Analysis of Employment Effect of Environmental Regulation
Based on the Pilot Policy of SO_2 Emission Trading

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ABSTRACT
Taking the pilot policy of SO_2 emissions trading as a "quasi-natural experiment", based on the data of industrial companies in China's listed companies, propensity score matching--difference in differences (PSM-DID) is used to explore the causal relationship between market-oriented environmental regulation policies and enterprise employment. Studies have shown that the pilot policy of SO_2 emissions trading has significantly increased the employment of enterprises. A group test based on the perspective of enterprise ownership shows that the pilot policy of SO_2 emissions trading has significantly improved the employment level of state-owned enterprises, but the employment effect is not obvious for non-state-owned enterprises. Therefore, the government should formulate different environmental regulations for different types of enterprises to achieve a win-win situation of environmental protection and employment promotion.

Keywords: *the pilot policy of SO_2 emissions trading, employment, propensity score matching--difference in differences (PSM-DID)*

I. INTRODUCTION

At the same time as China's economy is developing rapidly, environmental problems are becoming more and more serious, especially SO_2 pollution emissions (Yan & Toshihiko, 2009). The 19th National Congress of the Communist Party of China points out that pollution discharge standards are raising, the responsibility of polluters is strengthening, and the construction of ecological civilization is promoting. In order to reduce pollution emissions, China has promulgated the Environmental Protection Law, Water Pollution Prevention Law and Air Pollution Prevention Law, etc., but the mandatory environmental regulation policy has not played a good role. China has become the country with the most SO_2 emissions (He, 2010). Facing the increasingly serious environmental problems, China began to try market-oriented environmental regulation policies, such as the pilot policy of SO_2 emissions trading. In 2007, 11 provinces (autonomous regions or municipalities) such as Hebei Province, Tianjin City, Jiangsu Province, Zhejiang Province, Shanxi Province, Hubei Province, Chongqing City, Shaanxi Province, Hunan Province, Inner Mongolia Autonomous Region and Henan Province implemented the pilot policy of SO_2 emissions trading. Emissions trading pilot policy improves environment and how will it affect the employment of enterprises. Therefore, it is necessary to pay attention to the employment effect of the SO_2 emissions trading pilot policy, and strives to achieve a win-win situation for environmental protection and enterprise employment.

Scholars have three opinions about the impact of environmental regulation policies on enterprise employment. One view is that implementing environmental regulation policies can improve environment, but increase the production cost of the enterprise, thereby reducing the scale of production and triggering a reduction in the labor demand of the enterprise (Berman & Bui, 2001; Lu Yang, 2011). Dissou and Sun (2013) used a general equilibrium framework to analyze the impact of carbon emissions on corporate employment. The results show that carbon emissions policies can reduce the level of corporate employment when the permit income is transferred once. Another view is that implementing environmental regulation policies can achieve a win-win situation for environmental protection and employment. Strengthening environmental regulation policies can promote the increase in labor demand of enterprises (Cole and Elliott, 2007). Kondoh et al. (2012) found that increasing the carbon emission tax can increase the employment rates. Another view is that the impact of environmental regulation policies on labor demand is uncertain (Bezdek et al., 2008). Yong W et al.(2013)

explored the employment effect of environmental regulation from the perspective of action mechanism. The size and direction of this effect depend on the production effect and demand effect.

In summary, the research about the impact of environmental regulations on labor employment is relatively mature, but the conclusions are mixed. Based on previous researches, this paper takes the pilot policy of SO_2 emissions trading in 2007 as a quasi-natural experiment, adopts the data of industrial companies of listed companies from 2002 to 2012, and uses PSM-DID to explore the employment effects of the pilot policy of SO_2 emissions trading.

II. EMPIRICAL DESIGN

A. Construction of PSM-DID model

1) Propensity score matching: When conducting propensity score matching, the sample companies are divided into two categories for research: one is the region that implemented the pilot policy of SO_2 emissions trading in 2007, called the experimental group; the other is the region that did not implement the pilot policy of SO_2 emissions trading, called control group. According to propensity score matching method proposed by Rosenbaum and Donald (1983), using variables such as the enterprise age (age), asset-liability ratio (lev), net fixed assets ratio (fixs), asset return ratio (roa), capital intensity (den) and cash ratio (cashratio) matched the experimental group and the control group of enterprises. These observable variables were matched using 2006 data.

The basic idea of propensity score matching is to find an enterprise j in the control group and make it as similar as possible to the observable variable of enterprise i in the experimental group. When the effect of implementing the pilot policy of SO_2 emissions trading depends on the observable variables of the enterprise, the probability of the enterprise j and the enterprise i implementing the pilot policy of SO_2 emissions trading is similar. The propensity score matching method calculates the propensity score based on the observable variables of the enterprise, and matches individuals in the experimental group and the control group with similar propensity scores.

2) Double difference method: The policy dummy variable is set after the processing of the propensity score matching. If the enterprise belongs to the experiment group then treat = 1, otherwise treat = 0. The time dummy variable is set. When the pilot policy for emissions trading was implemented, time = 1,otherwise time = 0. The empirical regression model based on the double difference method is as follows:

$$Size_{it} = \beta_0 + \beta_1 Treat_i * Time_t + \beta_2 Treat_i + \beta_3 Time_t + \theta X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

In equation (1), $Size_{it}$ represents the number of employees in the t-th year of the i enterprise. The coefficient of $Treat_i * Time_t$ measures the causal effect of the pilot policy of SO_2 emissions trading on the employment level of enterprises, which is the main concern of this paper. X represent the control variables, including enterprise age (age), asset-liability ratio (lev), net fixed assets ratio (fixs), return on assets (roa), capital intensity (den) and cash ratio (cashratio). μ_i represents individual fixed effect, λ_t represents time fixed effect, ε_{it} represents random disturbance. The definition of each variable is shown in "Table I".

Seen from formula (1), employments of the enterprises in the control group (treat = 0) before and after the implementation of the SO_2 emissions trading pilot policy are respectively β_0 and $\beta_0 + \beta_3$. Therefore, the difference in employment after the implementation of the policy by the control group enterprises is β_3. Employments of the enterprises in the experiment group (treat = 1) before and after the implementation of the SO_2 emissions trading pilot policy are respectively $\beta_0 + \beta_2$ and $\beta_0 + \beta_1 + \beta_2 + \beta_3$. Therefore, the difference in employment after the implementation of the policy by the experiment group enterprises is $\beta_1 + \beta_3$. So β_1 is the net effect of SO_2 emissions trading policy on enterprise employment. If the pilot policy of SO_2 emissions trading increases the employment of enterprises, then $\beta_1 > 0$.

TABLE I. VARIABLE DEFINITION

Names	Variables	Definition
Employment	$Size_{it}$	Natural logarithm of the number of employees
Policy dummy variable	$Treat_i$	Enterprises in the experiment group taking 1 and the rest taking 0
Time dummy variable	$Time_t$	Taking 1 in 2007 and later, and taking 0 for the rest
Enterprises' age	*age*	The natural logarithm after the current year minus the establishment year
Gearing ratio	*lev*	Ratio of total liabilities to total assets
Proportion of net fixed assets	*fixs*	Ratio of net fixed assets to total assets
Asset return ratio	*roa*	Ratio of net profit to total assets
Capital intensity	*den*	Logarithm of the ratio of fixed assets to the number of employees at the end of the year
Cash ratio	*cashratio*	Ratio of cash and cash equivalents to current liabilities

B. Data description

This article selects listed companies from 2002 to 2012 as research samples. Specific steps are as follows:

- Industrial enterprises belong to pilot areas or non-pilot areas;
- The exception enterprises are removed, such as ST and * ST enterprises;
- Enterprises with incomplete years are deleted;
- Imputation method is used to fill in individual missing values.

The data in this article comes from CSMAR. The descriptive statistical results of each variable are shown in "Table II".

TABLE II. DESCRIPTIVE STATISTICAL RESULTS

Variables	Number of samples	mean	Standard deviation	Minimum	Maximum
$Size_{it}$	7150	7.808	1.225	0.000	12.945
age	7150	2.398	0.439	0.693	3.526
lev	7150	0.616	1.798	0.007	96.959
fixs	7150	0.322	0.168	-0.206	0.881
roa	7150	0.022	0.362	-6.338	22.005
den	7150	13.793	0.969	9.719	19.978
cashratio	7150	0.387	0.942	-0.158	33.414

III. EMPIRICAL RESULTS AND ANALYSIS

A. PSM processing

According to the design of the previous chapter, the experimental group conducting PSM is a total of 185 enterprises in regions that implemented the pilot policy of SO_2 emissions trading in 2007. The control group is a total of 260 enterprises in regions that did not implemented the pilot policy of SO_2 emissions trading. First, logit regression is used to estimate the propensity score of observable variables; Secondly, Using the nuclear matching method determines the weight. Finally, the balance of the matched data is checked to ensure the effectiveness of the policy evaluation.

TABLE III. BALANCE TREND TEST

Variables	Unmatched	mean		bias	reduct |bias|	t-test
	Matched	treated	untreated	(%)	(%)	P value
age	Unmatched	2.317	2.373	-18.8	77.2	0.022
	Matched	2.317	2.330	-4.3		0.631
lev	Unmatched	0.557	0.737	-9.2	87.2	0.315
	Matched	0.557	0.534	1.2		0.283
fixs	Unmatched	0.346	0.360	-8.4	52.6	0.305
	Matched	0.346	0.353	-4.0		0.658
roa	Unmatched	0.015	0.012	1.9	-146.1	0.835
	Matched	0.015	0.023	-4.6		0.340
den	Unmatched	13.673	13.701	-3.0	70.4	0.720
	Matched	13.673	13.664	0.9		0.918
cashratio	Unmatched	0.298	0.343	-6.3	83.8	0.478
	Matched	0.298	0.290	1.0		0.834

As shown in "Table III", the standardized deviation of the observable variables is less than 5% after matching the data. Compared with the data before matching, the P value of all observable variables is greater than 0.1, and there is not significantly different. In general, the distribution of different observable variables is more balanced in the experimental group and the control group, and the balance trend test is passed.

TABLE IV. COMMON SUPPORT TEST

	off support	On support	Total
Untreated	14	396	410
Treated	0	240	240
Total	14	636	650

In addition to the balance trend test, a "common support" test is also required.("Table IV") Both the experimental group and the control group are tested to see if the common support area is large enough to ensure the effectiveness of the matching. When the amount of enterprise employment is used as the result variable, the sample sizes of the experimental group and the control group in the common support domain are 240 and 396 respectively, then the sample sizes that do not fall in the common support domain are 0 and 14 respectively. Therefore, the common support domain of the experimental group and the control group is large.

B. Double difference estimation

After the nuclear matching, the samples of the supporting areas in the experimental group and the control group are used for double difference estimation, in order to obtain the average treatment effect of the environmental regulation policy. The results are shown in "Table V". If no control variables are added to the column(1) regression model, the double difference estimator coefficient is 0.079 and it is significant at the 1% level. If control variables are added to the column(2) regression model, the double difference estimator coefficient is 0.103 and it is significant at the 1% level. The results show that the pilot policy of SO_2 emissions trading has significantly improved enterprises' employment.

TABLE V. DOUBLE DIFFERENCE ESTIMATION

Variables	*Size*	
	(1)	(2)
*Treat*time*	0.079*** (0.003)	0.103*** (0.000)
age		0.391 (0.000)
lev		-0.130*** (0.000)
fixs		-0.337*** (0.000)
roa		-0.080*** (0.007)
den		-0.531*** (0.000)
cashratio		-0.181*** (0.000)
cons	7.698*** (0.000)	14.379*** (0.000)
Year	Yes	Yes
Firm	Yes	Yes
N	6996	6996
R^2(*Within*)	0.042	0.287

[a.] Note: *, **, and *** represent respectively 10%, 5%, and 1% significance levels, and the p-values are in parentheses. The following tables are the same.

C. Heterogeneity test

This section examines the effects of the SO_2 emissions trading pilot policy based on the type of enterprise ownership. The results of group regression are shown in "Table VI". State-owned enterprises are estimated in column (1) and (2). It can be seen that the coefficient(*Treat*Time*)of state-owned enterprises is significantly positive at the level of 1%. Non-State-owned enterprises are estimated in column (3) and (4).

It can be seen that the coefficient (*Treat*Time*)of non-state-owned enterprises is not significant. The implementation of the SO_2 emissions trading pilot policy will only affect the employment of state-owned enterprises, but not the employment of non-state-owned enterprises. The market-oriented environmental regulations issued by the state may be more effective for state-owned enterprises.

TABLE VI. HETEROGENEITY TEST

Variables	State-owned enterprises		Non-State-owned enterprises	
	(1)	(2)	(3)	(4)
*Treat*Time*	0.086*** (0.001)	0.089*** (0.000)	-0.032 (0.645)	0.072 (0.208)
age		0.448*** (0.000)		0.219 (0.244)
lev		0.230*** (0.000)		-0.148*** (0.000)
fixs		-0.438*** (0.000)		-0.524*** (0.002)
roa		0.077 (0.178)		-0.094** (0.021)
den		-0.443*** (0.000)		-0.713*** (0.000)
cashratio		-0.109*** (0.000)		-0.171*** (0.000)
cons	7.636*** (0.000)	12.881*** (0.000)	7.863*** (0.000)	17.350*** (0.000)
Year	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
N	5115	5115	1881	1881
R^2(*Within*)	0.087	0.284	0.016	0.359

IV. CONCLUSION

Based on the PSM-DID model, this article examines impact of the SO_2 emissions trading pilot policy on employment. The study finds that the SO_2 emissions trading pilot policy will significantly increase enterprise employment. The purpose of development is to improve and protect people's livelihood, and employment is the foundation of people's livelihood. At present, China's air pollution problems, especially SO_2 pollution, have caused widespread problems. Governments at all levels need to adapt to local conditions and plan related environmental regulations and policies in order to improve the environment and ensure employment. Therefore, the following suggestions are made.

Firstly, governments at all levels should adjust and optimize the industrial structure, encourage the development of green economy, and increase the proportion of tertiary industry. Optimizing the industrial structure can not only increase the efficiency of resource utilization, but also increase employment. Secondly, labor skills training should be strengthened. With the implementation of environmental regulation policies, the government, schools and enterprises jointly cultivate highly skilled personnel. Thirdly, appropriate environmental regulation policies are made according to the type of different enterprises. State-owned enterprises increase the intensity of environmental regulations gradually to force enterprises increase their level of innovation and achieve a win-win situation in environmental protection and employment. For non-state-owned enterprises, strict environmental regulations will lead to production cuts or even bankruptcy. Relevant government departments should provide appropriate financial and technical support to guide the transformation of non-state-owned enterprises. In short the implementation of appropriate market-oriented environmental regulation policies can stimulate enterprise employment.

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