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## Article

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# The environmental protection law and the zombie companies – evidence from a quasi-natural experimental method

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## ABSTRACT

This paper takes the public companies as a sample during 2012–2017, using DID analysis to test the relationship between 2015 new ‘Environmental Protection Law’ and zombie companies. The results show that the promulgation of the new environmental protection law has significantly negative with zombie enterprises. The strengthening of environmental regulation has accelerated of transformation and upgrading by assets restructuring and promoted technological innovation, which inhibiting the formation of zombie enterprises. Furthermore, this paper found that the negative relationship between environmental law and zombie companies mainly concentrate in non-state-owned enterprises, small-scale enterprises and enterprises with high regional environmental law enforcement intensity. Moreover, the promulgation of the new environmental law has a significant positive effect on corporate value in the medium and long term. This paper enriches the research literature in the field of zombie enterprises and economic consequences of environmental regulation.

## KEYWORDS

Environmental protection law; zombie companies; enterprises innovation; asset restructuring

## 1. Introduction

The concept of zombie firms was first proposed by Kane (1987) to refer to a special type of firm that lacks the ability to survive on its own but can rely on bank loans and government subsidies to maintain its ‘stiff but deathless’ status (Ahearne & Shinada, 2005). Such firms can lead to capital market misallocation and disorderly market competition among industries or regions, and give rise to problems for banks and the economy (Caballero et al., 2008; Hoshi & Kashyap, 2010). This can further dramatically impair sustainable economic development. As the pace of economic transformation accelerates, it is of great importance to explore appropriate ways to prevent the formation of zombie firms if China is to realise high-quality economic development (Chen & Huang, 2017).

Over the past four decades, the Chinese government has implemented a series of favourable policies for firms, which have contributed to China’s economic development

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miracle. However, if a company relies too heavily on the assistance of the government and financial institutions, zombie companies are more likely to arise. This has attracted wide attention from researchers. There have been many studies on the identification, causes, and disposal of zombie firms in China (e.g. Chen & Huang, 2017), and the impact of zombie firms on resource allocation and economic development has also been investigated. However, few have probed how to prevent the formation of a new zombie firm in term of the design of system level and the comprehensive use of market mechanism (Jiang et al., 2012). This paper aims to address this gap in the existing literature by investigating whether the new environmental protection law implemented in China since 2015 has effectively alleviated the problem of zombie firms.

In 2015, China's central government officially implemented the new environmental protection law (NEPL), which has been called 'the strictest environmental protection law in China's history'. From the perspective of institutional theory (Scott, 2005), the new environmental protection law, as a legal institution, undoubtedly has a profound impact on corporate behaviours. Existing studies show that high polluting firms accelerate the adjustment of their production, operations, and investment activities to cope with the continuous pressure of environmental regulations and green development trends (Chen et al., 2022; Fang et al., 2021; Huang et al., 2021; Luo, 2017; Yu et al., 2021). Following these studies, we focus on whether the new environmental protection law enhances the rapid restructuring of polluting industries and prevent the formation of zombie enterprises.

As the most rigorous laws for environmental protection in China's history, the new environmental protection law stipulated a series of regulations that solved the previous problems (e.g. low costs of environmental violation and limited enforcement). These regulations imposed additional cost pressures on enterprises and provided rigorous enforcement tools for department of environmental protection to curb environmental violation activities (Zhang et al., 2019). Among these tools, the system of 'levy fines per diem' is especially rigorous and efficient, which means that the longer the activities such as illegal discharge, excessive discharge, and detection escape exist, the more fines will be levied. Additionally, the system of public involvement regulated by the new environmental protection law can impose deterrents on enterprises that breach the laws. Based on China's provisional data, the existing studies have found that public involvement increases companies' compliance (Fu & Geng, 2019). Therefore, against the new environmental protection law, loss to enterprises caused by their environmental violation activities may be greater than their compliance costs. To minimise the total costs, enterprises may adjust their management strategies, such as change their previous energy-intensive and heavily polluting behaviours and invest more in R&D. Due to technical innovation, the production process will be more standard, simple, and highly efficient, which can promote enterprises' productivity and further enhance enterprises' competitiveness. Consequently, heavily polluting companies are less likely to become zombie firms after the launch of the new environmental protection law.

Using a difference-in-differences (DID) research design, our findings, as expected, suggest that after the implementation of China's new and stringent Environmental Protection Law, high-polluting firms are less likely to become zombie firms in the future. Specifically, conditional on being a high-polluting firm, the probability to become a zombie firm decreases approximately 1.4% after the implementation of the new environmental protection law. Our findings are robust to using alternative

definitions of zombie firms and a propensity score matching (PSM) sample. Most important, we find technical innovation and transformation and upgrading are the transmission channels. Additional analyses suggest that the impact of the new environmental protection law on zombie firm formation is more salient for non-state-owned enterprises, small-scale enterprises and enterprises with high regional environmental law enforcement intensity. Moreover, the promulgation of the new environmental protection law has a significant positive effect on corporate value and profitability in the medium and long term.

The contribution of this paper is mainly in three aspects. First, this paper extends and enriches the relevant studies on the economic consequences of environmental regulations. Previous studies have focused mainly on the impact of environmental regulations on firms' specific investment behaviour such as R&D investment (Hamamoto, 2006; Jiang et al., 2018), environmental investment (Leiter et al., 2011), human capital investment (Berman & Bui, 2001), foreign investment (Cai et al., 2016), investment location choice (Kheder & Zugravu, 2012; Yang et al., 2018). We combine the launch of the new environmental protection law with the formation of zombie firms and find that environmental regulation has a significantly negative effect on the formation of zombie firms. We then identify increased technological innovation and the accelerated transformation and upgrading as potential channels for this effect. These results provide insight into the adjustments in firms' behaviour triggered by environmental regulations and broaden our understanding of the impact of environmental regulation on firms' economic consequences.

Second, this study explores the formation of zombie firms from the perspective of environmental regulation. While previous studies mainly explore the causes and effects of zombie firms, they investigate less about how to prevent the formation of a new zombie firm in terms of the design of system level and the comprehensive use of market mechanism. Moreover, the existing literature on the disposal of zombie firms is dominated by qualitative analysis, with quantitative research mostly focused on the macro perspective. Unlike existing literature, this study theoretically analyses the impact mechanism of the new environmental protection law on preventing the formation of zombie firms and conducts a quantitative study. It thus provides a new analytical perspective for the effective disposal of zombie firms and is of great significance for achieving high-quality economic development.

Third, because of the lack of quasi-natural experiments of the transition of environmental legal system, the existing studies mainly use emission reduction targets (Zhang & Du, 2020), discharge rate, pollutant charge (Shen et al., 2019; Zhang et al., 2019), or expenditures on pollution control (Kneller & Manderson, 2012) as proxy variables for environmental regulation intensity. Based on the enforcement of the new environmental protection law, which is a rare quasi-natural experiment, this study adopts the difference-in-differences (DID) method to evaluate this policy and overcome the possible endogenous problems during the evaluation process. Thus, we provide a reference for other developing countries to solve environmental problems from the levels of system and legislation.

## 2. Literature review

This paper mainly reviews literature in two fields: zombie businesses and the impact of environmental regulations on businesses.

### 2.1. Literature on zombie firms

In terms of the identification of zombie firms, Caballero et al. (2008) proposed the CHK criterion on the identification of zombie firms with a view to the low interest on debt paid by zombie firms. Further, Fukuda and Nakamura (2011) developed the FN-CHK criterion by updating CHK criterion, which identifies firms with the following three characteristics as zombie firms: earnings before interest and taxes (EBIT) are less than the minimum interest paid, the asset-to-liability ratio from the prior year is greater than 50%, and current-year borrowing has increased. This method enhances the accuracy and usability of identifying zombie firms.

In addition to continuous low interest rate bank subsidies, government subsidies are another blood transfusion avenue for zombie businesses in China. Ignoring the government subsidies will lead to an incorrect classification of zombie enterprises. Chen and Huang (2017) developed a strategy based on this to identify zombie businesses government subsidies and bank interest rate subsidies.

The causes for zombie businesses are complicated and depend on particular nations, institutions, and cultural as well as the connections between various economic organisations (governments, banks, and firms). Zombie businesses commonly appear in developed nations like Japan and South Korea due to banks' lending subsidies to bankruptcy firms (Caballero et al., 2008; Hoshi & Kim, 2012). In China, government intervention is the main cause to formation zombie firms (Zhang et al., 2016). Government intervention, soft budget constraint, and unfair competition are important reasons for the formation of zombie firms (Chen & Huang, 2017; Nie et al., 2016)

With regard to the disposal and recovery of zombie firm, Fukuda and Nakamura (2011) noted that corporate restructuring, such as the sale of idle fixed assets and the downsizing of employees, is one of the effective ways to recovery of zombie enterprises. Additionally, encouraging managers rather than punishing them would help recovery of zombie firms (Zhang et al., 2016).

### 2.2. Literature on the effect of environmental regulation

Environmental regulation limits the production choices of firms, which inevitably results in an increase in corporate costs and a reduction in business performance (Gollop & Roberts, 1983; Gray, 1987). However, some studies show that environmental regulation enhances company performance (Porter & Van Der Linde, 1995). Porter and Van Der Linde (1995) proposed that environmental regulation can encourage corporate innovation and enhance corporate value. Furthermore, environmental regulation can improve total factor productivity (Yu et al., 2021) and promote environmental protection investment (Liu et al., 0000), resulting in improving corporate performance.

There are many papers investing the relationship between environmental regulation and corporate innovation to verify the 'Porter Hypothesis'. Those paper finds that

environmental regulation can motivate firms to innovate, thereby establishing a competitive advantage.

This point of view has generated a lot of debate among academics. The 'Porter Hypothesis', which contends that environmental regulation has an innovation compensatory effect, is supported by most of academics (Horbach, 2008; Lin et al., 2014). Huang and Liu (2006) find that environmental regulation puts cost pressure on businesses and promotes innovation.

### **3. Institutional background, theoretical analysis, and hypotheses**

#### **3.1. Institutional background**

As a result of years of rapid economic growth, China is now facing more and more serious environmental problems, environmental pollution has become an important problem issue in China. To deal with this problem, the Chinese government has introduced a series of policies and reforms. China has issued the new environmental protection law in 2015, which is called the strictest environmental protection law.

The stringency of this new law is mainly embodied in the following aspects: first, the system of 'daily penalty' is introduced to impose daily and continuous fines on persistent environmental violations, and the number of fines is uncapped. As a result of this system, corporate costs will be directly impacted by improving of their pollution-producing habits and increased investment in environmental protection. Second, this system of resignation for the blame is adopted to increase the legal responsibility of local officials for the environmental supervision, which strengthen local officials' motivation to protect the environment, and reduce government subsidies to those pollution firms. Third, the administrative detention system is taken to impose the most severe administrative punishment against violators and to subject related institutions to joint liability at the same time. This will further encourage firm involved in environmental regulation to increase investments in environmental protection. As a result, the new environmental protection law's implementation will have a significant impact on firms' investment and management behaviours.

#### **3.2. Theoretical analysis and hypotheses**

There are many reasons for the formation of zombie firms. Besides the inefficiency of the firms themselves, macro-economic policy factors such as government subsidies and bank credit also contribute to the formation of zombie firms in China (Nie et al., 2016; Rao & Wan, 2018).

The implementation of environmental regulation will increase anti-pollution costs and the cost of production, which induce firms to increase innovation input (Porter & Van Der Linde, 1995; Yu et al., 2017). The compensation obtained through innovation can cover the increased costs brought on by environmental regulations, thereby offsetting the detrimental impact of environmental regulations on the firm performance (Porter & Van Der Linde, 1995). Generally, there are two different reactions to rigorous environmental regulations. Under the unfavourable

reaction, firms don't try to assume responsibility for enhancing environmental quality. As a result, firms must deal with rising direct costs (such as fines for breaking environmental laws and spending on environmental protection equipment) as well as implicit costs (such as the opportunity cost of a declining corporate reputation). In the event of a favourable response, firms actively make use of technological innovation to prepare for the pressure brought on by environmental regulations and improve their operational performance to mitigate its negative consequences (Xie et al., 2014).

Compared with other environmental regulation, the new environmental protection law implemented in 2015 has greatly strengthened the responsibilities of polluting firms and the severity of punishment against environmental violations. Firms now face increasingly harsh penalties for environmental violations with the implementation of the new environmental protection law. Particularly, the system of resignation for the blame of local authorities' actions has diminished the chances for firms that are involved in environmental regulation to get government subsidies, and as a result, the costs for firms to respond negatively are great (Li & Wang, 2019). Additionally, the new environmental protection law's reward programmes for firms that achieve outstanding anti-pollution (encompassing fiscal, tax, price, and government procurement) can reduce some of their 'worries' and motivate them to use innovative technology. Additionally, the government has released a series of fiscal assistance programmes, including tax deductions and innovation funds for technological upgrade. These assistance policies further increase firms' incentives to pursue technical innovation in the face of rigorous environmental regulation (Jiang et al., 2013).

Next, the proper advice of environmental regulation can decrease the risks and uncertainties of innovation and increase innovation success rates (Pietrobelli & Rabellotti, 2010). Environmental regulation's survival pressure encourages management to engage in innovation for the purpose of maximising company value, which enhances corporate competitiveness (Ambec & Barla, 2006). It can be seen that the adoption of the new environmental protection law, which has strengthened environmental regulation, can encourage firms to invest more in innovation and boost their corporate competitiveness, lowering the likelihood of zombification.

Finally, firms need to purchase anti-pollution equipment to meet the requirements of environmental regulation, which increase their pollution costs, forcing firms to restructure their assets, transform and upgrade business to respond to the low productivity and high environmental costs (Haepf & Lin, 2017; Qu et al., 2018). Assets restructure can improve their operating performance (Liang et al., 2018), and recovery from the zombie.

As a result, firms will increase anti-pollution innovation, or assets restructure and upgrade business to improve operating performance, which prevent the formation of zombie firms. So, we put forward the following hypothesis:

**Hypothesis:** *Ceteris paribus*, the implementation of the new environmental protection law has a negative effect with the formation of zombie firms.

## 4. Research design

### 4.1. Measurement of zombie firms

Zombie firms are measured mainly by the official document method and the literature method. The criteria proposed by the State Council include 'failure to meet national standards on energy consumption, environmental protection, quality, or safety; sustained loss for more than three consecutive years; and incompliance with the direction of structural adjustment'. Firms meeting all of these criteria are identified as zombie firms. The sustained loss method is simple, clear, and easy to operate, but can be one-sided in some cases. If 'sustained loss for three consecutive years' is taken as a criterion, it will be impossible to find zombie firms in listed firms, as any listed firm which has sustained loss for three consecutive years must be delisted. In addition, the method of 'sustained loss for three consecutive years' fails to take into account an important feature of zombie firms, that is, zombie firms obtain a large amount of credit resources at prices and interest rates lower than market levels. Unlike official criteria, the academic circle defines zombie firms mainly from the perspective of credit. Caballero et al. (2008) studied the problem of zombie firms in Japan in the 1990s, and proposed the 'CHK criterion', i.e. the receiving of credit subsidies, as the core criterion for judging a zombie firm. Later, Fukuda and Nakamura (2011) introduced the 'profitability criterion' and the 'evergreen lending criterion' to modify the 'CHK criterion'. The above methods have captured an essential characteristic of zombie firms (i.e. their ability to continuously get bank credit despite their poor profitability and insolvency), but still fail to fully describe the causes of zombie firms in China. One cause of zombie firms in China lies in the massive subsidies provided by the government. Besides credit subsidies, government subsidies also need to be deducted from the actual profit of a zombie firm. Therefore, introducing a government subsidy correction factor better suits China's national conditions.

Referring to the approaches of Chen and Huang (2017), this paper further considers profit and government subsidy factors in measuring zombie firms based on the CHK criterion. Criterion for identifying zombie firms: the sum of the actual profits of three consecutive years after deducting all kinds of subsidies is negative.

### 4.2. Sample selection and research design

#### 4.2.1 Sample selection and data source

This paper takes the A-share listed firms on Shanghai and Shenzhen stock exchanges in 2012–2017 as its research object, and empirically investigates the effect of the promulgation of the new environmental protection law on zombie firms by constructing a difference-in-differences model. Sample selection is conducted according to the following principles: (1) Since ST and PT firms are more likely to be identified as zombie firms, excluding these firms may pose the problem of sample selection bias and further affect the research conclusions of this paper. Therefore, the research samples of this paper have included ST, PT, and other firms with abnormal financial status. (2) We exclude firms in the financial industry due to their different accounting rules. (3) We exclude firms with missing substantial data. To avoid the effects of extreme values, we winsorise the main variables at the upper and lower 1%.

The data on interest rate are collected manually from the People's Bank of China and the China Money website (chinamoney.com.cn). The input in industrial pollution control and the GDP of each region are derived from the EPS database. The data on the transformation and upgrading of firms such as assets restructuring are gathered manually from the announcements of listed firms. The financial data of firms come from CSMAR and WIND databases.

#### 4.2.2. Model design and variable definitions

On the basis of the above analysis, the DID-based regression model of this paper is set up as follows:

$$Forma_{i,t} = \alpha_1 + \beta_1 did_{i,t} + \sum control_{i,t-1} + \mu_i + \gamma_i + \varepsilon_{i,t} \quad (1)$$

where the explained variable of the formation of zombie firms ( $Forma_{i,t}$ ) is a binary variable that measures the 'zombification' status of listed firms. We use two methods to measure: (1) If the enterprise is a normal enterprise in current year but is identified as a zombie enterprise in next period, it is defined as zombie enterprise formation ( $forma1$ ); (2) If the enterprise is a normal enterprise in current year and is identified as a zombie enterprise for two consecutive years, it is defined as a zombie enterprise formation ( $forma2$ ).  $period_t$  is a dummy variable for environmental protection law, it equals to 1 for the implementation year and subsequent years of environmental protection law but to 0 for the previous years.  $treated$  is a dummy variable for sample grouping. According to the *Environmental Information Disclosure Guidance for Listed Companies* and the *Directory of Industries under Classified Management of Environmental Verification for Listed Companies* released by the Ministry of Environmental Protection, there are 16 heavy polluting industries, namely, thermal power, steel, cement, electrolytic aluminium, coal, metallurgy, chemical, petrochemical, building materials, papermaking, brewing, pharmaceuticals, fermentation, textiles, tanning, and mining. We take the above firms as the treatment group, equals to 1, otherwise 0.  $did$  is a core explanatory variable set to 1 for the heavy polluting industries during first and subsequent years of implementation environmental protection law but to 0 for the previous years. Control variable definitions are listed in Table 1.

## 5. Empirical results

### 5.1. Descriptive statistical results

Table 2 discloses the descriptive statistical results of the main variables in this paper. The results in Table 2 show that the mean value of the formation of zombie firms ( $forma$ ) is 0.04, so the proportion of zombie firms in the research samples of this paper is 4%. The mean value of heavy polluting firms ( $treat$ ) is 0.36, meaning that about 36% of the listed firms in the research samples of this paper are heavy polluting firms. The descriptive statistical results of other control variables are largely consistent with the results of existing studies, and not detailed here.

**Table 1.** Definitions of main variables.

Variable	Definition
<i>forma1</i>	Dummy variable that equals to 1 if the firm was a zombie firm in year t + 1 and was not a zombie firm in year t
<i>forma2</i>	Dummy variable that equals to 1 if the firm was a zombie firm in year t + 1 and t + 2 but not a zombie firm in year t
<i>ifhp</i>	Equals 1 if the firm belongs to heavily polluting industries; otherwise equals 0
<i>period</i>	Equals 1 in or after year 2015; otherwise equals 0
<i>RD</i>	The natural logarithm of R&D investment to operating incomes
<i>trans</i>	Dummy variable, equals to 1 if the main business of the enterprise changes and 0 otherwise
<i>size</i>	Natural logarithm of total assets
<i>firmage</i>	Natural logarithm of firm age
<i>lev</i>	Total liabilities to total assets ratio
<i>ROA</i>	Net earnings to total assets ratio
<i>SOE</i>	A value of 1 if a firm is state-owned and 0 otherwise
<i>growth</i>	Total revenue growth
<i>netgrowth</i>	Net asset growth
<i>cfo</i>	The natural logarithm of the ratio of cash received from selling goods and providing labour services to total assets
<i>Dual</i>	1 if the chairman and CEO are the same person, and 0 otherwise
<i>outratio</i>	Percentage of independent directors on the board
<i>Mshr</i>	The measure of managerial ownership, equals the number of shares held by managers divided by total shares issued in year t.
<i>Board</i>	Log of the number of directors
<i>constrain</i>	Financial constraints, calculated as the SA index values following Pierce and Hadlock (2010)
<i>HHI</i>	The Herfindahl index of firm assets in the industry in year t.
<i>GIE</i>	Investment in industrial pollution control per unit output value
<i>gdpratio</i>	Energy consumed per unit of output value
<i>Marindex</i>	The province-level Marketization index by Fan et al. (2017)
<i>TQ</i>	Tobin's Q, calculated as market value of equity divided by total assets;
<i>gsub</i>	identify environmental protection subsidies in government subsidies by words such as energy saving, energy, comprehensive utilisation, green and environment
<i>year</i>	Year dummy variables
<i>ind</i>	industry dummy variables

**Table 2.** Descriptive statistics for the main variables.

Variable	mean	sd	min	P50	max
<i>forma1</i>	0.040	0.210	0.000	0.000	1.000
<i>forma2</i>	0.040	0.200	0.000	0.000	1.000
<i>ifhp</i>	0.360	0.480	0.000	0.000	1.000
<i>period</i>	0.480	0.500	0.000	0.000	1.000
<i>did</i>	0.170	0.370	0.000	0.000	1.000
<i>firmage</i>	2.690	0.370	0.000	2.710	4.110
<i>size</i>	21.910	1.260	17.600	21.740	25.410
<i>SOE</i>	0.330	0.470	0.000	0.000	1.000
<i>growth</i>	0.240	0.540	-2.300	0.130	3.690
<i>ROA</i>	0.050	0.070	-0.560	0.050	1.800
<i>lev</i>	0.400	0.240	-0.300	0.380	3.240
<i>caf</i>	1.400	3.690	-9.960	0.460	90.630
<i>netal</i>	0.960	1.490	-17.870	0.610	18.590
<i>board</i>	8.720	1.760	0.000	9.000	18.000
<i>dual</i>	0.280	0.450	0.000	0.000	1.000
<i>outratio</i>	0.370	0.060	0.140	0.330	0.800

This table presents the descriptive statistics of the variables used in the testing equation.

## 5.2. Parallel-trend tests

### 5.2.1. Test of identification condition

The most critical premise in using the DID model is the assumption of common trend. That is, the trends of the treatment group and the control group are consistent before the

**Table 3.** Parallel trend assumption.

	(1)	(2)	(3)	(4)
	forma1	forma1	forma1	forma1
lfhp*year03	-0.010 (-0.61)			
lfhp*year02	-0.000 (-0.03)			
lfhp*year01	0.018 (1.08)			
lfhp*current	-0.013 (-0.86)			
lfhp* year1	-0.016** (-2.13)			
lfhp* year2	-0.007** (-2.16)			
lfhp* post01		0.004 (0.31)		
lfhp*post02			0.015 (1.27)	
lfhp* post03				0.022 (1.57)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	6705	6705	6705	6705
adj. R <sup>2</sup>	0.046	0.046	0.046	0.047

This table presents the results for the parallel trend assumption of the difference-in-differences (DID) model. T-statistics are in parentheses.

occurrence of the policy event. Therefore, before using the DID model for estimation, it is necessary to test whether the policy effect is caused by the difference between the experimental group and the control group before policy implementation. To be specific, it is assumed that the experimental group and the control group have different changing trends before the promulgation of the new environmental protection law. In this paper, Model (2) is built to perform a parallel trend test on the probabilities of the firms in the experimental group (heavy polluting firms) and those in the control group (non-heavy polluting firms) becoming zombie firms:

$$forma_{i,t} = \beta_0 + \beta_1 ifhp_i + \beta_2 year_t + \beta_3 ifhp_i \times year_t + \sum controls + \mu_i + \gamma_i + \varepsilon_{i,t} \quad (2)$$

Model (2) has excluded the sample data after the promulgation of the new environmental protection law. The year dummy variable from 2012 to 2014 is constructed using 2011 as the base period. The descriptions of other variables and parameters are consistent with Model (1). The estimated coefficient of *lfhp\*year03*, *lfhp\*year02*, *lfhp01* variable is obtained by regression. The estimation results are provided in column (1) of Table 3. As can be known from regression coefficients, there is no difference change with years between the treatment group and the control group before the promulgation of the new environmental protection law.

Meanwhile, to ensure the randomness of the promulgation of the new environmental protection law, we have constructed false policy implementation time to perform the counterfactual test with reference to existing studies (Fan & Tian, 2013). That is, one year, two years, and three years before the promulgation of the new environmental protection

**Table 4.** The impact of the new environment protection law on zombie firm formation.

	(1) forma1	(2) forma1	(3) forma2	(4) forma2
did	-0.021*** (-5.00)	-0.014* (-1.94)	-0.019*** (-4.57)	-0.015** (-2.17)
firmage		0.005 (0.97)		0.004 (0.73)
size		-0.011*** (-5.13)		-0.010*** (-4.81)
SOE		0.016*** (3.22)		0.016*** (3.15)
growth		-0.019*** (-6.29)		-0.019*** (-6.66)
ROA		-0.357*** (-7.14)		-0.338*** (-7.01)
lev		0.002 (0.17)		0.002 (0.21)
caf		-0.000 (-0.89)		-0.000 (-0.80)
netal		0.011*** (5.20)		0.010*** (4.82)
board		-0.002 (-1.43)		-0.002 (-1.40)
dual		-0.002 (-0.56)		-0.002 (-0.59)
outratio		0.020 (0.51)		0.028 (0.71)
Year	No	Yes	No	Yes
Ind	No	Yes	No	Yes
N	12836	12836	12836	12836
adj. $R^2$	0.012	0.046	0.014	0.044

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

law are taken as false policy implementation years (*post01*, *post02*, and *post03*). The regression test is conducted according to Model (2). The regression results are provided in columns (2) – (4) of Table 3. The estimated coefficients of the cross-product terms (*treat*×*post01*, *treat*×*post02*, and *treat*×*post03*) between the experimental group and false policy implementation years are all non-significant. This further indicates that the difference between the experimental group and the control group is caused by the promulgation and implementation of the new environmental protection law, instead of other factors. It suggests that the implementation of the new environmental protection law has a good parallel trend, which is conducive to the subsequent analysis of this paper.

### 5.2.2. Regression results

The results are provided in Table 4. The regression results in column (1) of Table 4 indicate that the promulgation of the new environmental protection law lowers the probability of heavy polluting firms becoming zombie firms by 1.4%% and 1.5% compared with that of non-heavy polluting firms. The result suggests that the promulgation of the new environmental protection law lowers the probability of the formation of zombie firms. That is, the promulgation of the new environmental protection law significantly lowers the probability of heavy polluting firms becoming zombie firms compared with that of non-heavy polluting firms.

### 5.3. Further analysis

#### 5.3.1. Mechanism analysis

In this regard, we experimentally investigate how environmental regulation influences the likelihood of the emergence of zombie enterprises.

**5.3.1.1. Corporate innovation mechanism.** The effect of environmental regulation on corporate innovation is mainly embodied in two aspects, that is, providing an endogenous power for corporate innovation and reducing uncertainties in corporate innovation. The promulgation of the new environmental protection law increases the intensity of environmental regulation and provides an endogenous power driving firms to invest in innovation.

First, the promulgation of the new environmental protection law promotes and spreads the concept of green consumption, and enhances public awareness of environmental protection issues. In this case, firms are exposed to public supervision, which drives their technological innovation (Li & Mu, 2013). At the same time, it suppresses the problem of information asymmetry between firms and individuals, and makes the public more inclined to consume green and environment-friendly products. In addition, it also encourages firms to produce green products through innovation input, creates product differentiation advantages for firms, and enhances their (Zeng et al., 2016). Under the pressure of environmental regulation, firms tend to reduce pollution emissions or recycle pollutants, thereby increasing their production efficiency (Porter & Van Der Linde, 1995).

Second, the pressure of environmental regulation increases the production costs of firms, compelling them to carry out innovation activities for the purpose of survival and place the emphasis of technological innovation on improving product quality. As pointed out by Ambec and Barla (2006) from the perspective of behavioural science, innovation investment increases future profits for firms, but cannot guarantee their current profits, so corporate managers tend to delay innovation investment. That is, there is a 'present-biased preference'. The promulgation of the new environmental protection law will help to solve the 'self-control' problem of corporate managers and encourage them to invest in innovation for the maximisation of profit maximisation, hereby enhancing corporate competitiveness (Yu et al., 2021). Finally, environmental regulation creates first-mover advantage incentives for firms (Li & Mu 2013). If a firm affected by the new law can take the lead in obtaining technological innovation achievements that comply with government regulation, it will be able to apply for patents, while other firms will have to purchase such innovation achievements. This will create incalculable benefits, thereby encouraging firms to engage in technological innovation. For example, Haier Group improved its production efficiency and level through technological innovation under the pressure of environmental regulation. Taking the green barrier encountered in the export of washing machines in the 1990s as an opportunity, Haier Group created new intellectual property rights through technological innovation, and succeeded in improving its production efficiency and level. In particular, the 'environment-friendly dual power' technology developed by Haier Group and the series products developed on this basis have become industry standards.

On the other hand, the correct guidance of environmental regulation can reduce uncertainties and risks in corporate innovation, and raise the success rate of innovation. Environmental regulation increases the constraints over the technological innovation of firms, thereby affecting uncertainties in technological innovation. By means of the establishment of standards and the selection of tools, environmental regulation affects the path selection of firms for technological innovation, points out the development direction of technological, and reduces uncertainties in technological innovation, thus increasing the success rate of technological innovation and enhancing the competitiveness of firms (Zeng et al., 2016). Therefore, stringent and appropriate environmental regulation will impose innovation pressure on firms, which will partially or even completely offset the compliance costs caused by environmental regulation. Further, it will improve the productivity and competitiveness of firms, reduce the probability of the formation of zombie firms, and even revive zombie firms which have lost their viability.

To test whether the promulgation of the new environmental protection law has promoted corporate innovation, this paper builds Model (3), as expressed below:

$$RD_{i,t} = \alpha + \beta_1 did_{i,t} + \beta_2 controls + u_{i,t} + \gamma_{i,t} + \varepsilon \quad (3)$$

In Model (3), explained variable  $RD$  denotes corporate innovation, measured by innovation input. We use the values of current period ( $RD\_asset$ ) and lag period ( $fRD\_asset$ ) for regression analysis respectively. Other variables are described above. The estimated results are shown in columns (1) and (2) of Table 5.

The regression results in columns (1) and (2) of Table 5 show that the regression coefficients of  $did$  are all significantly positive, suggesting that heavy polluting firms have significantly increased their R&D input after the promulgation of the new environmental protection law. It can be seen that the promulgation of the new environmental protection law has significantly promoted the innovation activities of enterprises, enhanced the competitiveness of enterprises, and thus reduced the probability of zombification of heavily polluting enterprises.

**5.3.1.2. Transformation and upgrading mechanism.** The strengthening of environmental regulation eliminates polluting industries through the mechanism of ‘survival of the fittest’. To meet the requirements of environmental regulation, firms need to reduce yield, change the factor input mix, or purchase advanced pollution treatment equipment. These measures may reduce the productivity of firms and increase their pollution control costs. Therefore, under circumstance of tightened environmental regulation, firms have to adjust their business structure and introduce superior assets through asset restructuring,

**Table 5.** Transmission mechanism.

	(1) $RD\_asset$	(2) $fRD\_asset$	(3) trans	(4) ftrans
did	0.003*** (3.43)	0.011** (2.06)	-0.007 (-0.98)	0.013* (1.71)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
$N$	12836	12789	12836	12830
adj. $R^2$	0.196	0.067	0.031	0.028

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

which in turn promotes their transformation and upgrading, improves their financial status (Liang et al., 2018), and helps them exit from the rank of zombie firms. On the other hand, with the promulgation of the new environmental protection law, the public is attaching increasingly great importance to, accompanied by the enhancement of environmental protection awareness and the upgrading of consumption concepts. As a result, the demand structure of consumption resources has changed as well. The increase in consumers' preference for 'clean' products further stimulates firms to increase green product input and R&D to meet market demands, which further drives the transformation and upgrading of firms and effectively inhibits the formation of zombie firms.

Therefore, the promulgation of the new environmental protection law significantly increases the operating costs of firms. To cope with the pressure of rising costs, firms have to adjust their business structure, introduce superior assets through asset restructuring, and realise the transformation and upgrading of main businesses. In this way, they can improve their financial status (Liang et al., 2018), and exiting from the rank of zombie firms. To test whether the promulgation of the new environmental protection law has promoted the transformation and upgrading of heavy-polluting firms, this paper builds Model (4), as expressed below:

$$Trans_{i,t} = \alpha + \beta_1 did_{i,t} + \sum controls_{i,t-1} + u_{i,t} + \gamma_{i,t} + \varepsilon \quad (4)$$

where  $Trans_{i,t}$  is a dummy variable. According to the approach of Ning and Zhang (2001), if firm  $i$  carries out assets restructuring in year  $t$  and completes business transformation (such as adding new businesses and switching to a new industry), the firm will be considered as having succeeded in transformation. In that case, the variable will be assigned a value of 1; otherwise, it will be assigned a value of 0.  $u_i$  and  $\gamma_i$  denote year and industry fixed effects, respectively. The definitions of other variables are consistent with Model 1. The estimation results are provided in columns (3) and (4) of Table 6.

As can be known from columns (3) and (4) of Table 5, the coefficients of  $did$  are all significantly positive, suggesting that the promulgation of the new environmental protection law has significantly increased the probability of the successful transformation of heavy polluting firms relative to non-heavy polluting firms in the current phase and the coming phase. It is possibly because, due to environmental regulation, firms have to pay for personnel, equipment, materials, and other expenditures related to environmental regulation, which leads to rising operating costs. In this case, firms with poor business performance have to introduce superior assets through assets restructuring to realise the transformation and upgrading of main businesses, so as to improve their financial status and business performance (Liang et al., 2018) and further inhibit the formation of zombie firms.

### 5.3.2. Heterogeneity test

We investigate grouped regressions that referring to corporate ownership, business size, financial restrictions, the level of local law enforcement, and the level of market competitiveness.

**5.3.2.1. Heterogeneity analysis at corporate level.** Table 6 demonstrates the results of heterogeneity analysis at corporate level. Table 6 Panel A demonstrates that the influence of environmental legislation on zombie firms is particularly pronounced in

**Table 6.** Heterogeneity test at corporate level: environmental protection law and the formation of zombie firms.

Panel A: Heterogeneity test :by ownership				
	forma1		forma2	
	(1) SOE	(2) Non_SOE	(3) SOE	(4) Non_SOE
did	-0.036** (-2.50)	-0.003 (-0.40)	-0.037*** (-2.61)	-0.004 (-0.57)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	4161	8675	4161	8675
adj. R <sup>2</sup>	0.069	0.040	0.066	0.038
Chi2	4.06**		4.11**	
Panel B: Heterogeneity test: by financial constraints				
	Low-FC	High-FC	Low-FC	High-FC
	(1)	(2)	(3)	(4)
did	-0.020** (-1.98)	-0.007 (-0.70)	-0.024** (-2.40)	-0.007 (-0.65)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	6964	5872	6964	5872
adj. R <sup>2</sup>	0.049	0.048	0.048	0.043
Chi2	3.77*		4.45**	
Panel C: Heterogeneity test: by firm size				
	Large Size	Small Size	Large Size	Small Size
	(1)	(2)	(3)	(4)
did	-0.025** (-2.38)	-0.008 (-0.79)	-0.027*** (-2.60)	-0.009 (-0.88)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	6964	5872	6964	5872
adj. R <sup>2</sup>	0.052	0.050	0.051	0.045
Chi2	3.21*		3.41**	

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

businesses with SOE subsample. One possible reason is that SOEs bear the policy burden of national development to a certain extent, and have received more fiscal subsidies and policy support than private firms for a long time (Lin et al., 2004). With the implementation of the new environmental protection law, the cost of state-owned firms investing in technological innovation will be less expensive than obtaining rent from local governments. Additionally, state-owned businesses with inherent political advantages will experience increased regulatory pressure. In contrast to non-state-owned businesses, state-owned businesses have greater motivation and capacity to invest in R&D and transform and upgrade in compliance with environmental regulations. State-owned businesses also have asymmetric advantages in external subsidies, property rights protection, taxation, and market opportunities. Therefore, state-owned firms are more likely to carry out technological innovation, transformation, and upgrading when the new environmental protection law is released, thereby lowering the likelihood of zombie enterprises.

Table 6 Panel B demonstrates that the influence of environmental legislation on zombie firms is particularly pronounced in businesses with financial constraints. The

new Environmental Protection Law has significantly increased the responsibility and punishment of polluting businesses, making the punishment of business behaviour related to environmental pollution more and more powerful, and the follow-up cost of businesses to deal with it in a negative way will be bigger and bigger. Enterprises with minimal funding limitations are more driven to cut costs and aggressively respond through technological innovation, transformation, and upgrading than those with severe financing constraints. Therefore, enterprises with low financing constraints have more negative effect of environmental regulation on zombie enterprises.

Table 6 Panel C demonstrates that the influence of environmental legislation on zombie firms is particularly pronounced in businesses with larger firms. We group firm size based on total assets. According to the regression coefficients, the adoption of the new environmental protection law greatly reduces the emergence of zombie enterprises for large-sized businesses. One possible explanation is that, when faced with high intensity environmental regulations, larger enterprises tend to be more capable of responding positively to the adverse effects of environmental regulatory pressure through technological innovation and transformation and upgrading, and after the promulgation of the new environmental protection law.

**5.3.2.2. Heterogeneity analysis at districts level.** Table 7 demonstrates that the influence of environmental legislation on zombie firms is particularly pronounced in districts under stringent supervision. One possible explanation is that, after the promulgation of the new environmental protection law, regions with low law enforcement often have low environmental regulation intensity. In these regions, compliance costs account for a low proportion in the total cost of firms, and there is a lack of sufficient drive on the part of firms to engage in technological innovation and management system innovation for the purpose of energy conservation and emission reduction. Generally, under the pressure of environmental regulation, firms need to control pollution to meet the requirements of environmental regulation. When the supervision cost incurred is low, it is not enough to stimulate firms to conduct environmental R&D innovation.

**5.3.2.3. Heterogeneity analysis at industrial level.** Table 8 demonstrates that the influence of environmental legislation on zombie firms is particularly pronounced in

**Table 7.** Heterogeneity test at regional level: environmental protection law and the formation of zombie firms.

	forma1		forma2	
	(1) High_intensity	(2) Low_intensity	(3) High_intensity	(4) Low_intensity
did	-0.021* (-1.66)	-0.011 (-1.06)	-0.023* (-1.84)	-0.012 (-1.20)
controls	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	5797	7039	5797	7039
adj. R <sup>2</sup>	0.047	0.042	0.045	0.040
Chi2	3.40*		3.48*	

Notes: \*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table 8.** Heterogeneity test at industrial level: environmental protection law and the formation of zombie firms.

	forma1		forma2	
	(1) High_competition	(2) Low_competition	(3) High_competition	(4) Low_competition
did	-0.026** (-2.29)	-0.007 (-0.74)	-0.025** (-2.16)	-0.012 (-1.23)
control	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	6420	6420	6416	6416
adj. R <sup>2</sup>	0.050	0.048	0.049	0.045
Chi2	4.23**		4.20**	

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

industry under higher market competition. We use the Herfindahl-Hirschman Index (HHI5) to measure the degree of market competition. The results in Table 8 suggest that, in industries with higher market competition, the promulgation of the environmental protection law significantly lowers the probability of the formation of zombie firms. The promulgation of the environmental protection law significantly increases the costs of pollution firms. To survive in higher competition market, firms need to innovate and upgrade their technology to increase their operational capability.

### 5.3.3. Analysis of economic consequences

The strengthening of environmental regulation following the adoption of the new environmental protection law has been found to encourage the internalisation of environmental costs, raise production costs for businesses, and place restrictions on their ability to make certain production decisions. Through technical innovation, transformation, and upgrading, businesses attempt to lessen the strain of environmental legislation in order to remain competitive. In this situation, it is worthwhile to investigate if the increasing investment in technical innovation contributes to company value. We measure company value by *Tobinq* and *ROA*, where  $Tobinq = \text{market value} / (\text{total assets} - \text{net intangible assets} - \text{net goodwill})$ ;  $ROA = \text{net profit} / \text{total assets}$ .

Table 9 shows that the adoption of the new environmental protection law has a negligible impact on company value in the current year, but a considerable positive impact on corporate value in the next two years. This finding suggests that, in the long run, increased environmental regulation will encourage businesses to pursue

**Table 9.** Economic consequences.

	(1)	(2)	(3)	(4)	(5)	(6)
	TQ	ROA	TQ for next year	ROA for next year	TQ for next two year	ROA for next two year
did	-0.063 (-0.51)	0.012 (1.45)	0.431** (2.48)	0.017*** (7.15)	0.546** (2.01)	0.025*** (8.52)
control	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes	Yes	Yes
N	Yes	Yes	Yes	Yes	Yes	Yes
adj. R <sup>2</sup>	0.132	0.025	0.057	0.115	0.052	0.085

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

technological innovation, which will ultimately lead to a 'win-win' between environmental regulation and corporate growth and a decrease in the number of zombie firms rather than harming their ability to compete.

### 5.3. Robustness test

#### 5.3.1. Alternative method for identifying zombie firms

We measure zombie enterprise formation are based on data for the prior three years in the previous regression, however it may have inter-period effects using historical cumulative data. This paper remeasures zombie enterprise formation using current year data. Therefore, we follow Hoshi and Kim (2012), adopting the following model to measure zombie enterprise formation, which incorporates profitability and leverage.

$$Z_{it}(f, h) = \begin{cases} 1 & \text{if } FES_{it} > f, \text{ and } BH_{it} > h \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

In the model,  $FES_{it}$  is the interest expense of the company  $i$  in the  $t$  year.  $BH_{it}$  is the total loan amount of company  $i$  in the  $t$  year, which is measured by the ratio of *total new loan amount in the current year/(short-term loan amount in the previous year + long-term loan amount due within one year in the previous year)*. However, this index is highly dependent on the benchmark values of  $f$  and  $h$ . This paper uses four sets of benchmark values of 5% and -10%, 5% and -10%, 3% and -10% and 3% and 10%, respectively, to calculate and measure zombie enterprise formation (*forma1, forma2, forma3 and forma4*).

Table 10 show that the implementation of the environmental protection law is significant negative with zombie enterprise formation, which is consistent with the main results. Our findings are relatively robust.

#### 5.3.2. Propensity score matching

We retest the primary regression results using the *PSM-DID* approach. We use one-to-four propensity score matching to assess the robustness of the new environmental protection law's impact on the development of zombie firms. Table 11 shows that the promulgation of the new environmental protection law still has a significant negative effect with the formation of zombie enterprises, which is consistent with our main findings.

#### 5.3.3. Limitation of research samples to firms listed before 2012

Due to their increased environmental awareness and advanced environmental protection methods, newly listed companies are generally less susceptible to environmental protection regulations. Furthermore, because they are still in the stages of growth or maturation in their life cycles, they are less likely to become zombie enterprises. As a result, those earlier outcomes might have been skewed by those newly listed corporations. We retest our results using the sample which is listed before 2012. The results in Table 12 shows that there is still a significant negative correlation between the promulgation of the environmental protection law and the formation of zombie firms, suggesting that our main results are robust.

**Table 10.** Robustness checks: Re-measuring zombie firms based on annual data.

	(1)	(2)	(3)	(4)
	forma1	forma1	forma2	forma2
did	-0.018** (-2.31)	-0.024** (-2.57)	-0.011* (-1.83)	-0.014** (-1.97)
firmage	0.008 (1.64)	0.024*** (3.96)	0.005 (1.34)	0.012*** (2.62)
size	-0.020*** (-7.79)	-0.033*** (-10.37)	0.000 (0.21)	0.003 (1.15)
SOE	0.015*** (2.88)	0.023*** (3.54)	0.008* (1.87)	0.003 (0.60)
growth	-0.018*** (-4.93)	-0.025*** (-5.18)	-0.008*** (-2.68)	-0.012*** (-4.19)
ROA	-0.264*** (-3.25)	-0.247** (-2.29)	-0.159*** (-5.68)	-0.182*** (-5.89)
lev	0.201*** (8.17)	0.294*** (11.10)	0.096*** (6.54)	0.112*** (7.43)
caf	0.002*** (4.72)	0.002*** (4.30)	0.000 (0.70)	0.000 (1.08)
netal	0.005 (1.38)	0.008* (1.86)	0.005** (2.46)	0.009*** (4.09)
board	0.002 (1.63)	0.004** (2.54)	0.003*** (2.61)	0.004*** (2.61)
dual	-0.002 (-0.46)	-0.003 (-0.56)	0.004 (1.16)	0.002 (0.53)
outratio	0.043 (1.19)	0.113** (2.43)	0.052 (1.51)	0.035 (0.97)
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	12016	12016	12016	12016
adj. R <sup>2</sup>	0.095	0.118	0.052	0.064

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

**Table 11.** Regression analysis with matched sample.

	(1)	(2)	(3)	(4)
	forma1	forma1	forma2	forma2
did	-0.013* (-1.67)	-0.015* (-1.94)	-0.014* (-1.91)	-0.016** (-2.19)
controls	No	Yes	No	Yes
Year	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes
N	11502	11502	11502	11502
adj. R <sup>2</sup>	0.021	0.047	0.021	0.044

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

### 5.3.4. Control of firm fixed effects and year fixed effects

We control for year fixed effects and industry fixed effects to get rid of the year and industry effects on firm productivity. The estimation findings will be skewed if variables that do not change over time at the firm level are ignored in the regressions. As robustness tests, we further control for firm fixed effects. The results in columns (3) and (4) of Table 12 continue to be reliable.

### 5.3.5. Alternative explanation of environmental subsidies

The improvement in performance following the adoption of the environmental protection law may really be the result of performance manipulations (such as earnings management) made by corporate management in order to get environmental subsidies.

**Table 12.** Robustness checks: Limitation of research samples to firms listed before 2012, alternative test of environmental subsidies and control of firm fixed effects.

	Limitation of research samples to firms listed before 2012		control of firm fixed effects		alternative test of environmental subsidies
	(1) forma1	(2) forma2	(3) forma1	(4) forma2	(5) gsub
did	-0.016** (-1.98)	-0.017** (-2.15)	-0.015* (-1.94)	-0.015** (-2.00)	0.071 (0.62)
controls	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
Ind	Yes	Yes	Yes	Yes	Yes
N	11131	11131	12836	12836	3864
adj. R <sup>2</sup>	0.045	0.042	-0.212	-0.211	0.142

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively.

Therefore, we test the relationship between environmental subsidies received by firms and the adoption of the environmental protection law. The results indicate that there is no correlation between environmental protection laws and subsidies, which suggests that environmental subsidies received by businesses have not increased significantly after the implementation of environmental protection laws. As a result in Table 12 column (5), it is possible to rule out the possibility of companies using performance-based tactics to increase their access to environmental subsidies.

## 6. Conclusions

In order to ensure high-quality economic development, it is crucial to prevent the formation of new zombie enterprises. This paper examines the implementation of the new environmental protection law on the formation of zombie firms. It is found that the promulgation of the new environmental protection law has significantly inhibited the formation of zombie firms, and also strengthened environmental regulation. The strengthening of environmental regulation further stimulates firms to engage in technological innovation, carry out transformation and upgrading, and improve operating benefits, thereby lowering the risk of corporate zombification. The new environmental protection law also lessens the likelihood of zombie enterprises forming for state-owned enterprises, large-scale enterprises, and enterprises with a high level of environmental law enforcement in their regions. Additionally, when there is greater market competition, the environmental protection law has a stronger inhibitory effect on the formation of zombie enterprises. This paper also finds that the promulgation of the environmental protection law increase corporate value in the future two years.

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## References

- Ahearne, A. G., & Shinada, N. (2005). Zombie firms and economic stagnation in Japan. *International Economics & Economic Policy*, 2(4), 363–381. <https://doi.org/10.1007/s10368-005-0041-1>
- Ambec, S., & Barla, P. (2006). Can environmental regulations be good for business? An assessment of the Porter hypothesis. *Energy Studies Review*, 14(2), 42–62. <https://doi.org/10.15173/esr.v14i2.493>
- Berman, E., & Bui, L. T. M. (2001). Environmental regulation and productivity: Evidence from oil refineries. *Review of Economics and Statistics*, 83(3), 498–510. <https://doi.org/10.1162/00346530152480144>
- Caballero, R. J., Hoshi, T., & Kashyap, A. K. (2008). Zombie lending and depressed restructuring in Japan. *American Economic Review*, 98(5), 1943–1977. <https://doi.org/10.1257/aer.98.5.1943>
- Cai, X., Lu, Y., Wu, M., & Yu, L. (2016). Does environmental regulation drive away inbound foreign direct investment? Evidence from a quasi-natural experiment in China. *Journal of Development Economics*, 123, 73–85. <https://doi.org/10.1016/j.jdeveco.2016.08.003>
- Chen, Y., & Huang, J. (2017). Regional favoritism and the emergence of zombie company: Evidence from China. *Economic Management (In Chinese)*, 39(9), 149–166. <https://doi.org/10.19616/j.cnki.bmj.2017.09.010>
- Chen, X., Li, W., Chen, Z., & Huang, J. (2022). Environmental regulation and real earnings management—Evidence from the SO2 emissions trading system in China. *Finance Research Letters*, 46, 102418. <https://doi.org/10.1016/j.frl.2021.102418>
- Fang, Z., Kong, X., Sensoy, A., Cui, X., & Cheng, F. (2021). Government's awareness of environmental protection and corporate green innovation: A natural experiment from the new environmental protection law in China. *Economic Analysis and Policy*, 70, 294–312. <https://doi.org/10.1016/j.eap.2021.03.003>
- Fan, Z. Y., & Tian, B. (2013). Tax competition, tax enforcement, and corporate tax avoidance. *Economic Research (In Chinese)*, 9, 99–111. <https://doi.org/10.19571/j.cnki.99-111.2013-09-008>
- Fan, G., Wang, X., & Yu, J. (2017). *China provincial marketization index report (2016)*. Social Sciences Literature Publishing House.
- Fu, J., & Geng, Y. (2019). Public participation, regulatory compliance and green development in China based on provincial panel data. *Journal of Cleaner Production*, 230, 1344–1353. <https://doi.org/10.1016/j.jclepro.2019.05.093>
- Fukuda, S., & Nakamura, J. I. (2011). Why did “zombie” firms Recover in Japan? *The World Economy*, 34(7), 1124–1137. <https://doi.org/10.1111/j.1467-9701.2011.01368.x>
- Gollop, F. M., & Roberts, M. J. (1983). Environmental regulations and productivity growth: The case of fossil-fueled electric power generation. *Journal of Political Economy*, 91(4), 654–674. <https://doi.org/10.1086/261170>
- Gray, W. B. (1987). The cost of regulation: OSHA, EPA and the productivity slowdown. *American Economic Review*, 77, 998–1006. [https://doi.org/10.1016/0038-0121\(88\)90025-0](https://doi.org/10.1016/0038-0121(88)90025-0)
- Haepf, T., & Lin, C. (2017). How does the minimum wage affect firm investments in fixed and human capital? Evidence from China. *Review of Development Economics*, 21(4), 1057–1080. <https://doi.org/10.1111/rode.12296>
- Hamamoto, M. (2006). Environmental regulation and the productivity of Japanese manufacturing industries. *Resource and Energy Economics*, 28(4), 299–312. <https://doi.org/10.1016/j.reseneeco.2005.11.001>
- Horbach, J. (2008). Determinants of environmental innovation: New evidence from German panel data sources. *Research Policy*, 37(1), 163–173. <https://doi.org/10.1016/j.respol.2007.08.006>
- Hoshi, T., & Kashyap, A. K. (2010). Will the US bank recapitalization succeed? Eight lessons from Japan. *Journal of Financial Economics*, 97(3), 398–417. <https://doi.org/10.1016/j.jfineco.2010.02.005>
- Hoshi, T., Kim, Y. Macprudential policy and zombie lending in Korea [R]. SSRN working paper, 2012.
- Huang, D., & Liu, Z. (2006). Environmental regulation and firm autonomous innovation: Building firm competitive advantage based on Porter's hypothesis. *China Industrial Economics (In Chinese)*, 3, 100–106. <https://doi.org/10.19581/j.cnki.ciejournal.2006.03.013>

- Huang, J., Zhao, J., & Cao, J. (2021). Environmental regulation and corporate R&D investment—evidence from a quasi-natural experiment. *International Review of Economics & Finance*, 72, 154–174. <https://doi.org/10.1016/j.iref.2020.11.018>
- Jiang, F., Geng, Q., Lv, D., & Li, X. (2012). Mechanism of excess capacity based on China's regional competition and market distortion. *China Industrial Economics, (In Chinese)*, 2012(6), 44–56. <https://doi.org/10.19581/j.cnki.ciejournal.2012.06.004>
- Jiang, F. X., Wang, Z. J., & Bai, J. H. (2013). The dual effect of environmental regulations' impact on innovation—an empirical study based on dynamic panel data of Jiangsu manufacturing. *China Industrial Economics, (In Chinese)*, 7, 44–55.
- Jiang, Z., Wang, Z., & Li, Z. (2018). The effect of mandatory environmental regulation on innovation performance: Evidence from China. *Journal of Cleaner Production*, 203, 482–491. <https://doi.org/10.1016/j.jclepro.2018.08.078>
- Kane, E. J. (1987). Dangers of capital forbearance: The case of the FSLIC and “zombie” S&Ls. *Contemporary Economic Policy*, 5(1), 77–83. <https://doi.org/10.1111/j.1465-7287.1987.tb00247.x>
- Kheder, S. B., & Zugravu, N. (2012). Environmental regulation and French firms location abroad: An economic geography model in an international comparative study. *Ecological Economics*, 77, 48–61. <https://doi.org/10.1016/j.ecolecon.2011.10.005>
- Kneller, R., & Manderson, E. (2012). Environmental regulations and innovation activity in UK manufacturing industries. *Resource and Energy Economics*, 34(2), 211–235. <https://doi.org/10.1016/j.reseneeco.2011.12.001>
- Leiter, A. M., Parolini, A., & Winner, H. (2011). Environmental regulation and investment: Evidence from European industry data. *Ecological Economics*, 70(4), 759–770. <https://doi.org/10.1016/j.ecolecon.2010.11.013>
- Liang, S. K., Dan, L. I., Xu Ting, G. U., & Yi-Fei, M. A. (2018). Superposition of M&A risk behind backdoor listing and leveraged holdings——case study on phicomm backdoor Guangxi future technology. *China Industrial Economics (In Chinese)*, 6, 136–155.
- Li, P., & Mu, X. (2013). The hysteresis and optimal environmental regulation intensity of Porter Hypothesis: Evidence from a threshold effect test based on system GMM. *Industrial Economics Research (In Chinese)*, 2013(4), 21–29. <https://doi.org/10.13269/j.cnki.ier.2013.04.001>
- Lin, Y. F., Liu, M. X., & Zhang, Q. (2004). Policy-induced burden and enterprise budget constraint: Empirical evidence from China. *Management World (In Chinese)*, 2004(8), 81–89. <https://doi.org/10.19744/j.cnki.11-1235/f.2004.08.010>
- Lin, H., X, Z. S., Y, M. H., Qi, G. Y., & Tam, V. W. Y. (2014). Can political capital drive corporate green innovation? Lessons from China. *Journal of Cleaner Production*, 64, 63–72. <https://doi.org/10.1016/j.jclepro.2013.07.046>
- Liu, Y. Y., Huang, Z. Y., & Liu, X. X. Environmental regulation, management's compensation Incentive and corporate environmental investment——Evidence from the implementation of the environmental protection law in 2015. *Accounting Research. ((In Chinese))* 2021(5), 175–192.
- Li, B., & Wang, B. (2019). Has the implementation of the new environmental protection law increased the company's technological innovation investment? Research based on PSM-DID method. *Journal of Audit & Economics (In Chinese)*, 34(1), 87–96. <https://doi.org/10.3969/j.issn.1004-4833.2019.01.009>
- Luo, J. (2017). How does smog affect firms' investment behavior? A natural experiment based on a sudden surge in the PM2. 5 index. *China Journal of Accounting Research*, 10(4), 359–378. <https://doi.org/10.1016/j.cjar.2017.09.001>
- Nie, H. H., Jiang, T., & Zhang, Y. X. (2016). China's zombie firms: Cause, consequence, and cure. *Macroeconomic Management*, 7, 63–68. <https://doi.org/10.19709/j.cnki.11-3199/f.2016.09.017>
- Ning, X. D., & Zhang, H. W. (2001). Research on the function of special treatment in corporate governance of the listed companies. *Accounting Research, (In Chinese)*, 8, 15–21. <https://doi.org/10.3969/j.issn.1003-2886.2001.08.003>
- Pierce, J. R., & Hadlock, C. J. (2010). New evidence on measuring financial constraints: Moving beyond the Kz Index. *Review of financial studies (In Chinese)*, 23(5), 1909–1940. <https://doi.org/10.1093/rfs/hhq009>

- Pietrobelli, C., Rabellotti, R. Upgrading to compete global value chains, clusters, and SMEs in Latin America[R]. SSRN working paper, 2010.
- Porter, M. E., & Van Der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97–118. <https://doi.org/10.1257/jep.9.4.97>
- Qu, Y. Y., Wu, W. X., & Shen, R. (2018). IPO or RM: What influence the listing choice of Chinese firms? *Journal of Management World*, 34(9), 130–142+ 192. <https://doi.org/10.19744/j.cnki.11-1235/f.2018.09.011>
- Rao, J., & Wan, L. (2018). Government subsidy, heterogeneity and the formation of zombie firms: Evidence from China's listed companies. *Accounting Research*, 3, 3–11. <https://doi.org/10.3969/j.issn.1003-2886.2018.03.001>
- Scott, W. R. (2005). Institutional theory: Contributing to a theoretical research program. *Great minds in management: The process of theory development*. 37(2), 460–484.
- Shen, N., Liao, H., Deng, R., & Wang, Q. (2019). Different types of environmental regulations and the heterogeneous influence on the environmental total factor productivity: Empirical analysis of China's industry. *Journal of Cleaner Production*, 211, 171–184. <https://doi.org/10.1016/j.jclepro.2018.11.170>
- Xie, M. H., Wang, J., & Liu, D. M. (2014). Environment regulation, technological innovation and corporate performance. *Nankai Business Review*, 17(6), 106–113. <https://doi.org/10.1016/j.jclepro.2014.06.012>
- Yang, J., Guo, H., Liu, B., Shi, R., Zhang, B., & Ye, W. (2018). Environmental regulation and the pollution haven hypothesis: Do environmental regulation measures matter? *Journal of Cleaner Production*, 202, 993–1000. <https://doi.org/10.1016/j.jclepro.2018.08.144>
- Yu, W., Chen, Q., & Chen, H. (2017). Environmental Regulation, technological innovation, and operational performance: An empirical analysis of 37 industrial sectors. *Science Research Management (In Chinese)*, 38(2), 18–25. <https://doi.org/10.19571/j.cnki.1000-2995.2017.02.003>
- Yu, H., Liao, L., Qu, S., Fang, D., Luo, L., & Xiong, G. (2021). Environmental regulation and corporate tax avoidance: A quasi-natural experiments study based on China's new environmental protection law. *Journal of Environmental Management*, 296, 113160. <https://doi.org/10.1016/j.jenvman.2021.113160>
- Zeng, Y., Feng, Z., & Zhang, Q. (2016). Geographical location, environmental regulation, and corporate innovation transformation. *Finance and Economic Research (In Chinese)*, 42(9), 87–98. <https://doi.org/10.16538/j.cnki.jfe.2016.09.008>
- Zhang, D., & Du, P. (2020). How China "Going green" impacts corporate performance? *Journal of Cleaner Production*, 258, 120604. <https://doi.org/10.1016/j.jclepro.2020.120604>
- Zhang, G., Fang, C., Zhang, W., Wang, Q., & Hu, D. (2019). How does the implementation of the new environmental protection law affect the stock price of heavily polluting enterprises? Evidence from China's capital market. *Emerging Markets Finance and Trade*, 55(15), 3513–3538. <https://doi.org/10.1080/1540496X.2019.1648250>
- Zhang, D., Xie, Z., & Wang, J. (2016). China's zombie companies and their detection—an exploratory research based on listed companies in iron and steel industry. *China Industrial Economics*, 11, 90–107. <https://doi.org/10.19581/j.cnki.ciejournal.2016.11.008>