adj. R^2	0.173	0.173	0.662	0.663	0.215	0.133

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

Table 13 The results of two other parallel trend tests

	Two-phases before and after legislation (1) *Job_growth*	Multi-phases before and after legislation (2) *Job_growth*
bef × *treatment*	− 0.0004	
	(− 0.141)	
aft × *treatment*	− 0.018***	
	(− 6.258)	
b_3 × *treatment*		0.052
		(2.166)
b_2 × *treatment*		0.005
		(1.300)
b_1 × *treatment*		− 0.002
		(− 0.903)
cur × *treatment*		− 0.006**
		(− 2.133)
a_1 × *treatment*		− 0.019***
		(− 6.694)
a_2 × *treatment*		− 0.029***
		(− 7.401)
a_3 × *treatment*		− 0.021***
		(− 3.131)
Control variable	Yes	Yes
Time-fixed effect	Yes	Yes
Region-fixed effect	Yes	Yes
N	577,408	577,408
adj. R2	0.122	0.122

The acronyms *N* and adj. R^2 refer to sample size and adjust R-squared, respectively. Control variables include *size*, *age*, *soe*, *export*, *lntfp*, *lnkl*, *lngdp* and *urbanization*. *t* values of the regression coefficient are in parentheses. ***, **, and * refer to statistical significance at 1%, 5%, and 10% respectively

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Data availability The data underlying this article will be shared on reasonable request to the corresponding author.

Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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