PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT
2015, vol. 10, no 1, 41-48

Environmental Regulations and Industrial Performance Evidence from the Revision of Water Pollution Prevention and Control Law in China

Regulacje środowiskowe i wskaźniki ekonomiczne wynikające z nowelizacji prawa odnoszącego się do kontroli i zapobiegania zanieczyszczeniu wód w Chinach

Wei Yu*, Qiang Chen**

School of Economics & Management, Tongji University, Shanghai 200092, China
*E-Mails: *rickychina@163.com, **chenqiang@tongji.edu.cn*

Abstract
Stringent environmental regulations are urgently needed as China's environmental pollution is increasingly become an important issue both domestically and internationally. Based on a natural experiment of water pollution prevention and Control Law's revision in 2008(WPPCL2008), this study investigates the effects of environmental regulatory policy on industry in China by using the industrial sectors' data from 2003-2011. The results show that the WPPCL2008 significantly increases the total labor productivity, but has no ROA-inducement effect for water pollution-intensive sectors. Furthermore, WPPCL2008 has an insignificant negative influence on employment level of the water pollution-intensive sectors. At the same time, this study provides evidence on the effectiveness of the current written environmental laws in China.

Key words: environmental regulations; water pollution prevention and control law; industrial performance; a differences-in-differences approach

Streszczenie
Tworzenie rygorystycznego systemu prawa środowiskowego jest w Chinach niezbędne, z uwagi na rosnący poziom zanieczyszczenia środowiska i to tak w wymiarze krajowym, jak i międzynarodowym. Artykuł jako przykład analizuje konsekwencje nowelizacji prawa odnoszącego się do kontroli i zapobiegania zanieczyszczeniu wód, w oparciu o dane z lat 2003-2011. Uzyskane wyniki pokazują, że akt prawny WPPCL2008 doprowadził do znacznego wzrostu wydajności pracy, zarazem towarzysząca mu zmiana wskaźnika rentowności aktywów nie wpłynęła w znaczący sposób na funkcjonowanie przemysłu odpowiedzialnego za największą część zanieczyszczenia wód. Ponadto wprowadzeniu WPPCL2008 towarzyszył niewielki negatywny wpływ na poziom zatrudnienia w sektorach intensywnie zanieczyszczających wody. Artykuł omawia także aktualnie przygotowywane akty prawne, które mają szanse wyeliminować te niedogodności.

Słowa kluczowe: regulacje środowiskowe, prawo kontroli i ochrony zanieczyszczania wód, wydajność przemysłu, metody ekonometryczne

1. Introduction

Along with economic development, the accompanied pollutions created by economic activities have seriously harmed global environment and further caused climate change. Coping with the challenges of climate change has become a crucial task for both scientists and economists (Yang et al., 2012). Theoretically, pollution is recognized as a public good with negative externality, and environmental consumption is non-excludability and non-rivalry. Economic development generally leads to the overproduction of pollutants if there is no policy intervention. Therefore, reducing the emission of industrial pollutants and protecting environment require proactive environmental regulations from government.

In the last three decades, China has achieved a veritable economic miracle, but her rapid development of manufacturing industries lead to the deterioration of environment. China's environmental pollution is increasingly become an important issue both domestically and internationally. China's total CO_2 emissions by fossil fuel consumption were estimated to be 2.63 billion tons in 2012, which ranked China first in the world (Boden et al., 2013). Hence, as the largest developing country, China has been under intense international pressure to reduce its environmental pollution. At the Copenhagen Climate Summit 2009, the Chinese government has made the commitment of reducing CO_2 emissions per unit of GDP by 40%-45% in 2020 compared with 2005 (Ma et al., 2013), and China's twelfth five-year plan (2011-2015) also proposed binding target – 16% reduction in energy consumption per unit of GDP and 17% reduction in CO_2 emission per unit of GDP.

But worryingly, stringent environmental regulations may erode China's industrial competitiveness. According to conventional wisdom among economists (Jenkins, 1998; Luken, 1997; Clift and Wright, 2000), environmental regulations such as technological standards, environmental taxes, or tradable emissions forces firms to allocate some inputs (labor, capital) to pollution reduction, which is unproductive from a business perspective even if it offers environmental or health benefits to society. But this traditional paradigm was contested by a number of economists, notably Professors Michael Porter and Claas van der Linde (1995). Relying primarily on case studies, they argue that more stringent but properly designed environmental regulations can *trigger innovation that may partially or more than fully offset the costs of complying with them* and then lead to improved competitiveness. This is the so-called Porter hypothesis: stringent environmental regulations can achieve a win-win situation in which an economy can simultaneously attain both goals of a cleaner environment and competitiveness.

If stringent environmental regulations are enforced, whether the Porter hypothesis holds in the case of China and regulatory stringency leads to improved industrial competitiveness in terms of industrial performance, resulting in a win-win situation? The answer to this question may not only help clarify the theoretical divergence between environmental regulations and competitiveness, but also have great practical significance to the improvement of environmental regulatory policy in China. In this paper, we examine the impact of environmental regulations on industrial performance based on a natural-experiment of the revision of China's water pollution and control law in 2008 (WPPCL2008). From the analysis, we find that WPPCL2008 significantly increase the total labor productivity, but there is no ROA-inducement effect for water pollution-intensive sectors. Besides, interesting and importantly, we find that WPPCL2008 has an insignificant negative influence on industrial employment level.

This study contributes to the literature in the following ways.

First, this study utilizes a natural-experiment – the revision of China's water pollution and control law in 2008 (WPCL2008) to evaluate the impact of environmental regulations on industrial performance. Owing to the difficulty to acquire proper indicators to directly measure government regulatory stringency, the existing studies mainly adopt pollution abatement and control expenditure (PACE) and sewage charge as the proxy variable for environmental regulations (Keller and Levinsion, 2002; Brunnermei and Cohen, 2003; Cole et al., 2005; Yang et al., 2012). But these indicators may have serious measurement error, which may impart a bias for estimation. This study can avoid the above problem and thus obtain more robust results in contrast to previous studies with the help of a natural-experiment.

Second, previous studies generally adopt productivity as a proxy for *competitiveness* to test the Porter hypothesis, which links environmental regulations to productivity. There are two opposing views on this relationship, resulting in an uncertain result *a priori.* In contrast to previous studies, this study examines the effects of environmental regulations on industrial performance including Return on Assets (*ROA*), Overall Labor Productivity (*LABOR*) and total employment (*EMPLOYMENT*). These indicators may serve as more satisfactory indicators and enable to obtain insight analyses for the Porter hypothesis.

Third, this study provides evidence on the effectiveness of the current environmental regulatory system in China. Since 1980s, China has enacted a series of environmental laws. However, regulators are keenly aware of the *enforcement gaps* limiting the effectiveness of the current regulatory system (Stokoe and Gasne, 2008). The general consensus is that the legal system is undermined by weak local enforcement. Beyer (2006) points out that no effective oversight mechanism exists to ensure policy set at the national level is actually enforced at the local level. This study helps to rationally evaluate the real effectiveness of environmental laws in China.

The rest of this paper is organized as follows. The next section briefly reviews the literature. Section 3 presents the empirical model, explains the data and defines variables. Section 4 presents the empirical results and related discussions. Section 5 concludes the study and provides some policy implications.

2. Previous Literature

The empirical research on the relationship between environmental regulations and business performance, which is often measured by productivity to test the Porter Hypothesis, displays different results. Most papers reviewed in Jaffe et al. (1995) highlight a negative impact of environmental regulation on productivity. For instance, Gollop and Roberts (1983) estimate that SO_2 regulations slowed down productivity growth in the United States in the 1970s by 43 percent. Barbera and McConnell (2001) separate the productivity effects of environmental regulations into direct (abatement costs) and indirect effects (via other inputs and production). Estimating the cost function for five American emission-intensive industries, they find a decline in productivity in every sector following more stringent abatement requirements in the 1970s. Taking the plant vintage and technology differences into account, Gray and Shadbegian (2003) find that US pulp and paper mills with higher pollution abatement operating costs have significantly lower productivity levels, especially in integrated paper mills. This suggests a strong significant negative effect of environmental regulations on productivity.

However, several more recent studies find more positive results. For example, Berman and Bui (2001) report that refineries located in the Los Angeles area enjoyed significantly higher productivity than other US refineries despite the more stringent air pollution regulation in Los Angeles. Similarly, Alpay et al., (2002) find that the productivity of the Mexican food-processing industry is increasing with the pressure of environmental regulation, which leads them to conclude that more stringent regulation is not always detrimental to productivity. Other studies including Managi et al., (2005), Hamamoto (2006), Laonie et al.,(2008) and Yang et al.,(2012) all find a positive relationship between environmental regulations and productivity. The most recent contribution by Teng et al., (2014), by utilizing a sample of publicly listed corporations in Taiwan over the period 1996-2008, find that the relationship between economic performance and environmental commitment is neither strictly negative nor strictly positive, but is instead U-shaped. The evidence suggests that, although a firm bears costs for environmental management in the short term, the benefits of it accumulate over time, and a firm benefits from environmental management in the long term.

Reviewing the literature, we find more stringent environmental regulations seem to have an uncertain influence on performance. But all the above literature is still problematic. Most studies use pollution abatement control expenditure (PACE) to measure the stringency of environmental regulations. In fact, PACE cannot accurately reflect the economic costs of environmental regulation. For example, if a plant replaces an old boiler and the new equipment is more efficient and thus produces less emission, managers must decide whether part or all of this expenditure should be classified as abatement. The PACE questionnaires are often confusing on this point, asking them classify as PACE all expenditures that they would not have made if no pollution regulations were in place (Berman and Bui, 2001). Therefore, PACE will result in serious measurement error, which may impart a bias on the relationship between environment regulation and economic outcomes. This paper, using the natural-experiment of the revision of China's water pollution and control law in 2008 (WPPCL2008) to examine the effects of Chinese environmental legislation on industrial performance, can avoid the measurement error and obtain more objective and accurate conclusion.

3. A Natural Experiment – The Revision of *Water Pollution Prevention and Control Law of China* in 2008

Water pollution is becoming one of the most serious problems that China faces. According to data released by the Ministry of Environmental Protection (MEP) in 2013, 59.6% of the total 4778 groundwater quality monitoring points are inferior, and 10.3% of the total control sections of surface water are at grade V, only 64.1% are at grade III (MEP,2013). Moreover, more than 1700 water pollution accidents happened every year in recent years, and 1.4 billion inhabitants are seriously affected by the insecurity of water quality (Xinhuanet, 2014).

To echo the emerging public concern for rapid deterioration of water quality, the Chinese government enacted Water Pollution Prevention and Control Law (WPPCL) in 1984 and revised the law in 1996 (WPPCL1996). The WPPCL1996 clearly defined responsibilities and duties of water protection for local governments and the ministries of the state council, and the discharge requirement and responsibilities of enterprises. With the pollution of environment becoming increasingly serious and economic system reform getting constantly perfect, the Chinese government implemented the second revision of WPPCL in 2008, raising the number of law articles included in WPPCL1996 from 62 to 92.

The second revision of WPPCL in 2008 (WPPCL2008) further enriched the contents and legal norms of Water Pollution Prevention and Control Law. Specifically, WPPCL2008 specified the responsibilities of local governments for water pollution prevention, expanded the power of local governments and environmental protection department, improved regulatory system of conservation areas for drinking water and compensation system of water pollution, strengthened control system of total discharge for major pollutants, and raised the penalties for illegal sewage.

Therefore, we can use the revision of Water Pollution Prevention and Control Law in 2008 (WPPCL2008) as a natural-experiment to assess the impacts of environmental regulations on China's industrial performance. If environmental regulations indeed significantly affect industrial performance, there will be apparent difference in the growth trend of industrial performance between water pollution-intensive sectors and non water pollution-intensive sectors after the revision of WPPCL in 2008.

4. Empirical Model and Data Sources

In this study, we apply a differences-in-differences approach (Allers and Hoeben, 2010) to estimate the effect of the revision of WPPCL2008 on China's industrial performance. First of all, we consider the water pollution-intensive sectors as treatment group, the rest sectors – non water pollution-intensive sectors are considered as control group, and then we divide time-series interval (2000-2012) 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.* Referring to specification, the basic regression equation is specified as follows:

$$Performance_{it}=\beta_0+\beta_1 du_{it}+\beta_2 dt_{it}+\beta_3 du_{it}\times dt_{it}+\varepsilon_{it} \quad (1)$$

where *i* denotes industries and *t* years. *Performance* represents an industrial sector's performance, which is measured by various indices including Return on Assets (*ROA*), Overall Labor Productivity (*LABOR*) and total employment (*EMPLOYMENT*). *ROA* fully captures an industrial sector's financial performance, measured as the ratio of total assets to industrial output. *LABOR* mainly captures an industrial sector's production efficiency, measured as the ratio of industry value added to the annual average number of employed personnel. *EMPLOYMENT* mainly captures an industrial sector's employment level, measured as the annual average number of employed personnel.

In model (1), *di* is industry dummy variables, if industry *i* belongs to the treatment group, then $du_i=1$. If industry *i* belongs to the control group, then $du_i=0$. *dt* is time dummy variables, *if* year *t*(2003-2008) is ahead of the revision of WPPCL2008, then $dt=0$, otherwise, $dt=1$. Therefore, by estimating the coefficient β_3 of interaction term $du_{it}\times dt_{it}$ (differences-in-differences estimator), we can evaluate the real impact of the revision of WPPCL2008 on industrial performance. If $\beta_3>0$, we can conclude that industrial performance of the treatment group will increase more than the control group after the revision of WPPCL2008. Finally, ε_{it} is a residual error term capturing all other effects.

Besides environmental regulations, we also include industrial characteristics including industrial size (*SIZE*), industrial growth (*GROWTH*) and industrial cost(*COST*) as control variables in our regressions (see, e.g., Tosi et al., 2000). So we expand equation (1) as follows:

$$Performance_{it} = \beta_0+\beta_1 du_{it}+\beta_2 dt_{it}+\beta_3 du_{it}\times dt_{it}+\beta_4 SIZE_{it} +\beta_5 GROWTH_{it}+\beta_6 COST_{it}+\varepsilon_{it} \quad (2)$$

where *GROWTH* is measured by the growth rate of industry sales, *SIZE* is represented by an industry's fixed assets (Bloom & Milkovich,1998; Finkelstein & Boyd,1998), *COST* is measured as the ratio of profit to cost in an industry.

This paper selects the panel data of 37 two-digit manufacturing industries under China's industrial classification system from 2003-2011. Two manufacturing industries – *Mining of Other Ores* and *Utilization of Waste Resources* are omitted due to missing data, so we exclude the two manufacturing industries from the sample (See Appendix: Table 6 for 37 two-digit industry category in China). We deflate the data using industry-specific price deflators to obtain real series.

Table 1. Descriptive statistics

Variables	Mean	S.D.	Min.	Max.
ROA	0.1457	0.1145	0.0008	0.8354
LABOR	13.0247	0.7126	11.0865	15.1962
EMPLOYMENT	4.3512	0.9726	2.3125	6.5833
SIZE	2.1845	1.02435	1.0043	6.5833
GROWTH	0.2354	0.1569	-0.2972	1.0672
COST	0.1015	0.1254	-0.0531	0.9924
Industry Obs.	37 333	37 333	37 333	37 333

5. Empirical Results

5.1 Baseline regression results

As WPPCL was enacted to restrain the emission of water pollution of enterprises, the impact of the revision of WPPCL on water pollution-intensive sectors and non water pollution-intensive sectors is significantly different. In this study, we regard the manufacturing industries of which waste water emissions per unit of output value exceed the average of total manufacturing industries as water pollution-intensive and treatment group. Other manufacturing industries of which waste water emissions per unit of output value are below the average of total manufacturing industries are regarded as non water pollution-intensive and control group.

This study utilizes panel data regressions to estimate the effect of WPPCL2008 on China's industrial performance. Firstly, we utilize OLS to estimate regression equation. Table 2, Table 3 and Table 4 report the estimation results for three indices of industrial performance (*LABOR*, *ROA* and *EMPLOYMENT*) respectively. We include year dummy to capture the time-invariant constant effect of WPPCL2008 in the base regression.

The results in Table 2 show that the estimated coefficient for $dt\times du$ is positive and statistically significant at the 1% statistical level when we include no control variables in regression equation (column 1 in Table 2), moreover, the estimated coefficient for $dt\times du$ is still positive and statistically significant at the 1% statistical level with control variables included (column 2 in Table 2). However, the regression result with OLS may not be valid as Breusch-Pagan test displays that there are significant autocorrelation and heteroscedasticity with regression equation. Therefore, we further conduct regression with panel-corrected standard errors (PCSE) (columns 3 and 4 in Table 2). The results with PCSE show that the estimated coefficients for $dt\times du$ are still positive and statistically significant at the 10% and 5% statistical level respectively, implying that WPPCL2008 can significantly improve the total labor productivity of China's manufacturing industries, specifically, the total labor productivity of water pollution-intensive manufacturing industries would be triggered to increase by about 0.15% by WPPCL2008 annually.

The above results support the Porter hypothesis that stringent environmental regulations are positively related to industrial total labor productivity, suggesting that the possibility of the win-win situation in which both a better environmental quality and firm total labor productivity can coexist.

As for the influences of other control variables, the results obtained overall are consistent with theoretical estimations.

Table 2. Effects of WPPCL2008 on LABOR

Variable	Model 1(OLS)	Model 2(OLS)	Model 3 (PCSE)	Model 4 (PCSE)
dt×du	0.163***	0.135***	0.089*	0.101**
	(0.000)	(0.000)	(0.056)	(0.016)
dt	1.090***	1.555***	1.147***	1.114***
	(0.000)	(0.000)	(0.000)	(0.000)
du	-0.202	-0.200	-0.232***	-0.248***
	(0.335)	(0.340)	(0.000)	(0.000)
SIZE		-0.176***		-0.004
		(0.000)		(0.923)
GROWTH		0.131		0.072
		(0.101)		(0.379)
COST		0.793***		0.626***
		(0.000)		(0.000)
C	12.473***	12.711***	12.450***	12.403***
	(0.000)	(0.000)	(0.000)	(0.000)
Industry dummy	Yes	Yes	Yes	Yes
Time dummy	Yes	Yes	Yes	Yes
R-square Industry	0.8544 37	0.8736 37	0.9943 37	0.9971 37
Observations	333	333	333	333

Note: Figure in parentheses are P-values.
* Significance at 10% levels; ** Significance at 5% levels; ***Significance at 5%levels.

Table 3 displays the estimates obtained using ROA as the dependent variable. Estimates in columns (1)-(2) in Table 3 are obtaining by OLS, showing that the estimated coefficient for *dt*×*du* are insignificantly negative when we include no control variables in regression equation (column 1 in Table 3), but the estimated coefficient for *dt*×*du* is negative and statistically significant at the 5% statistical level with control variables included (column 2 in Table 3), however, when we further conduct regression with panel-corrected standard errors (PCSE) (columns (3) and (4) in Table 3), we also find that the estimated coefficients for *dt*×*du* are still negative but not significant, suggesting that WPPCL2008 have a negative effect on ROA of China's manufacturing industries, although the effect shown above is not significant. The above results indicate that WPPCL2008 will reduce ROA of manufacturing industries and there is no possibility of the win-win situation in which both a better environmental quality and firm ROA can coexist.

Table 3. Effects of WPPCL2008 on EMPLOYMENT

Variable	Model 1(OLS)	Model 2(OLS)	Model 3 (PCSE)	Model 4 (PCSE)
dt×du	-0.003	-0.013**	-0.006	-0.002
	(0.773)	(0.017)	(0.512)	(0.767)
dt	0.074***	0.121***	0.088***	0.118***
	(0.000)	(0.000)	(0.000)	(0.000)
du	-0.020	-0.013	-0.015	-0.020***
	(0.598)	(0.601)	(0.633)	(0.001)
SIZE		-0.023***		-0.023***
		(0.001)		(0.000)
GROWTH		0.015		0.004
		(0.252)		(0.863)
COST		0.665***		0.664***
		(0.000)		(0.000)
C	0.116***	0.101***	0.117***	0.103***
	(0.000)	(0.000)	(0.000)	(0.000)
Industry dummy	Yes	Yes	Yes	Yes
Time dummy	Yes	Yes	Yes	Yes
R-square Industry	0.2599 37	0.7179 37	0.4017 37	0.5804 37
Observations	333	333	333	333

Note: Figure in parentheses are P-values.
* Significance at 10% levels; ** Significance at 5% levels; ***Significance at 1% levels.

Table 4 displays the estimates obtained using EMPLOYMENT as the dependent variable. Estimates in columns (1)-(2) in Table 3 are obtaining by OLS, showing that the estimated coefficient for *dt*×*du* are significantly negative when we include no control variables in regression equation (column 1 in Table 3), however the estimated coefficient for *dt*×*du* is insignificantly negative with control variables included (column 2 in Table 3). When we further utilize PCSE to correct the regression equation (columns (3) and (4) in Table 3), we also find that the estimated coefficients for *dt*×*du* are still negative but not significant, implying that WPPCL2008 has a negative effect on employment level of China's manufacturing industries, although the effect shown above is not significant. The estimate results suggest that WPPCL2008 can restrain employment of water pollution-intensive industries, although the effect is not significant.

Why does WPPCL2008 has a positive influence on total labor productivity rather than ROA for water pollution-intensive sectors in China? The intuitive explanation is that China's water pollution-intensive sectors do indeed engage in innovation-based solutions including both technological and organizational changes that increase a firm's resource efficiency to meet the requirements of environmental regulations, which in turn will improve the total labor productivity. On the other hand, stringent environmental regulations urge the firms to divert investment in profitable asset from productivity to abatement to achieve pollution reduction targets, which may lead to reduction for firm ROA. Furthermore, why does WPPCL2008 has an insignificant negative influence on employment level for water pollution-intensive sectors in China? The main reason is that new environmental legislation effectively restrains expansion of waste water intensive firms, resulting in the decline in the annual average number of employed personnel.

Table 4. Effects of WPPCL2008 on EMPLOYMENT

Variable	Model 1(OLS)	Model 2(OLS)	Model 4 (PCSE)	Model 3 (PCSE)
dt×du	-0.057**	-0.054	-0.026	-0.012
	(0.039)	(0.216)	(0.460)	(0.831)
dt	0.642***	-0.224**	0.637***	0.156***
	(0.000)	(0.050)	(0.000)	(0.003)
du	-0.097	-0.078	-0.120	-0.089**
	(0.765)	(0.510)	(0.294)	(0.032)
SIZE		0.286***		1.311***
		(0.000)		(0.000)
GROWTH		0.129**		0.162
		(0.015)		(0.054)
COST		-0.140		-0.650**
		(0.442)		(0.023)
C	4.106***	03.595***	4.090***	1.815***
	(0.000)	(0.000)	(0.000)	(0.000)
Industry dummy	Yes	Yes	Yes	Yes
Time dummy	Yes	Yes	Yes	Yes
R-square	0.7835	0.8148	0.9380	0.8967
industry	37	37	37	37
Observations	333	333	333	333

Note: Figure in parentheses are P-values.
* Significance at 10% levels; ** Significance at 5% levels; ***Significance at 1% levels.

The above results also imply that Chinese environmental legislations have significant influences on China's industrial performance. Although many papers prove the widespread under-enforcement of environmental regulations in China (Winalski, 2009; Beyer, 2006; Wang and Jin, 2007; Stokoe and Gasne, 2008), our study provides evidence on the effectiveness of the current environmental regulatory system in China, which contradicts existing views that China's current environmental legal system is not important (Allen et al., 2005).

5.2 Robustness Tests

In this subsection, we make comprehensive tests to check the robustness of our main results present in Table 2. Based on a differences-in-differences approach, we find WPPCL2008 has significantly improved total labor productivity of China's manufacturing industries. However, a differences-in-differences approach is based on the following premise – if there is no influence of WPPCL2008, the growth trend of industrial performance between treatment group and control group will not be systematically different with time. In this section, we will utilize a counterfactual test to examine whether the above premise is valid. Specifically, because WPPCL2008 only create incentive and constraint for waste water emissions, but will not affect waste gas and solid wastes emissions, so we can test the robustness of above estimate results with a differences-in-differences approach by examining the impact of WPPCL2008 on total labor productivity of waste gas intensive sectors (WGIS) and solid wastes intensive sectors (SWIS). If WPPCL2008 has no significant impact on the industrial performance of WGIS and SWIS, we can conclude that the estimate results with a differences-in-differences approach are robust.

First, we regard the manufacturing industries of which waste gas emissions per unit of output value exceed the average of total manufacturing industries in 2008 as WGIS and treatment group, other industrial sectors are treated as control group. The estimate results of regression equation (column (1)-(2) in table 4) indicate that the estimated coefficient for *dt×du* is not significant.

Second, we regard the manufacturing industries of which solid wastes emissions per unit of output value exceed the average of total manufacturing industries in 2008 as SWIS and treatment group, other industrial sectors are treated as control group. The estimate results of regression equation (column (3)-(4) in table 4) indicate that the estimated coefficient for *dt×du* is not significant too. The above results suggest that difference will not exist for the growth of total labor productivity without the impact from WPPCL2008 with time, justifying the robustness of the above estimate results with a differences-in-differences approach.

6. Concluding Remarks and Policy Implications

Based on a natural experiment of the Water Pollution Prevention and Control Law's revision in 2008 (WPPCL2008), this study investigates the impact of environmental regulations on industrial performance in China by using manufacturing industries' data from 2003-2011, and we derive interesting and important findings. WPPCL2008 significantly increase the total labor productivity of the water pollution-intensive industries, suggesting that the possibility of the win-win situation in which both a better environmental quality and firm total labor productivity can coexist, providing evidence for the so-called Porter hypothesis. However, there is no evidence to support an ROA-inducement effect for industries brought about by WPPCL2008. It indicates that WPPCL2008 has different impact on China manufacturing industries' total labor productivity and

Table 5. Effects of WPPCL2008 on LABOR: Counterfactual Test

Variable	Treatment group: WGIS		Treatment group: SWIS	
	(1)	(2)	(3)	(4)
du×dt	0.098	0.072	0.168	0.165
	0.396	0.573	0.183	0.185
du	0.355	0.335	-0.306	-0.174
	0.002	0.001	0.124	0.321
dt	1.159	1.1005	1.126	1.174
	0.000	0.000	0.000	0.000
Control variables	NO	YES	NO	YES
Industry dummy	YES	YES	YES	YES
Time dummy	YES	YES	YES	YES
R-square Industry	0.9933 37	0.9659 37	0.9976 37	0.9946 37
Observations	333	333	333	333

Note: Same to Tables above.

ROA. A further examination of WPPCL2008 on employment level shows that new water pollution prevention and control law has an insignificant negative impact on the annual average number of employed personnel of water pollution-intensive industries. At the same time, this study provides evidence on the effectiveness of the current written environmental laws in China.

From the above analyses, this study derives two policy implications. First, environmental regulations have different impacts on various performance indices including ROA, total labor productivity and total employment. Thus, it is very necessary for the Chinese government to design differentiated and properly environmental regulation policies according to different performance indices of firms in Chinese industrial sectors. Second, the environmental written laws indeed are important in China. Therefore, the Chinese government should make the existing environmental laws to continue to play a positive role in preventing environmental pollution. Furthermore, the Chinese government should properly implement a series of major revisions to the various environmental laws in time according to environmental situation, giving firms more incentive to innovate to offset the costs of complying with environmental regulations and then lead to improved competitiveness.

Acknowledgements
This study was supported by the major program of national soft scientific research (2013GXS1D005) of Ministry of Science and Technology of China.

References

1. ALLEN F., QIAN J., QIAN M., 2005, Law, finance, and economic growth in China, in: *Journal of Financial Economics* 77, p. 57-116.

Appendix: **Table 6.** Composition of industry categories

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

Note: Industry *Mining of Other Ores* (SIC code 11) and *Utilization of Waste Resources* (SIC code 43) are omitted due to missing data.

2. ALLERS M.A., HOEBEN C., 2010, Effects of unit-based garbage pricing: a differences-in-differences approach, in: *Environmental and Resource Economics* 45, p. 405-428.
3. ALPAY E., BUCCOLA S., KERKVLIET J., 2002, Productivity growth and environmental regulation in Mexican and U.S. food manufacturing, in: *American Journal of Agricultural Economics* 84(4), p. 887-901.
4. BARBERA A.J., MCCONNEL V.D., 1990, The impact of environmental regulations on industry productivity, in: *Journal of Environmental Economics and Management* 18, p. 50-65.

5. BERMAN E., BUI L. T. M., 2001, Environmental regulation and productivity: Evidence from oil refineries, in: *Review of Economics and Statistics* 83(3), p. 498-510.
6. BEYER S., 2006, Environmental law and policy in the People's Republic of China, in: *Chinese Journal of International Law* 5, P. 185-211.
7. BLOOM M., MILKOVICH G., 1998, Relationships among risk, incentive pay, and organizational performance, in: *Academy of Management Journal* 41(3), P. 283-297.
8. BODEN T., ANDRES J., MARLAND G., *Global, Regional, and National Fossil-Fuel CO2 Emissions*, CDIACenter, Oak Ridge, 2013.
9. BRUNNERMEIER S. B., COHEN M. A., 2003, Determinants of environmental innovation in US manufacturing industries, in: *Journal of Environmental Economics and Management* 45, p. 278-293.
10. CLIFT R., WRIGHT L., 2000, Relationships between environmental impacts and added value along the supply chain, in: *Technological Forecasting & Social Change* 65, p. 281-295.
11. COLE M., ELLIOTT R., 2005, FDI and the capital intensity of *dirty* sectors, in: *Review of Development Economics* 9(4), p. 530-548.
12. FINKELSTEIN S., BOYD B. K., 1998, How much does the CEO matter? The role of managerial discretion in the setting of CEO compensation, in: *Academy of Management Journal* 41(2), p. 179-199.
13. GOLLOP F. M., ROBERTS M. J., 1983, Environmental regulations and productivity growth: The case of fossil-fuelled electric power generation, in: *Journal of Political Economy* 91(4), p. 654-74.
14. GRAY W. B., SHADBEGIAN R. J., 2003, Plant vintage, technology, and environmental
1. regulation, in: *Journal of Environmental Economics and Management* 46(3), p. 384-40.
15. HAMAMOTO M., 2006, Environmental regulation and the productivity of Japanese manufacturing industries, in: *Resource and Energy Economics*. 28, p. 299-312.
16. JAFFE A. B., PERTERSON S. R., PORTNEY P. R., STAVINS R. N., 1995, Environmental regulation and international competitiveness: What does the evidence tell us? in: *Journal of Economic Literature* 93, p. 132-63.
17. JENKINS R., *Environmental Regulation and International Competitiveness: A Review of Literature and Some European Evidence*, UN University Institute for New Technologies 1998.
18. LANOIE P., PATRY M., LAJEUNESSE R., 2008, Environmental regulation and productivity: new findings on the Porter hypothesis, in: *Journal of Productivity Analysis* 30(2), p. 121-128.
19. LUKEN R., 1997, The effect of environmental regulation on industrial competitiveness of selected industries in developing countries, in: *Greener Management International* 19, p. 67-78.
20. KELLER W., LEVINSON A., 2002, Pollution abatement costs and foreign direct investment inflows to US states, in: *Review of Economics and Statistics* 84 (4), P. 691-703.
21. MA Z., XUE B., GENG Y., REN W., FUJITA T., ZHANG Z., DE OLIVEIRA J. P., JACQUES D. A., XI F., 2013, Co-benefits analysis on climate change and environmental effects of wind-power: A case study from Xinjiang, China. In: *Renewable Energy* 57, p. 35-42.
22. MANAGI S., OPALUCH J., JIN D., GRIGALUNAS T., 2005, Environmental regulations and technological change in the offshore oil and gas industry, in: *Land Economics* 81, p. 303-319.
23. MEP., 2014, 2013, *Report on the State of the Environment in China*, http://news.xinhuanet.com/live/2014-06/04/c_1110980565.htm.
24. PORTER M., VAN DER LINDE C., 1995, Toward a new conception of the environment-competitiveness relationship, in: *Journal of Economic Perspective* 9(4), P. 97-118.
25. STOKOE S., GASNE S., *China's Environmental Law Framework*. Pacific Business Press 2008.
26. TENG M. J., WU S. Y., CH S. J. H., 2014, Environmental commitment and economic performance, in: *Environmental Policy and Governance* 24, p. 16-27.
27. TOSI H L., WERNER S., KATZ J. P., GOMEZ-MEJIA L. R., 2000, How much does performance matter?, in: *Journal of Management* 26(2), p. 301-339.
28. WANG H., JIN Y., 2007, Industrial ownership and environmental performance: evidence from China, in: *Environmental and Resources Economics* 36(3), p. 255-273.
29. WINALSKI D., 2009, Cleaner water in China? The implications of amendments to China's law on the prevention and control of water pollution, in: *Journal of Environmental Law& Litigation* 24, p. 181-202.
30. XINHUANET, http://news.xinhuanet.com/
31. YANG C. H., TSENG Y. H., CHEN C. P., 2012, Environmental regulations, induced R&D, and productivity: evidence from Taiwan's manufacturing industries, in: *Resource and Energy Economics* 34(4), p. 514-532.