Does Environmental Regulation Affect Economic Growth and Restructuring? Evidence from a Quasi-Natural Experiment in China

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***Abstract*—Our study is relevant to the large literature on pollution regulations, especially to the studies on developing countries. Previous studies in U.S. have found that tougher air pollution regulations resulted in substantial welfare losses. Some earlier studies in China focused on the environmental performance with the environmental monitoring by the government and showed some significant effect on the overall environmental quality over the monitoring periods (see Guo *et al*., 2017, Zheng and Kahn, 2013). This paper also complements the existing studies examining the effect of environmental regulations especially TCZ policy in China. Cai *et al*. (2016) finds that TCZ policy caused a decline in FDI in TCZ cities, and the effect is much stronger in more polluting industries. Hering and Poncet (2014) shows there is a relative fall in exports of both foreign and private firms in TCZ cities, while state-owned firms are less intensively affect. Our result shows a relative rise in GDP in TCZ cities, which suggests tougher environmental regulation increases the local GDP growth. This result partially supports the "Porter Hypothesis" that a well-designed environmental regulation can lead to a "win-win" situation of environmental quality and economic growth.**

***Index Terms*—Component, environmental regulation, economic growth, quasi-natural experiment, China.**

I. Introduction

There is a rising concern of the public and government on the further deterioration of environmental quality in developing countries which pay more attention to economic growth but less attention to environmental protection. The relationship between economic development and environmental quality has also long been one of the focuses of economic researchers. The environmental Kuznets curve (EKC) hypothesized that environmental degradation tends to get worse as modern economic growth occurs until average income reaches a certain point over the course of development, implying an "inverted U-shaped" relationship between economic growth and environmental pollution (Kuznets, 1955). Although this hypothesis fails to hold for all indicators of environmental degradation, some evidences have been found to support such an inverted U-shaped curve for some environmental health indicators, such as water and air pollution [1]. Statistical data also indicate that cities in industrializing countries are more polluted than those in industrialized ones, and the cities in industrialized countries became cleaner than they were decades ago. To investigate the potential effect of environmental regulation on economic growth, this paper utilizes the Two Control Zones (TCZ) policy implemented by the Chinese government in year 1998. A total of 175 cities among 380 prefecture-cities were targeted as TCZ cities and were set stricter regulations of SO_2 emission and acid rain. Thus, polluting industries in regulated cities would face extra pollution abatement cost. To address the potential endogeneity issue (e.g. reverse causality) and isolate the effect of environmental regulation, we treat TCZ policy as a quasi-natural experiment and conduct a difference-in-difference (DD) analysis to identify the effect of TCZ policy on economic growth by comparing the GDP growth of TCZ cities with non-TCZ cities before and after the policy. Our city-level DD estimation results suggest that tougher environmental regulations can induce faster economic growth.

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II. Literature Review

Over the past decades, the rapid growth in China has been accompanied with serious environmental issues and it is reported that China has become the world's largest greenhouse gas emission country. And the deterioration of China's environment was closely related with a lack of interest from subnational government officials, who found that enforcing environmental regulations detracted from their ability to provide regional economic growth [2]. Realizing the serious situation of environmental issues, Chinese central government has implemented a series of environmental regulations over the past decades in order to reduce environmental pollution. There are concerns that these tougher regulations would possibly slow down the economic growth.

With a growing concern over the air pollution problem, Chinese governments decided to take stricter measures. In 1995, the 1987 APPCL was amended, and one chapter about the regulation on air pollution and SO_2 emissions was included. More importantly, a new policy, namely the Two Control Zones (TCZ) policy, was proposed to prevent the air quality of those heavily-polluted areas from deteriorating further.

Timeline: In 1997, "The Request for Approval of the Proposal of Designation for Acid Rain Control Areas and SO_2 Pollution Control Areas" was issued by National Environmental Protection Bureau (NEPB) and sent to State Council for approval. In January 1998, the proposal was approved by the State Council (or the cabinet) in the

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document "The Official Reply of the State Council Concerning Acid Rain Control Areas and SO_2 Pollution Control Areas". It was then put into effect. Among a total of 380 prefecture-cities, 175 were designated as TCZ cities, accounting for 11.4% of the nation's territory, 40.6% of population, 62.4% of GDP, and 58.9% of total SO_2 emissions in 1995 [3].

Criteria: The two control zones comprise SO_2 pollution control zones and acid rain control zones. The NEPB began designating cities as TCZ cities in late 1995, based on several criteria. Specifically, a city was designated as a SO_2 pollution control zone if: (1) its average annual ambient SO_2 concentration was larger than the national Class II standard (i.e. 60 ug/m^3) in recent years; (2) its daily average ambient SO_2 concentrations exceeded the national Class III standard (i.e., 250 ug/m^3); or (3) its SO_2 emissions were significant. And a city was designated as an acid rain control zone if: (1) its average PH value of precipitation was equal or smaller than 4.5; (2) its sulfate deposition was above the critical load; or (3) its SO_2 emissions were large.

Enforcement: In the 1998 reply, the State Council also laid out the targets for environmental controls in TCZ cities in the short run (by 2000) and in the long run (by 2010). Specifically, by the end of 2000, \the sources of industrial SO_2 pollution should achieve the national standard of SO_2 emission. The total amount of SO_2 emission should be within the required amount. Ambient SO_2 concentrations in important cities should achieve the national standards. The acid rain in the acid rain control zones should be alleviated." By the end of 2010, "the total amount of SO_2 emission should be lower than that in 2000. Ambient SO_2 concentrations in all cities should achieve the national standards. The number of acid rain areas with average PH value of precipitation equal or smaller than 4.5 should be reduced significantly."

These new environmental regulations have generated significant improvement in air pollution control. In 2000, 102 TCZ cities achieved the national Class II standard of average ambient SO_2 concentrations and 84.3% of severely polluted firms achieved the target level of SO_2 emissions (China Environment Yearbook, 2001). The average growth rate of SO_2 emissions from industries and livelihood in TCZ cities from 2001 to 2006 was -6.5% (Annual Statistic Report on Environment in China, 2007). In 2010, 94.9% of TCZ cities had achieved the national Class II standard of average ambient SO_2 concentrations, with no city reporting values above the national Class III standard (Report of Ministry of Environmental Protection of the People's Republic of China, 2011). For more discussion on the e ectiveness of the TCZ policies [4], [5].

A key challenge of using TCZ policy as a quasi-natural experiment to investigate the effect of environmental regulation of GDP is that the designation of TCZ cities may be correlated with some unobserved determinants of GDP. Note that we employ city fixed effect in all the following regressions; hence, the relevant concern is whether the designation of TCZ cities is correlated with any pre-existing city trends, in particular, the time trend of GDP. Two facts presented in Section I.B may help relieve such a concern. First, the initiation of the TCZ policy and the designation of TCZ status were conducted by the central government and largely exogenous to lower-level (such as city) governments. Second, the designation of TCZ cities was based on several criteria, in particular past pollution levels (i.e., ambient SO_2 concentration value or the PH value of precipitation) and specific threshold levels, both of which could not be manipulated by city governments retrospectively.

III. Math

Our main firm data source is the China Economic Survey of 1995 and 2004, the most comprehensive firm census data, collect by National Bureau of Statistics. Since our analysis focus on the 2-digit industry level, we generate the gross output Y_{ict} of 2-digit industry i in city c of year t by aggregating the output y_{ijct} of all firms j in the industry in the same city.

$$Y_{ict} = \sum_j (y_{ijct})$$

Our first-step empirical analysis is designed to estimate the effect of TCZ regulations on GDP growth. To test this effect, we compare GDP growth in TCZ cities before and after the implementation of TCZ policy in 1998 with the change in non-TCZ cities in the same period. We estimate the following equation on our panel of GDP for 287 cities over 1992-2009

$$Y_{ct} = Y \cdot TCZ_c \times Post_t + \alpha_c + \delta_t + X'_{ct}\beta + \varepsilon_{ct}$$

where Y_{ct} is the logarithm of GDP per capita in city c at year t; TCZ_c is the a dummy for the city having been targeted by the policy in year 1998, i.e., $TCZ_c = 1$ if city c is a TCZ city and $TCZ_c = 0$ if city c is a non- TCZ city; Postt is the a dummy for year post 1998, the year the TCZ policy was implemented. It takes the value 0 for the years 1992-1997 and 1 for the years 1998-2009. c are city fixed effects, capturing city c's all time-invariant characteristics, such as geographic features, climate, natural endowment, etc. t are year fixed effects, capturing all yearly factors common to all cities such as business cycle, monetary policy, macro shocks, etc.; and E_{ct} is the error term. We also in the baseline estimation control for many other potential determinants of GDP, $X_{ct,}$ to isolate the effect of environmental policy. These controls include education (i.e., number of college students and number of high school students), infrastructure (i.e., number of telephone and road density), economic growth, and market size (i.e., industrial production and retail consumption).

IV. Empirical Results

In our city-level GDP analysis, our main coefficient of interest is that on the double interaction term r which captures the effect of TCZ policy on GDP growth. The estimation results of equation above are presented in TABLE I, column 1 reports the estimation result with only city and year fixed effect. Columns 2 to 6 present robustness test with other control variables and TCZ city determinants discussed in previous section. We find that the coefficients on the double interaction term TCZ_c X Postt remain positive and statistically significant, suggesting that TCZ cities have higher GDP growth when comparing to non-TCZ cities after the policy implementation. Therefore, this result supports the

hyperpiesis that well-defined tougher environmental regulations can a positive effect on GDP growth.

TABLE I: CITY-LEVEL GDP ANALYSIS_A

DV：GDP_PC(log)	(1)	(2)	(3)
TCZ*POST	0.066*	0.068*	0.100***
	(0.038)	(0.037)	(0.036)
Fixed Assets		-0.039	
Investment/GDP		(0.024)	
Government Purchase/GDP		-0.078***	
		(0.025)	
Trade/GDP		-0.010	
		(0.013)	
College Stu/Population		0.128***	
		(0.021)	
FDI/GDP		0.004	
		(0.008)	
Post*TCZ designation			
Northern			√
Coastal			
Industrial Production			
Share of polluted industries			
Provincial capital city			
Special economic zone			
Old industry city			
City fixed effects	√	√	√
Year fixed effects	√	√	√
Observations	4256	3366	4240
R^2	0.781	0.827	0.786

Standard errors in parentheses
*p<0.1, **p<0.05, ***p<0.01

TABLE II: CITY-LEVEL GDP ANALYSIS_B

DV：GDP_PC(log)	(4)	(5)	(6)
TCZ*POST	0.104***	0.089**	0.079*
	(0.039)	(0.042)	(0.042)
Fixed Assets			-0.033
Investment/GDP			(0.023)
Government Purchase/GDP			-0.064**
			(0.025)
Trade/GDP			-0.021
			(0.013)
College Stu/Population			0.125***
			(0.021)
FDI/GDP			0.007
			(0.007)
Post*TCZ designation			
Northern	√	√	√
Coastal	√	√	√
Industrial Production	√	√	√
Share of polluted industries	√	√	√
Provincial capital city		√	√
Special economic zone		√	√
Old industry city		√	√
City fixed effects	√	√	√
Year fixed effects	√	√	√
Observations	4053	4053	3239
R^2	0.793	0.795	0.836

Standard errors in parentheses
*p<0.1, **p<0.05, ***p<0.01

Table I and Table II suggests that the environmental regulation is economically effective, however there still remains concern that whether the policy is effective on environmental quality. To further test the environmental quality change, we replace the left-hand side of second equation above to the city-level SO_2 emission level and the estimation results are presented in in Table III and Table IV.

We find that the coefficients on the double interaction term are negative and statistically significant, suggesting a relative higher decline of SO_2 emission in regulated cities than non-regulated cities which is consistent to Fig. 1. Huang *et al*. shows that environmental indicators, such as PM10, SO_2, are highly correlated, our further estimations on other environmental indicators yield similar results [6].

Results in previous sections have shown a positive effect of TCZ policy on GDP growth. However, Cai *et al.* finds that TCZ policy caused a decline in FDI in TCZ cities [7], and the effect is much stronger in more polluting industries. Hering and Poncet shows that there is a relative fall in exports of both foreign and private firms in TCZ cities [8]. To further explore the reason of such contrary growth, we further draw analysis on industry-level output.

Regression results of industry-level output are reported in Fig. 1. Column (1) are the DD estimation results of equation (2.3), the TCZ effect on average industrial output growth is captured by the coefficient on the double interaction term TCZc X Postt. This positive and significant coefficient suggests a faster average output growth for industries in TCZ cities, which is consistent with our estimation for the city GDP growth.

The coefficient on the triple interaction term TCZc X Postt X SO_2i shows whether there is a differential effect by different industry level pollution intensity. We find that the coefficient is negative and statistically significant, suggesting outputs reduce faster in more polluting industries in TCZ cities. Combined with the result that industrial outputs rises in TCZ cities on average in Column (1), we can further conclude that less polluting industries grows even faster in TCZ cities. And overall, the whole economy grew faster in regulated cities. Therefore, our results suggest that tougher environmental regulations induce a restructuring of economic composition in regulated cities and potential reallocation of results from more polluting industries to less polluting industries. Column (3) to Column (6) present some robustness check with di erent controls and TCZ designation determinants.

TABLE III: CITY-LEVEL SO_2 EMISSION LEVEL GDP ANALYSIS_A

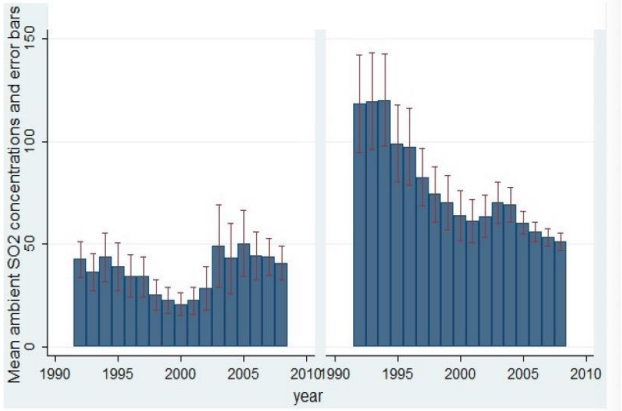
DV：GDP_PC(log)	(1)	(2)	(3)
TCZ*POST	-35.069***	-25.743*	-34.740***
	(8.884)	*	(8.037)
		(8.201)	
Fixed Assets		-8.122	
Investment/GDP		(5.166)	
Government		1.060	
Purchase/GDP		(3.951)	
Trade/GDP		1.525	
		(4.000)	
College Stu/Population		3.982	
		(5.510)	
FDI/GDP		-3.496*	
		(1.680)	
Post*TCZ designation			
Northern			√
Coastal			
Industrial Production			
Share of polluted industries			
Provincial capital city			
Special economic zone			
Old industry city			
City fixed effects	√	√	√
Year fixed effects	√	√	√
Observations	1439	1081	1423
R^2	0.254	0.205	0.262

Standard errors in parentheses
*p<0.1, **p<0.05, ***p<0.01

TABLE IV: CITY-LEVEL SO_2 EMISSION LEVEL GDP ANALYSIS_B

DV : GDP_PC(log)	(4)	(5)	(6)
TCZ*POST	-34.375***	-34.510**	-22.503**
	(7.867)	(7.982)	(8.514)
Fixed Assets Investment/GDP			-6.567 (4.839)
Government Purchase/GDP			-0.473 (3.881)
Trade/GDP			-1.307 (3.801)
College Stu/Population			1.728 (5.796)
FDI/GDP			-3.382 (1.942)
Post*TCZ designation			
Northern	√	√	√
Coastal	√	√	√
Industrial Production	√	√	√
Share of polluted industries	√	√	√
Provincial capital city		√	√
Special economic zone		√	√
Old industry city		√	√
City fixed effects	√	√	√
Year fixed effects	√	√	√
Observations	1407	1407	1060
R^2	0.307	0.320	0.262

Standard errors in parentheses
*p<0.1, **p<0.05, ***p<0.01



Plot of the mean and standard deviations for ambient SO2 concentrations (ug/m^3) in TCZ cities and non-TCZ cities

Fig. 1. DD estimation results of equation.

V. DISCUSSION ON MECHANISM

In the previous sections, we have identified a significant and positive effect of environmental regulation on average manufacturing output along with a negative effect on polluting industries. In this section, we provide some further evidence to shed light on the underlying mechanisms through which tougher environmental regulation may affect cities' industrial output. One potential reason is that environmental regulation may affect firms' location choices. The implementation of TCZ policy induces extra non-production cost to firm in polluting industries in regulated cities, therefore increases firms' the marginal production cost. Many studies argue that tougher environmental regulations will induce relocation of polluting industries from more to less regulated area due to the extra cost, however there is a general consensus that the extra environmental cost is relatively small share of production value for most sectors [8]. But environmental regulatory effect could be possibly crucial for the births of new firms, since these cost bigger sunk investment and limited turnovers in regulated cities. Many studies of the US Clean Air Act support these arguments, for example, Becker and Henderson (2000) finds that birth of new plants in polluting industries falls dramatically in regulated state, Ryan (2012) finds that the 1990 Amendments had no impact on the marginal (variable) costs of the Portland cement industry, but they made incumbent firms more competitive by increasing the average sunk costs of entry [9]. However early studies focus on the polluting industries only, since direct effect of tougher environmental regulation is direct and straightforward. We also would like to take clean industries into account, tougher environmental regulations would induce better environment quality, therefore the regulated cities would be more attractive for non-polluting firms.

VI. CONCLUSION

In this paper, we investigate the effect of tougher environmental regulations on economic growth. More specifically, we explore the question that whether well-defined environmental regulation and economics growth can achieve "win-win" situation. To control for potential endogeneity, we use China's Two Control Zones policy implemented in year 1998 as a quasi-natural experiment. Our identification of the effect of environmental regulation comes from a comparison of the outcome variable for TCZ cities with that for non-TCZ cities before and after the policy change.

By using the amount of GDP for 280 cities over the 1992-2009 period, we find that cities designated as TCZ have around 10% higher GDP growth than their non-TCZ counterparts. The results are robust to a series of robustness checks on the identifying assumption, along with other econometric concerns.

We also conclude that economic composition change is the main reason for GDP growth. using firm-level census data of year 1995 and 2004, we find significant fall of polluting sector in TCZ cities while a rise in in less polluting sectors comparing to non-TCZ cities. This result suggests an economic restructuring towards cleaner sectors forced by the policy. By further explore the mechanism, we show that locations of newly entered firms are significantly affected by the policy, contributes to the literature of environmental regulation on firms' location choices.

Lastly, we also present compilation change among three major industries, suggesting a "win-win" possibility between environmental regulation and economics growth through inducing a more environmental-friendly economy composition.

Conflict of Interest

The author Zewei Yao declares no conflict of interest.

Author Contributions

The author Zewei Yao had approved the final version.

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