PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT
2018, vol. 13, no 2, 7-16

Environmental Regulation and Employment: Evaluating the Role of Water Pollution Prevention and Control Law in China

Prawo ochrony środowiska a zatrudnienie: ocena Ustawy o zapobieganiu zanieczyszczeniu i kontroli jakości wód w Chinach

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Abstract
In this paper, we investigate the impact of environmental regulations on employment in China. We apply a quasi-natural experiment on the revision of Water Pollution Prevention and Control Law in 2008 (WPPCL2008), and we analyze manufacturing sectors' reaction to WPPCL2008 by using a differences-in-differences approach based on China's thirty five sectors at the 2-digit level from 2003 to 2014. Our results show that although environmental regulations can reduce waste-water emissions, at the same time cause a decrease in employment. The results suggest that stringent environmental regulation is not cost free. Furthermore, this finding contradicts the popular view that the effect of Chinese legislation enforcement is insignificant.

Key words: environmental regulation; differences-in-differences; employment; Water Pollution Prevention and Control Law (WPPCL)

Streszczenie
W tym artykule analizujemy wpływ środowiskowych regulacji prawnych na zatrudnienie w Chinach. Przygotowaliśmy eksperyment odnoszący się do poprawionej Ustawy o zapobieganiu zanieczyszczeniom wody i kontroli jakości wód z 2008 r. (WPPCL2008) i przeanalizowaliśmy reakcję na zmienione prawo ze strony sektora produkcyjnego korzystając z metody DID (differences-in-differences), uwzględniając 35 sektorów występujących w Chinach i 2-cyfowy poziom pomiędzy 2003 a 2014 r. Otrzymane rezultaty pokazują, że surowe regulacje środowiskowej nie są wolne od kosztów. Co więcej, okazuje się, że są one sprzeczne z poglądem, że chińskie prawodawstwo jest nieistotne.

Słowa kluczowe: prawo ochrony środowiska, DID, zatrudnienie, Ustawa o zapobieganiu zanieczyszczeniom wody i kontroli jakości wód

1.Introduction

In recent decades, China has achieved an economic miracle, but the rapid development of its manufacturing sectors has led to environmental deterioration (Yu and Chen, 2015). China's environmental pollution is increasingly becoming an important issue both domestically and internationally, and serious environmental problems call for proactive environmental regulations at different government levels.

In this context, impact on employment has played a central role in the political debate over environmental regulations in China, especially during the recent economic transition, with supporters of strict environmental legislation touting *green jobs* and the opposition deriding regulations as *job killers*. China has announced the *Thirteenth Five-Year Plan;* one of its major goals is to improve the quality of the natural environment and sustain current growth of employment.

China will persist in constructing resource-conserving and environmentally friendly society, accelerating the transformation of economic development mode, and prioritizing employment in economic and social development (China's 13th Five-Year Plan, 2015), aiming at sustainable development by promoting economic growth in line with population, resources, and the environment. Therefore, an important challenge that China currently confronts is the implementation of a policy that secures energy-saving, reduction of emissions, and employment growth at the same time.

Extensive research on the impact of environmental regulation on employment appeared since the beginning of the 1990s, but the results are far from unanimous. Walker (2012) examines the effects of environmental regulatory stringency represented by the 1990 *Clean Air Act Amendments* (CAAA) on employment[1]. Based on sectoral difference, it is found that the effects are more significant for the petroleum refining sector, the chemical sector, and the paper manufacturing sector. Hafstead et al. (2016) analyse the casual links between pollution tax and employment. They find that pollution tax leads to the transfer of a large number of employment opportunities to less polluting sectors, and the employment growth of non-pollution intensive sectors will offset the loss of employment in pollution-intensive sectors. Based on regional differences, Kahn et al., (2013) find that a carbon tax of 15 dollars per ton leads to a loss of 6,600 jobs in California due to the spatial effect of inter-regional labour mobility, whereas 47,000 jobs were lost in the northeastern United States. Bezdek et al., (2005) carry out a simulation of the impact of corporate average fuel economy standard (CAFES) in the U.S., it is found that the implementation of CAFES may create approximately 300,000 jobs. Deschenes (2010) presents a case study of an electricity price rise caused by *Clean Energy and Security Act* in 2009, and found that a 4% increase in electricity prices led to a fall of total employment by 0.6% in the short term. Curtis (2012) finds that the implementation of emissions trading projects may cut more than 100,000 jobs.

The review of relevant literature shows that the empirical studies of the impact of environmental regulation on employment have yielded divergent results. However, those studies may suffer from problems of generalization and methodological errors. First, most studies were based on the predominant U.S. and EU samples, while the relation between environmental regulation and employment at sectoral level in developing countries has not been fully investigated yet. China constitutes an excellent case for a re-evaluation of this issue. Furthermore, most studies used the costs imposed by a regulation to measure its stringency. Such regulation-based measure faces two main challenges: multidimensionality and simultaneity, which may impose bias on the relation between environment regulation and employment.

A popular solution to resolve the issue of simultaneity of regulations has been the application of natural experiments. Natural experiments are based on the assumption that some external factor determines the stringency of regulations. Therefore, it can address both the simultaneity and the multidimensionality problems. Our approach uses a natural experiment for the revision of *Water Pollution Prevention and Control Law* in 2008 (WPPCL2008) to examine the influence of environmental legislation regulation on employment, thereby effectively avoiding the calculation problem, and offers more objective and accurate conclusions.

Our paper is structured as follows: Section 2 examines in detail the revision of *Water Pollution Prevention and Control Law* in 2008; Section 3 introduces the econometric strategy and data sources; the empirical results are presented in Section 4; Section 5 explains and discusses our results.

2. The revision of *Water Pollution Prevention and Control Law* in 2008

Water pollution is one of the most important environmental problems in China. According to data released by the Ministry of Environmental Protection (MEP) of China in 2013, the water quality of 59.6% of the total groundwater monitoring area does not meet water environment quality standards (MEP, 2013). Moreover, more than 1,700 water pollution incidents occurred annually in recent years, and 280,000,000 people have access to only low-quality drinking water in China (Xinhuanet, 2014).[2]

To tackle emerging public concerns for the rapid deterioration of water quality, the Chinese government enacted the *Water Pollution Prevention and Control Law* (WPPCL) in 1984. This law was revised for the first time in 1996 (WPPCL1996). WPPCL1996 clearly defined responsibilities and duties of local governments and private enterprises regarding water protection and waste water discharge requirements. With the environmental pollution becoming increasingly serious, and the ongoing reformation of the economy, the Chinese government implemented the second revision of *Water Pollution Prevention and Control Law* in 2008 (WPPCL2008), which saw the amount of legislative articles in WPPCL increase from 62 to 92.

Compared with WPPCL1996, WPPCL2008 further enriched previous legal norms. More specifically, WPPCL2008 defined the responsibilities of local

[1] In literature, the terms *sector* and *industry* are mostly used as synonyms (e.g., Pavitt, 1984), but their definitions are occasionally debated (Hawawini et al., 2003). To avoid confusion, we use the term *sector* exclusively.

[2] http://news.xinhuanet.com/fortune/2014-03/15/c_126270719.htm.

governments regarding water pollution prevention, expanded the authority of local governments and environmental protection departments, strengthened control systems for emissions from major pollutants, and raised penalties for illegal sewage.

In short, the second revision of China's WPPCL in 2008 improved existing legislation and enhanced incentives to control waste-water emissions for enterprises. Empirical data has confirmed that WPPCL2008 effectively reduced sectoral waste-water emissions intensity. Figure 1 shows that the sectoral waste-water emissions intensity steadily decreased from 2003 until 2014, particularly, the decrease became more stable and discernible in the period between 2009 and 2014, after the revision of WPPCL in 2008.

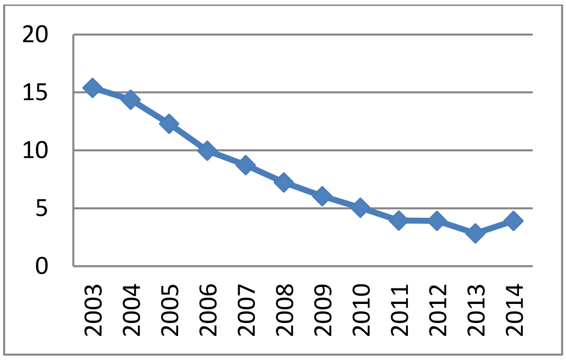


Figure 1. Sectoral waste water emissions intensity in China [million tons/billion yuans] (2003-2014)

The revision of Chinese WPPCL in 2008 provides an uncommon experimental sample to examine the relation between environmental regulation and employment. If environmental regulation indeed significantly affects sectoral employment, there would be apparent differences in the development trend of employment between water pollution-intensive sectors and non-water pollution-intensive sectors after the revision of WPPCL in 2008. Therefore, the revision of WPPCL in 2008 can be used as a natural experiment to assess the impact of environmental regulations on China's sectoral employment. To be more specific, this paper will take two-digit China SIC sectors as a sample in order to evaluate the difference in employment change between water pollution-intensive sectors and non-water pollution-intensive sectors before and after the revision of WPPCL2008, aiming to identify the possible effects of environmental regulation on sectoral employment in China.

3. Estimation Strategy and Data Sources

3.1. The econometric model

We intend to use a differences-in-differences estimation (Allers and Hoeben, 2010) to determine the effect of the revision of WPPCL2008 on China's sectoral employment. First of all, we consider the water pollution-intensive sectors as the treatment group and the non-water pollution-intensive sectors as the control group; then we divide the time interval of the sample into two periods according to the year in which WPPCL2008 was revised. In the end, we divide the above sample into four sub-samples by setting two dummy variables, *du* and *dt*. As to specification, the basic regression equation is specified as follows:

$$lnEmployment_{it}= \beta_0+\beta_1 du_{it}+\beta_2 dt_{it}+\beta_3 du_{it}\times dt_{it}+\theta_i+\eta_t+\varepsilon_{it}, \quad (1)$$

where *i* denotes sectors and *t* years and *Employment* represents the total number of employees in a sector. Referring to previous studies (i.e. Harrison et al., 2014; Horbach and Rennings,2013; Lachenmaier and Rottmann, 2011; Rennings et al., 2004), this paper employs log of employees as measures of *Employment*. *dt* is a time dummy, whose value equals 0 in the baseline period (2003-2008) and 1 in the post-treatment follow-up years (2009-2014). *du* is a dummy variable indicating whether a sector received the treatment (1) or not (0). β_3 is a differences-in-differences estimator, measuring the effect of environmental regulation WPPCL2008 on sectoral level employment, given that a sector belongs to the waste-water pollution-intensive sectors relative to other sectors, which potentially has the same characteristics as the treated sectors but are exogenous to the regulation. If $\beta_3>0$, we can conclude that the sectoral employment of the treatment group will increase more than the one of the control group after the revision of WPPCL2008. Furthermore, we follow Moulton (1990) and include sectoral fixed effects (θ_i) at the two-digit level of *National Industrial Classification* (NIC) in Eq.(1); η_t are year-fixed effects which control for any time-specific shocks that affect all sectors equally. ε is the idiosyncratic error term. We cluster our standard errors at the two-digit NIC level.

Besides environmental regulation, we include a variety of control variables which have been shown elsewhere to be important determinants of sectoral employment.

First, we control for market characteristics by including sectoral growth (*Salesgrowth*) per sector as a determinant of employment. A growing market provides incentives for firms, and thus increases employment. We estimate sectoral growth as the growth rate of sector sales and we deflate growth in nominal sales with a consumer price index.

Furthermore, capital intensity (*Capi*) serves as an alternative determinant that might negatively correlate with employment, because capital-intensive sectors generally require more capital investment and less labour compared to other sectors involving development of new technologies or processes. Capital intensity is measured by the fixed capital per employee.

Finally, we control wage level (*Wages*) as a proxy for the demand situation in a sector (Lachenmaier and Rottmann, 2011). The best approximation available is the average wage per sector. All information was obtained from *the China Labor Statistical Yearbook*, where an average annual earnings per work per sector is reported. We deflate growth in nominal sales with the consumer price index. Hence, we expand Eq.(1) as follows:

$$\ln Employment_{it}=\beta_0+\beta_1 du_{it}+\beta_2 dt_{it}+\beta_3 du_i dt_{it}+\beta_4 lnSalesgrowth_{it}+\beta_5 lnCapi_{it}+\beta_6 lnWages_{it}+\theta_i+\eta_t+\varepsilon_{it} \quad (2)$$

3.2. Data Sources

We use panel data from official China statistics that cover forty nine sectors at the two-digit level of NIC for the period between 2003 and 2014. Five sectors, including Mining of Other Ores, Rubber Products, Plastic Products, Utilization of Waste Resources, and Craftwork and other manufactures are omitted due to insufficient data; consequently, we exclude the five sectors from the sample (see Appendix: Table A1 for 39 sectors at the two-digit level of NIC in China). The main dataset for this research is derived from *China Statistical Yearbooks, China Industry Economy Statistical Yearbooks, China Labor Statistical Yearbook* and *China Environment Statistical Yearbooks.* We deflate the data using sector-specific price deflators to obtain real series.

Table 1 summarizes the definitions and summary statistics of all variables. All nominal variables are deflated into real variables by using manufacturing intermediate input-output price indices for the year 2003. Figure 2 illustrates time-trend graphs of employment for thirty five sectors in China.

In Figure 2, we can read that time-trend graphs of different sectors vary, especially in some waste pollution-intensive sectors[3], such as Textiles, Water Production and Supply, Non-metallic mineral products, show a declining tendency. However, we cannot determine whether Chinese WPPCL had a significant impact on sector employment rates only by comparing graphs.

4. Empirical Results

4.1. Baseline regression results

As *Water Pollution Prevention and Control Law* (WPPCL) was enacted to restrain water pollutant emissions from the private sector, we expect that the effects of the revision of WPPCL in 2008 on water pollution-intensive sectors and non-water pollution-intensive sectors will be significantly different. In this study, we regard sectors whose waste-water emissions per unit of output value exceeded total sectoral average waste-water emissions per unit of output value as water pollution-intensive sectors and treatment group. Other sectors exhibiting waste-water emissions per unit of output value below the total sectoral average waste water emissions per unit of output value are regarded as non-water pollution-intensive sectors and control group (see previous footnote).

Based on the division of treatment groups presented above, we utilize ordinary least squares (OLS) to estimate regression equation (column 1 and 2 in Table 2). To calculate the time-invariant constant effect of WPPCL2008, we include a year dummy in the base regression. The results in Table 2 show that the differences-in-differences estimator β_3 is negative and statistically significant at the 10% statistical level when we include no control variables in regression equation (column 1 in Table 2), and the differences-in-differences estimator β_3 is still negative, but not statistically significant with control variables included (column 2 in Table 2). However, the regression results with OLS may not be valid, since Woodridge and Breusch-Pagan tests display that there are significant first-order autocorrelation and heteroscedasticity with regression Eq.(2). Therefore, we use panel-corrected standard errors (PCSE) method to correct first-order autocorrelation and heteroscedasticity(column 3 and column 4 in Table 2). The results show that the estimated coefficients β_3 are negative and statistically significant at the 10% and 5% statistical level with and without control variables included respectively, implying that WPPCL2008 significantly reduced the employment of China's sectors. On average, the number of employees in water pollution-intensive sectors would be reduced by about 2%-5% annually, as a result of WPPCL2008. As for the influences of other control variables, the coefficient for *Capi* is negative and significant, showing that an increase in capital intensity induces a 0.405% decrease in employment on average. There are no significant effects of sales growth and average wage on employment in a sector, perhaps owning to the imprecise estimations of these two variables.

In addition, the results above challenge the popular notion that Chinese formal legislation is not important. Although many papers confirmed that Chinese legislation in general faces the problem of inadequate enforcement and implementation (Wang et al., 2003); Wang and Jin, 2007), the regression results in Table 2 show that the revision of WPPCL2008 significantly reduced employment in water pollution-intensive sectors, thereby implying

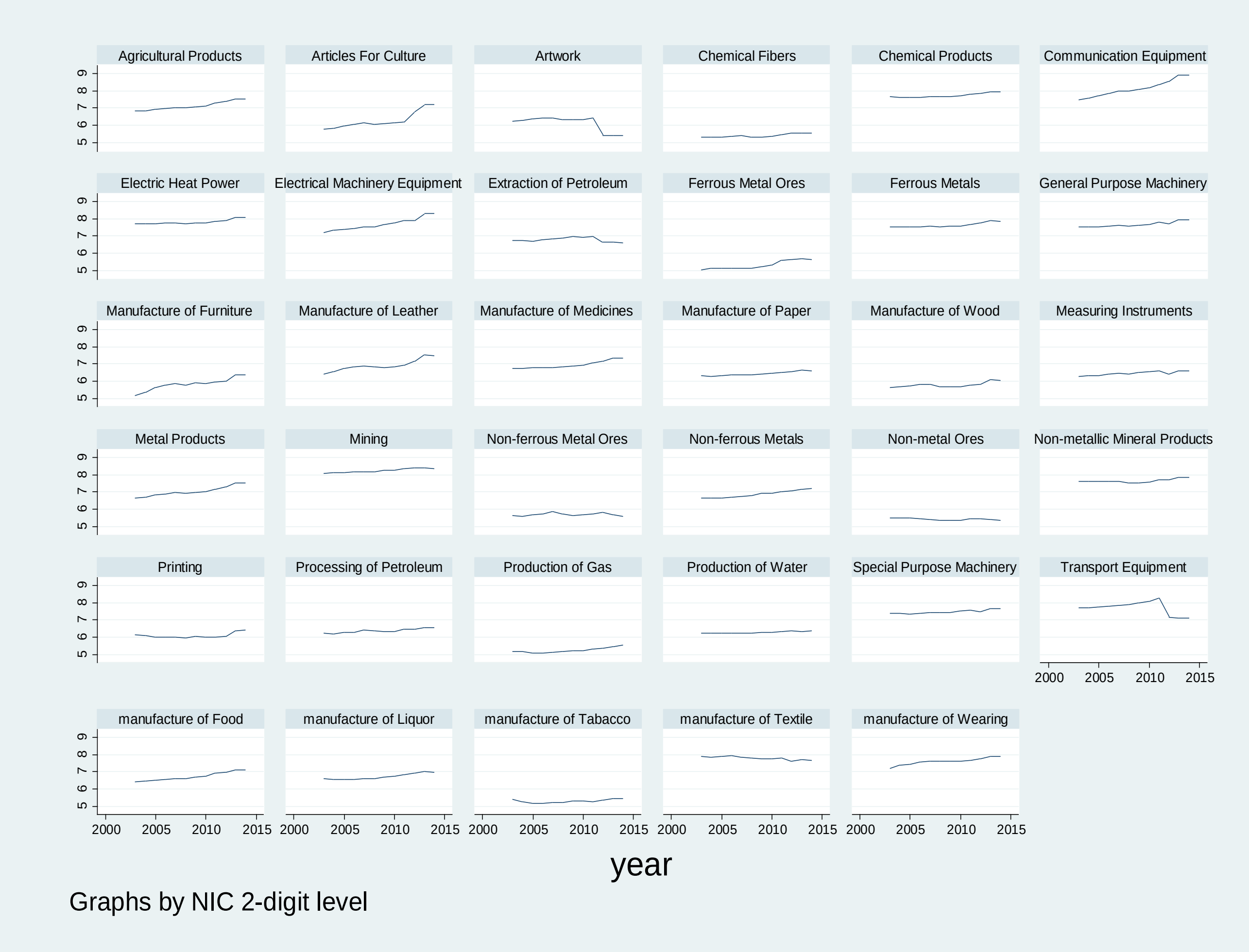
[3] Between 2009 and 2014, among all the sectors, coal mining and dressing, extraction of petroleum and natural gas, non-ferrous metal ores mining and dressing, mining and processing of nonmetal ores, agriculture and sideline foods processing, food production, beverage production, textile industry, pulp & paper, raw chemical material and chemical products, medical and pharmaceutical products, chemical fiber, electricity and heating production and supply, water production exceed total industrial average waste water emissions per unit of output value, These fourteen industries are therefore regarded as water pollution intensive sectors and treatment group in our study. Other sectors befall into the control group.

Table 1. Definitions and summary statistics of all variables

Variable	Definitions	Mean	SD
Employment	The total number of employees in a sector	1254.519	1082.948
Sales growth	Growth rate of sector sales (%)	0.2581727	0.3336515
Capi	Capital intensity: ratio of capital to labor employed (NT$ thousand/person)	270019	285737.8
Wages	The average annual earnings per worker per sector	30058.68	16922.67

Note: The summary of the statistics is based on data pooled from China's thirty five sectors for the period between 2003 and 2014. All monetary measures above are deflated to constant 2003 price using manufacturing intermediate input-output price indices

Figure 2. Time-trend graphs of Employment for thirty five sectors (2003-2014)



that China's Environmental Legislation had a significant impact on production behaviors of private enterprises, a fact which effectively refutes the traditional view on Chinese legislation.

4.2. Marginal effects

The above analysis shows that the revised Chinese WPPCL2008 significantly reduced the employment in the manufacturing sectors. Because the value of variable *dt* is 1 for the years 2009 to 2014, the regression Eq.(2) only estimates the average impact of the revision of WPPCL2008 on employment in water pollution-intensive sectors in the post-revision years (2009-2014) compared to the pre-revision period (2003-2008). However, the regression Eq.(2) fails to explain the marginal effect of the revision of Chinese WPPCL2008 on employment change. It also fails to show whether there is a time-lag problem regarding the effects of revision of WPPCL2008 on employment.. To solve this problem, we extend the regression Eq.(2) to the following form:

$$\ln Employment_{it}=\beta_0+\beta_1 du_{it}+\beta_2 dt_{it}+\beta_3 du_{it}dt_{it}+\beta_4 lnSalesgrowth_{it}+\beta_6 lnCapi_{it}+\beta_7 lnWages_{it}+\sum_{j=2009}^{2014}\alpha_j du_{it}\times dt_{it}\times year^j+\theta_i+\eta_t+\varepsilon_{it} \quad (3)$$

where $year^j$ is a year dummy variable, the value of which is 1 in $year^j$, and 0 in other years. The regression not only can reveal lagging effects of WPPCL2008 on employment of water pollution-intensive sectors, but also helps us estimate the marginal effects of WPPCL2008. For example, in the $year^j$, the marginal effect of the revision of WPPCL2008 on employment in water pollution-intensive sectors is '$\beta_3+\alpha_j$'. We use the panel-corrected standard errors (PCSE) method to estimate the regression equation (3), and modify the first order autocorrelation and heteroscedasticity of the equation.

Table 2. Impact of WPPCL2008 on sectoral employment in China

	OLS		PCSE	
dt×du	-0.051* (0.033)	-0.027 (0.034)	-0.051** (0.026)	-0.027* (0.020)
dt	0.414*** (0.072)	1.061** (0.282)	0.414*** (0.010)	1.061 (0.119)
du	0.867*** (0.111)	2.891** (0.314)	0.867*** (0.070)	2.891 (0.194)
Sales growth		-0.006 (0.049)		-0.006 (0.057)
Capi		-0.405*** (0.089)		-0.405*** (0.066)
Wages		-0.144 (0.180)		-0.144 (0.101)
Constant	6.107*** (0.110)	11.584*** (1.952)	6.107*** (0.010)	11.584 (0.757)
R^2	0.963	0.968	0.963	0.968
Sector dummy	YES	YES	YES	YES
Year dummy	YES	YES	YES	YES
Woodridge test(P)	0.000	0.000	0.000	0.000
Breusch-Pagan test(P)	0.000	0.000	0.000	0.000
Sector	35	35	35	35
Observations	420	420	420	420

Note: Figures in parentheses are Robust Std.Err.
* Significance at 10% levels; ** Significance at 5% levels; ***Significance at 1% levels.

The results in Table 3 depict the coefficients of interaction of the differences-in-differences estimator with year dummy variables ($dt\times du\times year^j$). We find the coefficients of $dt\times du\times year^{2009}$ and $dt\times du\times year^{2010}$ to be significant. On the contrary, the coefficients of $dt\times du\times year^{2011}$ and $dt\times du\times year^{2012}$ are all not significant. Interestingly, the coefficient of $dt\times du\times year^{2013}$ is positive, but not significant, suggesting that the negative impact of the revision of Chinese WPPCL2008 on employment has no time lag and only can last for two years.

The marginal effects calculated by the regression results show that the revision of Chinese WPPCL2008 could have reduced the employment of water pollution-intensive sectors by 10.8% and 8.5% in the first and second year (2009 and 2010) of its implementation, and thereafter affected the reduction of employment by 5.1% and 5.2% in 2011 and 2012 respectively, although the effects are not significant.

Table 3. Impact of WPPCL2008 on sectoral employment in China: Marginal effect estimation

	Coefficient	Robust standard deviation	Marginal effect
dt×du	-0.031	0.032	
$dt\times du\times year^{2009}$	-0.077	0.037	-0.108
$dt\times du\times year^{2010}$	-0.054	0.034	-0.085
$dt\times du\times year^{2011}$	-0.020	0.030	-0.051
$dt\times du\times year^{2012}$	-0.021	0.027	-0.052
$dt\times du\times year^{2013}$	0.011	0.027	-0.02
dt	0.073	0.030	
du	2.443	0.191	
Control variables	YES		
Sector dummy	YES		
Year dummy	YES		
R^2	0.966		

4.3. Robustness Check

Based on a differences-in-differences approach, we find that the revision of Chinese WPPCL2008 significantly decreased employment of China's water pollution-intensive sectors, and that the marginal effect decreased in time. Yet, the differences-in-differences approach requires the assumption that decreasing trends of sectoral employment between treatment group and control group will not be systematically different without the influence of WPPCL2008 over time. In this section, we will utilize the counterfactual analysis method to determine whether the above requirement is valid. To be more specific, WPPCL2008 only induces motivation to waste-water emissions in waste water-intensive sectors, but will not affect waste gas-intensive sectors and solid wastes-intensive sectors. Subsequently, we can test the validity of the estimated results above by examining the impact of WPPCL2008 on employment in waste gas-intensive sectors (*WGIS*) and solid wastes-intensive sectors (*SWIS*). If WPPCL2008 has no significant impact on the decline of employment in *WGIS* and *SWIS*, we can conclude that the estimated results with a differences-in-differences approach are robust.

First, we consider the sectors whose waste-gas emissions per unit of output value exceed total sectoral average waste-gas emissions per unit of output value in 2014 as *WGIS* and the treatment group, while other sectors are treated as the control group.[4] The estimated results of the regression equation (col-

[4] In 2014, among all sectors, Extraction of Petroleum and Natural Gas, Mining and Processing of Ferrous Metal Ores, Manufacture of Medicines, Manufacture of Chemical Fibers, Manufacture of Non-metallic Mineral Products,

Table 4. Impact of WPPCL2008 on employment in China: Counter-factual analysis method

	control group: *WGIS*		control group: *SWIS*	
	(1)	(2)	(1)	(2)
dt×du	-0.0003 (0.031)	.01655 (0.033)	-0.0720^{**} (0.031)	0.0257 (0.043)
dt	0.3935^{***} (0.070)	1.0536^{***} (0.290)	0.4079^{***} (0.068)	1.0706^{***} (0.272)
du	0.4920^{***} (0.120)	1.1507^{***} (0.143)	1.9831^{***} (0.106)	-0.5873^{***} (0.110)
R^2	0.962	0.968	0.963	0.968
Control variables	NO	YES	NO	YES
Sector dummy	YES	YES	YES	YES
Year dummy	YES	YES	YES	YES

Note: Figures in parentheses are Robust Std.Err.
*Significance at 10% levels; **Significance at 5% levels; ***Significance at 1% levels.

umn(1)-(2) in table 4) indicate that the regression coefficients of differences-in-differences estimator *dt×du* are not significant.

Then, we consider the sectors' whose solid-wastes emissions per unit of output value exceed total sectoral average solid-wastes emissions per unit of output value in 2014 as *SWIS* and the treatment group.[5] The estimate results of the regression equation (column (3)-(4) in table 4) indicate that the regression coefficients of differences-in-differences estimator *dt×du* are not significant either.

The above results suggest that there is no difference of change for sectoral employment without impact from WPPCL2008 over time, supporting the validity of the above estimated results with a differences-in-differences approach.

In addition, it should be noted that the method to construct the treatment group according to exhaust emissions per unit of output value as discussed above is of a little subjectivity. Furthermore, the revision of WPPCL in 2008 not only affected the production behavior of water pollution intensive sectors, but may have also affected the production behaviors of non-water pollution intensive sectors. As a result, coefficient β_3 in Eq.(2) may underestimate the effects of the revision of WPPCL2008 on employment of sectors. Following Nunn and Qian (2011), Eq.(2) is transformed as follows:

$$\ln Employment_{it}=\beta_0+\beta_0 Water_{it}+\beta_2 dt_{it}+\beta_3 Water_{it}\times dt_{it}+\beta_4 lnSalesgrowth_{it}+\beta_5 lnCapi_{it}+\beta_6 lnWages_{it}+\theta_i+\eta_t+\varepsilon_{it} \quad (4)$$

where the variable *Water* signifies sectoral waste-water emissions intensity. It is expected that the higher a sector's waste-water emissions intensity is, the stronger the impact of the revision of WPPCL2008 on the sector's production behavior will be. We adopt two indicators to measure sectoral waste-water emissions intensity. The first indicator is the amount of waste-water emissions per unit of output value, and the second indicator is the proportion of a sector's waste-water emissions to total sectors' waste emissions. Regression coefficient β_3 measures how the impact of the revision of WPPCL in 2008 on sectoral employment varies according to the emission-intensity of a sector. Because the approach of Eq.(4) has the advantages of the differences-in-differences approach (Nunn and Qian, 2011), we define it as *quasi differences-in-differences approach*. The estimated results from Eq.(4) using the panel-corrected standard errors (PCSE) method are presented in Table 5.

Table 5. Impact of WPPCL2008 on employment in China: Quasi differences-in-differences estimation

	water: emission of waste water unit output value		*water*: ratio of industrial waste-gas emissions to total industry	
	(1)	(2)	(3)	(4)
Water×dt	-0.005^{**} (0.002)	-0.005^{**} (0.002)	-0.530^{***} (0.158)	-0.556 (0.129)
Water	-0.006^{***} (0.0009)	-0.005^{***} (0.001)	0.839 (0.165)	1.136 (0.304)
dt	0.199^{***} (0.049)	0.159^{***} (0.061)	0.408 (0.004)	0.048 (0.026)
Control variables	NO	YES	NO	YES
Sector dummy	NO	NO	YES	YES
Year dummy	NO	NO	YES	NO
R^2	0.029	0.030	0.962	0.965
Sector	35	35	35	35
Observations	420	420	420	420

Note: Figures in parentheses are Robust Std.Err.
*Significance at 10% levels; **Significance at 5% levels; ***Significance at 1% levels.

When using the first indicator to measure *Water*, the regression coefficients of variable *Water×dt* in column (1) (without control variables) and column (2) (with control variables) are all negative at a significant level of 5%; when using the second indicator, the regression coefficient of variable *Water×dt* in column (3) (without control variables) is negative at a significant level of 10%; however, it is insignificantly negative in column(4) (with control variables).

Smelting and Pressing of Ferrous Metals, Smelting and Pressing of Non-ferrous Metals, Production and Supply of Electric Power and Heat Power, Production and Supply of Gas, exceed total industrial average waste-gas emissions per unit of output value.

[5] In 2014, among all sectors, Mining and Washing of Coal, Mining and Processing of Ferrous Metal Ores, Mining and Processing of Non-Ferrous Metal Ores, Mining and Processing of Non-Metal Ores, Manufacture of Raw Chemical Materials and Chemical Products, Smelting and Pressing of Ferrous Metals, Production and Supply of Electric Power and Heat Power, exceed total industrial average solid waste-emissions per unit of output value.

The above results show that the revised Chinese WPPCL2008 significantly reduced sector's employment, which is consistent with the estimated results using a differences-in-differences approach. More specifically, the results of column (1) and (2) show that if the proportion of a sector's waste-water emissions to total sector's waste water emissions increases by 1%, the revision of WPPCL2008 will cause an average annual decreasing rate of employment of a sector about 0.005%.

5. Conclusions

By applying a quasi-natural experiment on the revision of *Water Pollution Prevention and Control Law's* in China(WPPCL2008), we used a differences-in-differences approach with the aim to investigate the impact of environmental regulation on the employment of the manufacturing sector in China. The results show that the revision of Chinese WPPCL2008 significantly reduced employment in water pollution-intensive sectors, although the marginal effect shows a decreasing tendency over time.

Based on the above results, we infer that the stringent environment regulation comes at a price. Although environmental regulation can effectively reduce waste-water emissions, it comes at the expense of a decrease in manufacturing sectors' employment. However, this study cannot conclude that any environmental regulation will reduce employment of pollution-intensive manufacturing sectors. In fact, the design of environmental policies should focus on end-results rather than means, and market-based policy instruments (Ambec et al., 2013). The governments should treat any regulatory policy, including environmental regulations, with great caution.

In the end, this study shows that legislation in China is currently effective. Although relevant scholars casually emphasize the inadequate enforcement and implementation of Chinese legislation (Wang et al., 2003; Wang and Jin, 2007), our study produces empirical evidence which saw that the revision of Chinese WPPCL2008 has significantly reduced employment in the manufacturing sector. In turn, we argue that the results show that the Chinese environmental laws have effectively constrained the production behaviors of private enterprises. This contradicts the long-established belief that Chinese legislation is ineffective.

Acknowledgements

This study was supported by the Project of Humanities and Social Science of High School (NO: GL158), funded by Ministry of Education of Jiangxi province, the Major Project of Soft Science Research (NO :20161BBA10016), funded by Ministry of Science and Technology of Jiangxi province, and the Thirteenth-five Planned Research Project of Jiangxi Educational Science (NO: 16YB026), funded by Office of Educational Science Planning of Jiangxi province, China. The anonymous referee helped to improve the paper substantially. The usual caveats apply.

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Appendix A. Composition of sector categories

Table A1. Composition of sectors at the 2-digit NIC level in China

NIC code	2-digit category	NIC code	2-digit category
06	Coal mining and dressing	27	Medical and pharmaceutical products
07	Extraction of Petroleum and Natural gas	28	Chemical fiber
08	Ferrous metal mining & dressing	29	Rubber products
09	Non-ferrous metal ores mining and dressing	30	Plastic products
10	Mining and Processing of Nonmetal Ores	31	Nonmetal mineral products
11	Mining of Other Ores	32	Smelting & pressing of ferrous metals
13	Agriculture and sideline foods processing	33	Smelting & pressing of non-ferrous metals
14	Food production	34	Metal products
15	Beverage production	35	Ordinary machinery manufacturing
16	Tobacco products processing	36	Special equipment manufacturing
17	Textile industry	37	Transport equipment and manufacturing
18	Clothes, shoes and hat manufacture	39	Electric machines and apparatuses manufacturing
19	Leather, furs, down and related products	40	Communication equipment, computers, and other electronic equipment
20	Timber processing, bamboo, cane, palm fiber and straw products	41	Instruments, meters, cultural and office machinery manufacture
21	Furniture manufacturing	42	Artwork and other manufactures
22	Pulp & paper	43	Utilization of Waste Resources
23	Printing and record medium reproduction	44	Electricity and heating production and supply
24	Cultural, educational and sports articles production	45	Fuel gas production and supply
25	Petroleum processing, coking and nuclear fuel processing	46	Water production and supply
26	Raw chemical material and chemical products		

Note: Industry *Mining of Other Ores* (NIC code 11) , *Rubber Products*(NIC code 29), *Plastic Products*(NIC code 30), *Utilization of Waste Resources* (NIC code 43) and *Craftwork and other manufactures* (NIC code 42) are omitted due to missing data.
We consider the water pollution intensive sectors as treatment group, the rest sectors-non water pollution intensive sectors are considered as control group, as shown in Table 2.

Table A2. Treatment group and control group

Treatment group		Control group	
NIC Code	2-digit category	NIC Code	2-digit category
06	Coal mining and dressing	07	Extraction of Petroleum and Natural gas
08	Ferrous metal mining & dressing	11	Mining of Other Ores
09	Non-ferrous metal ores mining and dressing	16	Tobacco products processing
10	Mining and Processing of Nonmetal Ores	18	Clothes, shoes and hat manufacture
13	Agriculture and sideline foods processing	19	Leather, furs, down and related products
14	Food production	20	Timber processing, bamboo, cane, palm fiber and straw products
15	Beverage production	21	Furniture manufacturing

Treatment group		Control group	
17	Textile industry	23	Printing and record medium reproduction
22	Pulp & paper	24	Cultural, educational and sports articles production
NIC Code	2-digit category	NIC Code	2-digit category
26	Raw chemical material and chemical products	25	Petroleum processing, coking and nuclear fuel processing
27	Medical and pharmaceutical products	29	Rubber products
28	Chemical fiber	30	Plastic products
44	Electricity and heating production and supply	31	Nonmetal mineral products
46	Water production and supply	32	Smelting & pressing of ferrous metals
		33	Smelting & pressing of non-ferrous metals
		34	Metal products
		35	Ordinary machiner manufacturing
		36	Special equipment manufacturing
		37	Transport equipment and manufacturing
		39	Electric machines and apparatuses manufacturing
		40	Communication equipment, computers, and other electronic equipment
		41	Instruments, meters, cultural and office machinery manufacture
		42	Artwork and other manufactures
		43	Utilization of Waste Resources
		45	Fuel gas production and supply