Assessing Tax Revenue Implications of Environmental Policy: A Case Study of China's Channel City Policy

Yongwen Yang, School of Earth, Environmental, and Marine Sciences, University of Texas Rio Grande Valley, Email: yongwen.yang01@utrgv.edu

Juhee Lee, School of Earth, Environmental, and Marine Sciences, University of Texas Rio Grande Valley, Email: juhee.lee@utrgv.edu

Selected Paper prepared for presentation at the 2024 Agricultural & Applied Economics Association Annual Meeting, New Orleans, LA; July 28-30, 2024

Assessing Tax Revenue Implications of Environmental Policy: A Case Study of China's Channel City Policy

Yongwen Yang and Juhee Lee

Abstract

Recent studies suggest that while environmental policies yield positive environmental effects, they also incur costs for various entities. However, there is a gap in research regarding these policies' financial impact from the government's perspective. To investigate the extent to which government tax revenue is affected by environmental policies, we employ the Difference-in-Differences (DID) method to estimate the impact of a regional air pollution control policy in China known as the Channel City Policy on the tax revenue of city governments. Our findings indicate that the Channel City Policy (CCP) enhances air quality by reducing PM2.5, SO2, and NOx concentrations by more than 6%. However, it also results in significant tax revenue loss for regulated local governments of around 12%, approximately 1,282.7 billion CNY (equivalent to 189 billion USD). Furthermore, this policy leads to a 12% decrease in the number of new manufacturing entrants in the targeted industrial sectors and a 25% reduction in the profits of existing ones. These results highlight the need for additional fiscal support from the central government to regulate cities under regional environmental policies. Local governments need to find their bottom line to impose regulations without harming their fiscal health.

Keywords: air pollution, environmental policy, tax revenue, fiscal health, spillover effect

JEL Codes: Q51, Q52, Q53, Q58, H2

1. Introduction

As environmental pollution has become increasingly pressing in recent decades, many countries have implemented various environmental policies to address the challenge (Keiser and Shapiro, 2019; Wu et al., 2023). Recent studies indicate that while these measures yield positive environmental effects, they also incur direct and indirect costs for various entities, including residents (Meyer and Raff, 2023), industry companies (Wang et al., 2018), and labor markets (Walker, 2013; Liu et al., 2021) However, there is a lack of research investigating the financial impact of these policies from the perspective of governments and whether this impact varies based on regional characteristics.

Environmental policies can significantly affect an essential aspect of government revenue—tax revenue[1]—in specific regions, primarily in two ways. Stringent environmental policies with higher standards may discourage new or existing companies from operating in regulated zones, leading to a reduction in the tax base. Additionally, governments may experience tax losses when providing tax credits or deductions to incentivize companies to employ efficient abatement technologies or devices. In the context of government tax revenue losses or tax base erosion, prior literature has extensively examined the impact of profit shifting and optimal tax rate selection in economies (Amendolagine et al., 2021; Nerudova et al., 2023; Riedl and Becker, 2013). Nevertheless, there remains a research gap regarding government revenue losses attributed to environmental policies, warranting further investigation.

Excessive financial losses ultimately may lead to an unhealthy fiscal status, impairing the performance capabilities of governments. Furthermore, the financial burden caused by spatially

[1] Taking the USA and China as examples, according to the data from Tax Foundation and Chinese State Taxation Administration, the ratio of tax revenue to total income of government from 2015 to 2019 was 82.8%, 82.4%, 84.3%, 86.8% and 81.8% for the USA and 87.3%, 87.5%, 87.4%, 87.5% and 89.3% for China.

asymmetric environmental policies—only enforced in certain regions or with varying levels of imposition across regions—could potentially raise equity concerns for local governments. Therefore, it is crucial to ascertain whether governments experience financial losses through the implementation of environmental policies and to quantify these losses. This quantification holds heightened significance in China, given the fiscal system's emphasis on the role of local governments in economic development and public services and a substantial dependence on local governments for tax revenue.

To investigate the correlation between environmental policies and government tax revenue is affected by environmental policies, we estimate the impact of a regional air pollution control policy, the Channel City Policy (hereafter referred to as CCP), on the tax revenue of city governments, the administrative level at which the policy is implemented. Our dataset consists of three types of data from 2014 to 2021: city-level information on air pollution, meteorology and social characteristics, industrial and commercial registration data, and data from A-share listed companies.

After observing the significant spillover effect of pollution, China imposed cross-regional joint prevention and control policies to reduce pollution. The CCP, officially initiated by the central government of China in 2017 to improve air quality in the Beijing-Tianjin-Hebei region and its surrounding areas, serves as a representative policy. The policy is more suitable as an exogenous shock, given that the cities were selected solely based on their geographic location (Zhang and Zhao, 2023). The policy subjected 25 air pollution-intensive industrial sectors and sub-sectors in the "2+26" cities, including two centrally administered municipalities and 26 prefecture-level cities[2], to a new regulatory regime by creating a new class of pollution standards and strengthening existing standards. We initially employ Difference-in-Differences (DID) and negative binomial regression on three datasets to evaluate the CCP's impact on air quality and then estimate the tax revenue loss for city governments resulting from the policy.

The results of this study suggest that the CCP effectively improves air quality but also causes significant tax revenue loss to local governments. In the 28 cities where the policy was implemented, the concentration of air pollutants, including $PM_{2.5}$, (Sulfur Dioxide) SO_2, and (Nitrogen Oxides) NO_x, declined by more than 6% in the three years after the regulation. However, on average, every city experiences approximately a 9% decline in tax revenue each year following the introduction of the policy in these 28 cities. This amounts to approximately 1,282.7 billion CNY (equivalent to 189 billion USD)[3]. Furthermore, we find that environmental policies, such as the CCP, impact tax revenue by adversely affecting both potential and existing firms. This policy leads to a 12% decrease in the number of new manufacturing entrants in the targeted industrial sectors and a 25% reduction in the profits of existing ones.

Our study contributes to the existing literature in three ways. First, prior research on the cost of environmental policy has primarily focused on unemployment in the labor market or the productivity of manufacturing industries (Walker, 2013; Liu et al., 2021; Hancevic, 2016). For example, Walker (2013) finds that the Clean Air Act led to a 5% decline in average earnings for the workforce in the regulated sector. However, it is incomplete to interpret the effects of indirect costs without considering governments' benefits. To our knowledge, our study is the first research focused on approximating the potential cost of governments' revenue.

[2] Cities in China can be classified into two categories: centrally administered municipalities, which are directly governed by the Chinese central government and hold the administrative status of a province, and prefecture cities, which are governed by their respective provincial governments.
[3] We calculate the USD value using numerical average exchange rate from year 2018 to 2021, which is 6.79.

Second, our analysis extends the existing literature by highlighting environmental policy as a factor often overlooked when considering government tax revenue loss. Given the importance of tax revenue as a crucial tool to achieve redistribution and improve society's welfare, over the past three decades, a large number of studies examined the impact of corporate tax avoidance behaviors, such as profit shifting, on governments' tax-base loss (Beer et al., 2020; Fuest et al., 2022). These studies have shown that such behaviors significantly negatively affect tax revenue. Additionally, Mardan and Stimmelmayr (2018) experimentally analyzed the relationship between the switching from a system of separate accounting to formula apportionment. Besides these straightforward factors, we find evidence that environmental regulation could unintentionally put local governments in unfavorable positions that suffer from lower tax revenues. Clarifying the cost of environmental policy is also helpful for policymakers to find their bottom line of implementing environmental protection and related tax credit policy without compromising fiscal health. This is especially important for developing countries that face the challenges of balancing environmental conservation and economic growth.

Third, this study can also provide insight into whether it is necessary for the central government (or federal government) to offer more fiscal subsidies to areas with more stringent environmental regulations and how much the value should be. Pilot policies or other policies that are only in place enable policymakers to test the effect of new policies in a preliminary manner, but they can also raise fairness issues when there is a cost for local government in the field of externalities such as environmental protection. As we illustrate, the CCP improves air quality, benefiting the entire surrounding area or the entire country, but only these 28 cities bear the tax losses due to the relatively strict environmental policy.

In the subsequent sections, we delve deeper into these aspects. Section 2 outlines the

CCP, while Section 3 presents the data and econometric models used. Section 4 evaluates the impact of the CCP on air pollution and provides empirical evidence regarding its effect on local governments' tax revenue. Following this, Section 5 examines two potential mechanisms through which environmental policy influences tax revenue. Finally, Section 6 concludes with remarks and policy implications.

2. Policy Background

Since 2003, China has sought to achieve a balance between economic growth and environmental sustainability (He et al., 2020). To this end, a series of environmental policies were introduced, including the Two Control Zones Policy (Hering and Poncet, 2014; Cai et al., 2016), the carbon market pilot policy (Bai et al., 2023), and the environmental protection tax (Wang and Ye, 2023). Despite improvements in the overall environment due to these policies, China still grapples with regional pollution, notably in areas like Beijing-Tianjin-Hebei, stemming from long-term intensive industrial emissions and winter central heating. In response, China has implemented cross-regional joint prevention and control policies to address regional pollution and its spillover effects.

Due to its significant political implications, China has devoted considerable efforts to mitigating air pollution in Beijing and its surrounding areas, with the CCP representing one of these initiatives. In March 2017, the Chinese central government outlined primary air pollution sources, as depicted in **Figure 1**, encompassing 2 centrally administered municipalities and 26 prefecture-level cities (refer to them all as cities for simplicity).

Figure 1. Target cities of channel city policy. The 28 cities are presented in red. The 2 centrally administered municipalities are Beijing and Tianjin. Another 26 cities located in four provinces, Taiyuan, Yangquan, Changzhi and Jincheng in Shanxi province, Zhengzhou, Kaifeng, Anyang, Hebi, Xinxiang, Jiaozuo, Puyang in Henan province, Jinan, Zibo, Jining, Dezhou, Liaocheng, Binzhou, Heze in Shandong province, Shijiazhuang, Tangshan, Langfang, Baoding, Cangzhou, Hengshui, Xingtai and Handan in Hebei province.

In the context of CCP, special emission limits for SO_2, NO_x, and particulate matter were imposed on steel and coal-fired boilers starting from October 2017. Furthermore, more sectors, such as thermal power, petrochemical, chemical, non-ferrous metals and cement were incorporated into the regulated list in October 2018[4]. The special emission limit requires pollutant concentration to be around 50% lower or even lower than the general standards for unregulated sectors. Taking SO_2 as an example, the general emission standard is 100 μg/m3, whereas under the special emission limit, it is reduced to 30 μg/m3, indicating a 70% more stringent requirement.

[4] As of 2018, a total of 25 industrial sectors or subsectors were subject to these limitations. These included mining and ore processing, iron and steel sintering and pelletizing, ironmaking, steelmaking, steel rolling, ferroalloy production, coking, petroleum refining, petrochemicals, synthetic resins, caustic soda and polyvinyl chloride production, nitric acid production, sulfuric acid production, inorganic chemical production, aluminum production, lead and zinc production, copper, nickel, and cobalt production, magnesium and titanium production, rare earth element production, vanadium production, tin, antimony, and mercury production, regenerative copper, aluminum, lead, and zinc production, cement production, and boiler and thermal power plant operations.

The introduction and formulation of environmental policies by local governments are endogenous to their socio-economic factors, such as the unemployment rate, economic structure, and tax revenue. To address this concern, we employ the CCP to identify its impact on local governments' tax revenue for the following two reasons. First, the policy is formulated and executed by the central government, the highest-level authority, rather than local governments. Second, the selection of these cities is primarily informed by the examination of various objective factors, including the sources of pollution, characteristics related to transmission and diffusion, as well as geographic location and prevailing wind direction.

3. Data and Empirical Models

3.1. Empirical strategy

Our study exploits the quasi-natural experiment of the CCP for a DID estimation strategy to identify the influence of environmental regulation on local governments' tax revenue. Prior to that, we conducted a preliminary examination of the effectiveness of the CCP in pollution control. This step is essential, as the credibility of the policy's influence on tax revenue hinges on its actual impact on air pollution.

To be consistent with the administrative level at which the policy is implemented, we use annual data at the city level from 2014-2021 to assess the effectiveness of the CCP on pollution control for two reasons. First, the year 2014 was selected to mitigate potential bias caused by the introduction of an air pollution control regulation for certain cities by the Ministry of Ecology and Environment in February 2013. Second, the latest year of data on city characteristics we can obtain is 2021, which decided the last year in our sample.

Our baseline empirical specification is as follows:

$$Pollution_{i,t} = \alpha + \beta_1 Post_t \times Channel_i + \boldsymbol{\gamma}'\boldsymbol{Z_{i,t}} + \alpha_i + \alpha_t + \alpha_{p\times t} + \epsilon_{i,t}, \qquad (1)$$

where $Pollution_{i,t}$ is the concentration of three types of pollutants, $PM_{2.5}$, SO_2, and NO_x at year t in city i. $Post_t$ is a binary variable which equals 1 in year 2018 and after, and 0 in preceding years. $Channel_i$ denotes regulated cities, with a value of 1 assigned to city i if it belongs to the list of 28 regulated cities, and 0 zero otherwise. The matrix $\boldsymbol{Z_{i,t}}$ is a vector of controls, including the mean values of temperature, precipitation, humidity, wind speed, sun duration, and the second polynomial of these weather variables, in addition to GDP per capita and population density. We incorporate second-order polynomials of weather variables into our analysis to capture the nonlinear effects of them on air pollution (Chen et al., 2022). In addition, GDP per capita and population are essential factors for pollution emissions (Castells-Quintana et al., 2021; Andreoni and Levinson, 2001). Parameter α_i is city-fixed effect account for time-invariant variables including geographic location. The α_t is year-fixed effect to control factors common to all cities but differ by year, such as macroeconomic fluctuations. In addition, industrial emissions, comprising the largest share of air pollution, are influenced by local policies, industrial structure, and various input and output factors similar at the province level (Zhang and Zhao, 2023). To mitigate the impact of these factors, we incorporate the province-year fixed effect, $\alpha_{p\times t}$. The variable $\epsilon_{i,t}$ is the error term.

Then, we turn to the core part of our research, the impact of environmental policy on local governments' tax revenue. Tax revenue encompasses 12 types of lawful taxes, such as value-added tax (VAT)[5], corporate income tax, individual income tax, environmental protection tax, and others. Among them, VAT shares the biggest part of the tax revenue in both local and the central government in China. According to data at the central government level, the ratios of

[5] Unlike general VAT, there is special rules for calculating VAT payments when involving imports and exports. Thus, we only consider domestic VAT where both input and output occur within China.

VAT to total tax revenue from 2014 to 2021 were 25.7%, 24.9%, 31.2%, 39.1%, 39.3%, 39.5%, 36.8% and 36.8% respectively.[6] Notably, there was a significant increase in the ratio from 24.9% in 2015 to 31.2% in 2016. The notable shift can be attributed to the fiscal reform initiated in May 2016 across all industries in China, replacing the business tax with a VAT, thereby broadening the tax base of the VAT[7]. Consequently, to mitigate bias stemming from this fiscal reform, our core specifications utilize a truncated dataset spanning from 2016 to 2021.[8] In regard to the econometric model, we change the dependent variable to the logarithm of VAT amount to examine the impact of environmental policy on local governments' tax revenue:

$$Tax_{i,t} = \alpha + \beta_2 Post_t \times Channel_i + \boldsymbol{\delta}' \boldsymbol{X_{i,t}} + \alpha_i + \alpha_t + \alpha_{p\times t} + \epsilon_{i,t}, \quad (2)$$

where $Tax_{i,t}$ denotes the log of VAT amount. $\boldsymbol{X_{i,t}}$ represents control variables, which are GDP per capita, local government fiscal expenditures, the GDP of the industrial sector, and the number of above-scale manufacture[9], and area. The fiscal expenditures of local governments play a vital role in developing infrastructure, providing essential public services, and supporting citizens' welfare, all of which are integral components of business strategy and crucial for the growth of companies, as well as for generating tax revenue for the local government (Gurdal et al., 2021). We include the GDP of the industrial sector to mitigate the influence of industrial structure on tax revenue. In China, there are three VAT tax rates: the highest rate of 13% applies to most goods, including manufacturing, processing, and trading activities; a reduced rate of 9% applies to agricultural products, newspapers, and other cultural and educational items; and a 6%

[6] The second largest tax resource is corporate income tax, with share ratios of 2014 to 2021 were 20.1%, 21.7%, 22.1%, 22.2%, 22.6%, 23.6%, 23.6% and 24.3% from 2014 to 2021.
[7] The Business Tax is levied on the revenue generated from business activities, while VAT is applied to the value added at each stage of production or distribution.
[8] For the sake of robustness, we also perform the specification (1) with timeframe 2016-2021 to ensure the consistency with specification (2). Results can be found in **Table A1 in Appendix**.
[9] Above-scale manufacturing firm refers to industrial enterprises with an annual main business revenue of over 20 million CNY (or 2.9 billion USD).

rate applies to financial services and most other services. The variable number of above-scale manufacturing firms is used to indicate the business environment in each city, as it reflects various factors such as the ease of doing business, access to resources, infrastructure, and workforce skills, all of which play essential roles in shaping the overall business environment to a significant extent. The area represents the size of the city. The larger the area, the greater its capacity to accommodate companies, thereby generating more tax revenue. Other variables remain the same as equation (1). In this estimation, we also control province-year fixed effects, $\alpha_{p\times t}$, to address the possibility that there are province-specific economic conditions or policy changes.

3.2. Data description

To examine the efficacy of the CCP and its impact on local governments' tax revenue, we use various types of data for empirical analysis, which are briefly described here. Datasets are organized at the city level, aligning with the administrative level at which the policy is implemented.

In the context of investigating the environmental outcome of CCP, the air quality data is constructed from the China National Environmental Monitoring Centre (CNEMC), a widely used dataset in environmental research (Xie and Yuan, 2023). This dataset encompasses various air quality indicators, including the concentrations of $PM_{2.5}$, PM_{10}, SO_2, and NO_x, collected from 1436 monitoring stations across 338 cities in China. To get the city-year level data, we first calculate the annual average and then further average it at the city level.

The weather data are derived from the China Meteorological Data Sharing Service System (CMDSS). This dataset includes daily average temperature, precipitation, wind speed, sunshine duration, and relative humidity by 820 weather stations. Similar to the process we use for air pollution data, we restructure the weather data at the city-year level for analysis.

The dataset we used to test the CCP effect on tax revenue is structured in two parts: VAT revenue and data used to describe the socio-economic development. These two parts are collected from various sources, including the *China City Statistical Yearbook*, *China Statistical Yearbook for Regional Economy*, and the statistical yearbook at the local government level. These yearbooks are either released by the National Bureau of Statistics of China (NBSC) or local government authorities. We dropped samples from the Xinjiang and Tibet provinces for all the datasets because of missing values. The final dataset covers 285 cities in 29 provinces.

3.3. Variables definitions and summary statistics

Variables in our study can be categorized into four classes: (1) *Panel A: Air pollution indicators*—We use the logarithm of PM2.5, SO2, and NOx concentration values as indicators. (2) *Panel B: Weather information*—This category includes wind speed, precipitation, sun duration, humidity (relative humidity), and temperature, all calculated based on average values. (3) *Panel C: Tax revenue*—To represent local governments' tax revenue, we employ the logarithm of the VAT amount. (4) *Panel D: City characteristics*—We consider various city characteristics. Specifically, GDP per capita *is* represented as the logarithm of GDP per capita. Population density is calculated as the number of total populations divided by area. GDP of the industrial sector is the logarithm of GDP contributed by the industrial sector. The number of above-scale manufacture is the logarithm of number of industries with annual main revenue over 20 million. Area equals the logarithm of city size and fiscal expenditure takes the logarithm of public expenditure by local government in sectors such as education, healthcare and science.

As a result of the tax reform we mentioned earlier, the timeframes for a sample to evaluate the effectiveness of the CCP and its impact on tax revenue are 2014-2021 and 2016-2021, respectively. We utilize the city code to match and organize all datasets to panel data format. **Table 1** shows the summary statistics for variables involved in benchmark analysis.

Table 1: Summary statistics.

Variable	N	Mean	SD	Min	Max
Panel A: Air pollution indicators					
$PM_{2.5}$ [μg/m^3]	2,277	3.69	0.41	1.97	4.59
SO_2 [μg/m^3]	2,277	2.70	0.64	0.73	4.23
NO_x [μg/m^3]	2,277	3.33	0.36	1.61	4.00
Panel B: Weather					
Wind speed [m/s]	2,277	17.66	3.13	9.19	29.94
Wind speed square	2,277	321.79	119.33	84.53	896.19
Precipitation [mm per month]	2,277	87.97	47.62	5.91	206.23
Precipitation square	2,277	10,004.87	9,870.58	34.97	42,532.29
Sun duration [hours per day]	2,277	5.44	1.35	3.24	8.13
Sun duration square	2,277	31.41	15.10	10.54	66.02
Humidity [%]	2,277	0.69	0.10	0.39	0.84
Humidity square	2,277	0.49	0.14	0.16	0.70
Temperature [Centigrade]	2,277	14.49	5.25	0.76	25.14
Temperature square	2,277	237.49	144.45	0.57	632.21
Panel C: Tax revenue—VAT					
VAT [100 billion CNY]	1,507	8.12	1.08	4.87	10.02
Panel D: City Characteristics					
GDP per capita [billion CNY]	2,277	10.84	0.52	9.22	12.29
Population density [people per 100 m^2]	2,277	0.043	0.04	0.01	0.32
GDP of industrial sector [billion CNY]	1,507	15.88	0.99	13.11	17.59
Number of above-scale manufacture	1,507	6.67	1.08	3.04	9.47
Area [Square kilometer]	1,507	9.31	0.73	7.28	10.65
Fiscal expenditure [100 billion CNY]	1,507	10.52	0.61	7.79	11.64

4. Assessing the Effectiveness of the CCP and its Impact on Tax Revenue

4.1. Effectiveness of the CCP

We first check if the CCP imposes effective constraints on emissions within regulated sectors following the equation (1) specification. The results of $PM_{2.5}$, SO_2, and NO_x are reported in columns (1)-(3) in Panel A of **Table 2**, with robust standard errors clustered at the city level, and all control variables and fixed effects are included. The coefficient of our interest, β_1, is significantly negative and suggests that the average yearly emission of pollutants in the regulated cities decreases. Specifically, $PM_{2.5}$, SO_2, and NO_x were reduced by 8.0%, 9.7%, and 6.4% compared to unregulated cities. It implies that CCP has a real impact on industrial activities and results in reducing air emissions.

To validate the estimation, we further perform the parallel trend analysis to compare the time trends of regulated and unregulated cities on air pollution before and after CCP. This estimation also enables us to capture the dynamic effects of CCP. The specification is used as follows,

$$Pollution_{i,t} = \alpha + \sum_{\tau=-4(\tau\neq-1)}^{3} \beta_\tau Year_\tau \times Channel_i + \boldsymbol{\gamma}'\boldsymbol{Z}_{i,t} + \alpha_i + \alpha_t + \alpha_{p\times t} + \epsilon_{i,t}, \quad (3)$$

where $Year_\tau$ is a dummy variable denoting $|\tau|$ year after (if $\tau > 0$) or before (if $\tau < 0$) year 2018 ($\tau = 0$). We drop the year 2017 (where $\tau = -1$) as the baseline comparison group. The coefficient β_τ capture the difference in air emissions between regulated and unregulated cities over time. Other variables remain the same as specification (1). The results are presented in Panel B of Table 2. It is clear that air pollution was not statistically different between regulated and unregulated cities prior to 2018, suggesting a shared emission trend between the two groups of cities. Following the release of the CCP, regulated cities witnessed a sustained and improved decrease in air pollution compared to their unregulated counterparts, suggesting that the observed reduction can be attributed to the implementation of the CCP.

Table 2: The effect of CCP on air pollution and dynamic effects.

Panel A: Total effect			
	(1) $PM_{2.5}$	(2) SO_2	(3) NO_x
Post × Channel	-0.080***	-0.097**	-0.064***
	(-3.138)	(-2.499)	(-2.704)
Constant	2.733**	2.811*	3.141***
	(2.340)	(1.764)	(3.628)
Observations	2,277	2,277	2,277
R-squared	0.823	0.888	0.847
Panel B: Dynamic effect			
	(1)	(2)	(3)

	$PM_{2.5}$	SO_2	NO_x
$Year_{2014}$ × Channel	0.018	-0.047	-0.065
	(0.358)	(-0.713)	(-1.363)
$Year_{2015}$ × Channel	-0.000	-0.015	0.026
	(-0.007)	(-0.338)	(0.995)
$Year_{2016}$ × Channel	0.033	0.027	0.010
	(1.470)	(0.818)	(0.575)
$Year_{2017}$ × Channel	-	-	-
	-	-	-
$Year_{2018}$ × Channel	-0.061***	-0.083**	-0.050**
	(-2.849)	(-2.589)	(-2.582)
$Year_{2019}$ × Channel	-0.072**	-0.097**	-0.052**
	(-2.393)	(-2.132)	(-2.370)
$Year_{2020}$ × Channel	-0.037	-0.100*	-0.055**
	(-1.058)	(-1.893)	(-2.133)
$Year_{2021}$ × Channel	-0.120***	-0.151**	-0.145***
	(-2.864)	(-2.029)	(-4.355)
Constant	2.859**	3.150*	3.573***
	(2.405)	(1.894)	(4.114)
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province-Year Fixed Effects	Yes	Yes	Yes
Observations	2,277	2,277	2,277
R-squared	0.824	0.888	0.848

Note: The dependent variable is the logarithm of the concentration of pollutants. Columns (1)-(3) pollutants are $PM_{2.5}$, SO_2 and NO_x. Post × Channel equals 1 for 28 regulated cities starting from the year 2018; otherwise, 0. Control variables encompass the annual averages of temperature, precipitation, humidity, wind speed, and sun duration, each with their second-order polynomial; additionally, population density and the logarithm of per capita GDP are included in two panels. City and year fixed effects and province-year fixed effects are controlled for three columns. In Panel B, we drop the variable $Year_{2018}$ × Channel to serve as a baseline comparison and avoid collinearity. Standard errors are clustered at the city level and reported in parentheses. ***, **, and * represent the significance level at 1%, 5% and 10%, respectively.

4.2. Tax revenue effect of the CCP

Our study exploits the quasi-natural experiment of the CCP for a DID estimation strategy to identify the influence of environmental regulation on local governments' tax revenue. Prior to that, we conducted a preliminary examination of the effectiveness of the CCP in pollution control. This step is essential, as the credibility of the policy's influence on tax revenue hinges on its actual effect on air pollution.

4.2.1. Baseline specification

After assessing the effectiveness of CCP, we now turn to the core part of our study, investigating the potential impact on local governments' tax revenue and exploring the mechanisms through which this representative environmental policy may cause damage. The baseline estimation is conducted according to equation (2), with the dependent variable being the log of the VAT amount.

Table 3 displays estimates of the CCP impact on local government tax revenue. Column (1) exclusively incorporates the independent variable, *Post* × *Channel*, while column (2) supplements this with additional control variables. Both columns control city, year, and province-year fixed effects. The estimated coefficients in two columns are found to be negative and statistically significant with clustering the error at city level for tax revenue. We take column (2) to make further explanation. The coefficient of *Post* × *Channel* in column (2) is around -0.093, and significant at a 1% level. This outcome suggests that the implementation of CCP results in approximately a 9.3% reduction in VAT for cities subject to regulation. This reduction holds economic significance as well. The mean value of VAT for regulated cities before the environmental policy was approximately 13,792.3 billion CNY. After CCP implemented, there is an average decrease of 1,282.7 billion CNY (equivalent to 189 billion USD) in VAT.

Table 3: The effect of CC policy on local governments' tax revenue.

	(1) VAT	(2) VAT
Post × Channel	-0.077**	-0.093***
	(-2.480)	(-3.144)
GDP per capita	-	-0.068
	-	(-0.922)

GDP of the industrial sector	-	0.204***
	-	(3.702)
Number of above-scale manufacture	-	-0.073**
	-	(-1.981)
Area	-	0.095
	-	(0.224)
Fiscal expenditure	-	0.263***
	-	(2.902)
Constant	8.130***	2.470
	(3,524.078)	(0.626)
City Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Province-Year Fixed Effects	Yes	Yes
Observations	1,507	1,507
R-squared	0.987	0.988

Note: To mitigate potential bias resulting from the fiscal reform at the beginning of 2016, which replaced the business tax with a VAT, the sample period associated with tax revenue spans from 2016 to 2021. Cities in the provinces of Xinjiang and Tibet have been excluded due to a large amount of missing value. The dependent variable is the logarithm of VAT amount. *Post* × *Channel* equals 1 for 28 regulated cities starting from year 2018; otherwise, 0. Estimation in column (1) only consists independent variable, *Post* × *Channel*, and fixed effects. While column (2) adds control variables based on previous column, including the logarithm of GDP per capita, logarithm of total output value of secondary industry, logarithm of number of the above-scale manufacturing firms, log of land area and local governments' fiscal expenditure. Standard errors are clustered at city level and reported in parentheses. ***, **, and * represent the significance level at 1%, 5% and 10%, respectively.

4.2.2. Validity of the baseline specification

To validate our conclusion derived from column (1) in Table 3, we conduct the following robust tests. First, as Zhang and Zhao (2023), we replace the variable *Post* × *Channel* with the interactions between the *Channel* and the full set of year dummies, which is similar to specification (3). In conducting the test, we designate two different years, 2017 and 2021, as comparison groups to perform the parallel trend test twice, respectively. We initially performed the parallel trend test by excluding the year immediately preceding the environmental policy, 2017. Subsequently, to fully investigate the pre-trend over the two-year timeframe before the CCP, we dropped the last year, 2021, as the baseline group. To have a concise presentation, we depict the coefficients in **Figure 2**. Figures in Panel A and Panel B correspond to the baseline years of 2017 and 2021, respectively.

The figure illustrates that, regardless of the selection of baseline year, the difference in VAT between regulated and unregulated cities was not statistically significant before the policy implementation. Subsequently, following the implementation of the CCP, the coefficient of *Post* $Year_t$× *Channel* exhibits statistical negativity. Additionally, Panel A in Figure 2 indicates that the policy's negative impact becomes statistically insignificant in the year 2021, the third year post-implementation. This suggests that the environmental policy does not have a long-term negative effect on the local government's VAT.

Panel A. Baseline Year: 2017	**Panel B. Baseline Year: 2021**

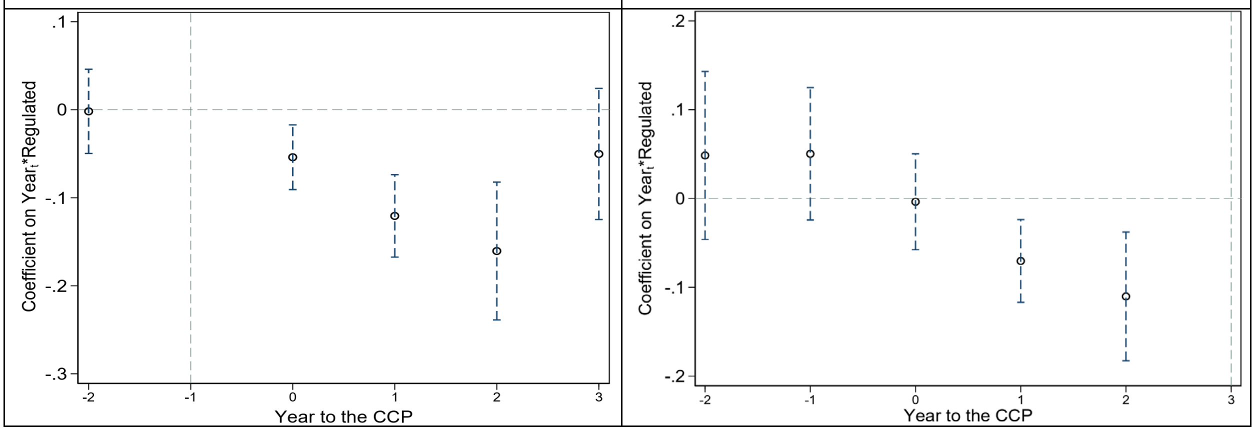

Figure 2: Parallel trend test. This figure illustrates the validity of our baseline DID regression. The horizontal axis shows the year before and after the CCP. The vertical axis shows the coefficients on the interaction variable, $Year_t \times Channel$. The years 2017 and 2021 are set as the base, respectively, and are not plotted in the figure.

4.2.3. Robustness checks

(1) Robustness check 1: calibration for estimating the effect of CCP on tax revenue

The environmental policy, CCP, is a regional policy that has only been implemented in 28 cities, meaning that only policy target industries in these cities are subject to regulatory control. In this scenario, policy-targeted industries may opt to relocate to unregulated cities to avoid additional complimentary costs (Wu et al., 2023). This cost-saving behavior of industries is the main concern of our research, as the decrease in tax revenue observed in regulated cities may be exacerbated by the relocation of industries, potentially leading to an increase in tax revenue for unregulated cities.

To address this concern, we employ two different approaches. Firstly, we use a shorter timeframe from 2016 to 2019 (one year after CCP was introduced). The reason behind this check is that the setting up of a typical manufacturing firm is time-consuming and involves multiple processes. It commonly requires land acquisition, equipment installation, and employee hiring in the new location, which may take a few years. Therefore, we truncate the timeframe to mitigate the potential impact caused by industrial relocation and subsequent tax revenue increase in unregulated cities caused by this factor. The result is presented in column (1) of Table 4. The coefficient of *Post* × *Channel*, -0.092, is slightly lower than the result in column (2) of Table 3, which is -0.093, but it remains statistically significant. This outcome aligns with our expectations that the longer period after the CCP's introduction does overstate the negative effect of environmental policy by around 0.1%. However, it does not alter our conclusion, given its minor magnitude.

The second method to avoid the influence of industrial relocation is excluding cities that are geographically close to regulated cities in samples. We define cities within one province as near areas. Taking Hebei province as an example, there are 11 cities in Hebei province in total, and 8 of them are under regulation. Therefore, we remove the remaining 3 unregulated cities from our control group. This is because relocating to unregulated cities within the same province is the most feasible way for industries targeted by the policy, as these geographically close cities are more likely to share input and output factors, such as transportation costs, raw material prices, and nature resources (Zhang and Zhao., 2023). Column (2) of Table 4 shows the results of removing nearby cities. The coefficient on *Post* × *Channel* is -0.086 and significant at the 1%

level, exhibiting a similar pattern to the coefficient in column (1), which is slightly lower than our baseline regression estimation but still consistent with our conclusion that environmental policy adversely affects the tax revenue of regulated cities.

(2) Robustness checks 2: variations in city administrative hierarchies

Our sample in baseline estimation (Column (1) in Table 3) includes two levels of city, centrally administered cities and prefecture cities. Four centrally administered cities in China enjoy the same administrative level, benefits, and development requirements as provinces, higher than prefecture cities. Thus, to structure a sample with completely comparative cities, we redo the baseline regression and exclude four centrally administered cities: Beijing, Tianjin, Shanghai, and Chongqing. The result is shown in column (3) of **Table 4**. The coefficient of our interest variable has the same statistical pattern as column (3) of **Table 3**.

(3) Robustness checks 3: concurrent events

Other concurrent events in the same timeframe may bias our estimation. We address this issue by taking two types of concurrent events. Firstly, we exclude the VAT deduction policy released at the beginning of 2019, which states that business incubators officially verified by governments are exempt from VAT. The number of incubators varies in different cities, which may impact total VAT revenue differently. To address this concern, we include an interaction term, $Exempt_t \times Incubator_{i,t}$, in the benchmark model. Variable $Exempt_t$ takes a value of 1 in year 2019 to 2021, and 0 otherwise. Another variable $Incubator_{i,t}$ represents the logarithm of the number of business incubators in each city i in year t. Table 3, specifically column (4), presents the estimated result. The coefficient of *Post* × *Channel* is -0.09, at 1% significant. There is no evident difference in magnitude and significance relative to our benchmark regression result, indicating that our baseline conclusion remains unbiased with respect to the VAT exemption policy introduced in 2019. Additionally, we observe that the coefficients of *Exempt*×*Incubator* are statistically negative, indicating a significant reduction in VAT revenue following the implementation of the exemption policy, which aligns with expectations.

The second type of concurrent policy is environmental policy or regulations. During 2016-2021, the most fundamental and influential change carried out in the environmental management field in China is an administrative reform system whereby environmental protection agencies below the provincial level come directly under the supervision of their respective provincial-level agencies in terms of environmental inspections and monitoring (refer to DUS, the abbreviation of directly under supervision). This reform transfers the authority to appoint city-level Environmental Protection Bureaus directors from city governments to the provincial level. This shift enhances the independence, enforcement, and monitoring capabilities of city-level Environmental Protection Bureaus by changing the previous arrangement, wherein environmental agencies were managed and supervised by the same level of government (Kong and Liu, 2024). We add a binary variable, *Dus*, to address this concern in the baseline model. The central government gradually initiated this administrative reform in 2016 and implemented it at the provincial level. As of 2021, all province and city governments operate under the new environmental management regime. Variable *Dus* takes a value of 1 for cities under *Dus*, and 0 otherwise. Column (5) in Table 2 shows the result. The coefficient of core variable *Post* × *Channel*, -0.09, is very similar to the baseline, which is restated in column (1) for comparison, indicating that our result is robust to the concurrent events.

It is noteworthy that the impact of DUS, another influential change in environmental management, does not significantly affect local governments' VAT revenue, in contrast to the CCP. The essential reason for this distinction lies in the regional scope of the DUS and CCP.

Different from the CCP, which is a regional regulation, *Dus* is clearly mandated by the central government, and as of 2021, environmental agencies across all regions in China are required to operate under this new regime, ensuring fair competition among local governments in terms of environmental regulations. This contrast highlights that only regional environmental policies or regulations have adverse effects on local governments' tax revenue, as they place regulated regions in a disadvantageous position.

(4) Robustness checks 4: avoid influence for replacing the business tax with a VAT

As mentioned earlier, the tax reform, which replaced the business tax with a VAT, began to be implemented across all industries in China starting in May 2016. The timeframe used in our baseline estimations presented in Table 3 is 2016-2021. To further avoid the potential impact caused by this tax reform, we adjusted the time window to 2017-2021 to perform the estimation. We present this result in column (6) in Table 4. The coefficient on the *Post* × *Channel* remains negative and statistically negative, indicating that our conclusion is very robust to considering this tax reform.

Table 4: Robustness checks.

	(1) VAT	(2)	(3)	(4)	(5)	(6)
Post × Channel	-0.092***	-0.086***	-0.088***	-0.094***	-0.093***	-0.079***
	(-3.017)	(-3.567)	(-2.922)	(-3.252)	(-3.144)	(-3.375)
Exempt × Incubator	-	-	-	-0.047***	-	-
	-	-	-	(-3.767)	-	-
Exempt	-	-	-	0.029***	-	-
	-	-	-	(2.621)	-	-
Dus	-	-	-	-	-0.011	-
	-	-	-	-	(-0.491)	-
Constant	4.655	2.144	2.626	1.625	2.484	6.918***
	(1.162)	(0.468)	(0.674)	(0.416)	(0.624)	(3.628)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Province-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,022	1,333	1,483	1,507	1,507	1,242
R-squared	0.991	0.988	0.988	0.988	0.988	0.990

Note: The dependent variable is the logarithm of the VAT amount. *Channel* equals one for 28 regulated cities and zero for unregulated cities. *Post* takes a value of one in the year 2018 and afterward zero for other years. Control variables encompass the log of GDP per capita, GDP of the industrial sector, number of the above-scale manufacturers, area, and local governments' fiscal expenditure. Samples in column (1) use a shorter time window, spinning from 2016 to 2019. Column (2) removes cities that are geographically close to regulated cities. Column (3) removes four centrally administered municipalities, Beijing, Tianjin, Shanghai, and Chongqing, which are at a higher administrative level than other cities. Columns (4) and (5) incorporate tax exemptions and DUS into consideration, which occurred during the same period as the research sample. Standard errors are clustered at the city level and reported in parentheses. ***, **, and * represent the significance level at 1%, 5% and 10%, respectively.

(5) Robustness checks 5: Placebo test

Aside from the above test, we are concerned our conclusion may derive from neglected or unobservable factors, such as city-level industry policies. To address this concern, we performed a placebo test with placebo-regulated cities and time under the specification (2) of the CCP 500 times. Suppose the coefficient on Channel is statistically negative, yet the tax revenue loss of local governments does not emerge as an effect of the CCP. In that case, the coefficient may still exhibit significance when considering placebo cities and implementation years. The result is presented in **Figure 3**. As the blue curve shows, the coefficient on *Post* × *Channel* is no longer significant with placebo samples, indicating that the CCP caused the decrease in VAT.

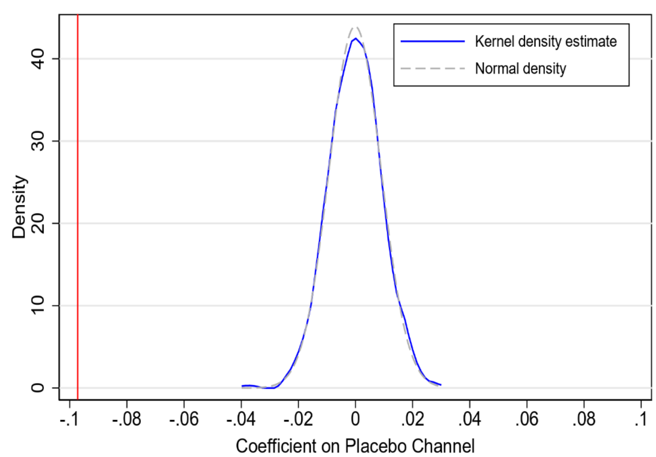

Figure 3. Placebo test. This figure illustrates the placebo robustness check. The solid blue curve line shows the coefficient on placebo *Post* × *Channel*. The vertical red line on the left side of the graph presents the coefficient on *Post* × *Channel* on baseline regression (column (1) in Table 3).

5. Potential Mechanisms on Environmental Policy How to Affect Local Governments' Tax Revenue

In Section 4, we posit that the presence of CCP undermines local governments' tax base. In this section, we shed light on the mechanisms through which the CCP influences tax revenue. We discuss two mechanisms along with new firm entrants and performance of existing firms.

5.1. Number of new firms

New entrants and their entrepreneurial activities are particularly important in economic development (Brandt et al., 2012). They also constitute a vital component of the local economy's taxpayers, evident in the local government's efforts to maintain an unreasonably low price for industrial land to attract new entrants and generate tax revenue (Song et al., 2020).

From the perspective of a new firm, the choice of location is integral to its business strategy, exerting significant influence on innovation investment, performance, and costs (Carosi, 2016). Apart from costs related to raw materials, transportation, and human resources comparable to those of other companies, industries with high pollution intensity also face additional concerns regarding environmental compliance costs (Jindal et al., 2024). These costs may manifest in expenditures for facility acquisition and installation, as well as penalties for emission violations. Consequently, manufacturers in pollution-intensive sectors often opt to invest in regions or counties with lax environmental regulations to avoid the expenses associated with pollution abatement (De Beule et al., 2022), a phenomenon commonly referred to as the pollution haven hypothesis (Cole, 2004). In summary, stringent environmental policies or regulations play a crucial role in deciding whether to invest in and establish a presence in specific cities for new firms, particularly those operating in sectors targeted by such policies.

Thus, we wonder if the implementation of environmental policies such as CCP prevents new firms in policy target sectors from entering regulated cities and induces a reduction in local governments' VAT tax revenue. To test this potential mechanism, we use firm registration data from the State Administration for Industry and Commerce of China (SAIC), widely used in studies focusing on the corporation and their activities (Cui and Li, 2023). According to the Company Law of the People's Republic of China, the establishment of a company requires applying for registration with the company registration authority. Additionally, companies are obligated to pay taxes to the government governing the respective region. The registration information consists of start year, province and city of location, industry classification (two-digital, three-digital, and four-digital), ownership, operating status, etc.

This dataset encompasses various types of businesses, including state-owned enterprises, collective enterprises, private enterprises, limited liability companies, and more. Among these businesses, the diverse nature of their operations results in varying contributions to VAT. For example, individual industrial and commercial businesses with monthly sales revenue not exceeding 100,000 CNY are exempt from VAT. Therefore, we initially exclude individual industrial and commercial entities, which typically make relatively minor contributions to VAT. Next, we organize the data spinning from 2016 to 2021 at the city, year, and two-digit manufacturing industry level. Finally, we compute the number of new firms in regulated sectors or sub-sectors for each city annually, contributing to this analysis's dependent variable.

As the number of entrants is a typical counting variable, we resort to Negative Binomial regression here. The detailed specification is:

$$Regulated\_entrant_{i,t} = \alpha + \beta_4 Post_t \times Channel_i + \boldsymbol{\sigma}'\boldsymbol{V_{i,t}} + \alpha_i + \alpha_t + \theta_{p\times t} + \epsilon_{i,t}, \quad (4)$$

where $Regulated\_entrant_{i,t}$ represent the number of new firms belonging to regulated sectors in city i in year t. Coefficient β_4 of core variable captures the difference of the number of new firms before and after the CCP in regulated and unregulated cities. $\boldsymbol{V_{i,t}}$ is a vector matrix contributing to control variables, including GDP per capita, population density, and logarithm number of existing firms. Other variables remain the same as equation (1).

Column (1) in Table 5 displays the results. The coefficient β_4 is statistically negative. This indicates that the 28 cities with stricter emission standards experienced fewer new firms in regulated sectors following the introduction of the CCP, potentially prompting a reduction in VAT.

We must acknowledge a concern regarding our conclusion, attributing the decline in VAT partly to the reduced presence of new firms in regulated sectors. The uncertainty arises from the possibility of more non-regulated businesses entering these 28 cities to benefit from improved air quality, which could offset the reduction of new firms in regulated sectors, which makes the overall influence of entrants on VAT revenue vague. Hence, we conduct a supplementary estimation by altering the dependent variable to the number of new firms in unregulated sectors. This aims to assess if there is a higher prevalence of new firms in unregulated sectors across the 28 cities compared to others. Column (2) of Table 4 presents the result. The coefficient of the core variable *Post*×*Channel* is positive but not statistically significant, suggesting that our previous conclusion was valid. The result also indicates that good air quality does not play a crucial role when businesses consider locations.

5.2. Performance of existing firms

To substantially improve air quality, the CCP imposed a hard constraint that manufacturing firms would cease production until they met special emission limitations. Especially in the winter season when central heating is operating, iron and steel industries must reduce their production by 50% compared to before the policy was introduced. With these harsh and explicit administrative commands, the production and sales of these pollution-intensive industries may be impaired. VAT is calculated by tax rate × (sales revenue excluding tax minus input VAT[10]). Given the VAT rate, the VAT of a firm is positively associated with its profit. Thus, we try to figure out whether the decline of local governments' VAT is partly driven by a reduction in firms' profit.

We employ data from China's A-share listed companies from 2016 to 2021 from the China Stock Market & Accounting Research Database (CSMAR) to test this assumption for two reasons. Firstly, due to the data available, only detailed financial data, such as profit and leverage of manufacturing companies, come from listed companies. Secondly, data from listed companies are more reliable because we collect data from annual financial statements that must be audited and verified by independent registered accounting firms. Notably, the negative impact of listed companies may be smaller compared with small-scale businesses. This is because listed companies, armed with strong financial resources, high technologies, and skilled workers, can afford efficient emission abatement facilities and educated workers to use them. To get the data ready for testing, we only keep data from industries affected by the CCP and remove data points with mass missing values. In this test, we follow the specification:

$$Profit_{c,t} = \alpha + \beta_5 Post_t \times Channel_i + \partial' W_{c,t} + \alpha_c + \alpha_t + \theta_{p\times t} + \epsilon_{i,t}, \quad (5)$$

where $Profit_{c,t}$ refers to the logarithm of the operating profit of manufacturing firm c in year t. We use operating profit to avoid the possible impact from other sources that are not regulated by the CCP. For instance, the profit generated from the transfer of intangible assets or leasing fixed assets. The meaning of $Post_t \times Channel_i$ remains the same. Matrix $W_{c,t}$ represents control variables, including leverage, Tobin Q value, logarithm of firm's age, return on equity, logarithm of total R&D expenditures, and state ownership status of the firm. Year and province-year fixed

[10] Input VAT is the VAT added to the price when firms purchase raw materials or services that are liable to VAT.

effects are controlled to keep consistent with previous estimations. We introduce firm fixed effects because this dataset is organized at the firm level, and standard errors cluster at the firm level as well.

Column (3) in Table 5 shows the effect of environmental policy, CCP, on the profit of existing firms. We observe -0.24862, which is statistically negative at 5%, indicating the implementation of the CCP reduced manufacturing's profit and could be an explanation for the reduction of VAT revenue.

Table 5. Mechanisms: number of new firms and sales of existing firms

	(1) Number of new firms in regulated sectors	(2) Number of new firms in unregulated sectors	(3) Profit
Post × Channel	-0.118***	0.021	-0.249**
	(-2.954)	(1.078)	(-2.025)
Constant	-1.953*	0.509	14.239***
	(-1.746)	(0.703)	(17.309)
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	-
Firm Fixed Effects	-	-	Yes
Year Fixed Effects	Yes	Yes	Yes
Province-Year Fixed Effects	Yes	Yes	Yes
Observations	2,210	2,210	4,537
(Pseudo) R-squared	0.264	0.256	0.875

Note: The first two columns show estimation results of the number of new firms, and the dependent variables of columns (1) and (2) are the number of new firms in regulated sectors and the number of new firms in unregulated sectors, respectively. Control variables are kept the same in two columns: GDP per capita, population density, and log of existing businesses. City, year, and province-year fixed effects are controlled. Standard errors are clustered at the city level and reported in parentheses. Column (3) is the result of the policy effect on the profit of existing firms. Control variables encompass leverage, Tobin Q value, logarithm of firm's age, return on equity, logarithm of total R&D expenditures, and state ownership status of the firm. Standard errors in column (3) are clustered at the firm level to align with the data structure. ***, **, and * represent the significance level at 1%, 5% and 10%, respectively.

6. Conclusions

We evaluate in this study the effect of a regional environmental policy or regulation on both air pollution and local governments' tax revenue by answering the following questions: (1) Does regional environmental policy or regulation has a positive effect on pollution control? (2)

Are there adverse effects of regional environmental policy on local governments' tax revenue? If so, what monetary value does this regulation entail? Furthermore, do these effects vary significantly across different cities? (3) What are the underlying mechanisms through which the environmental policy, CCP, influences tax revenue?

To answer these questions, by employing DID method with data structured from various sources in China, we find that the regional environmental policy, the CCP, does have a positive impact on the environment. The concentration of $PM_{2.5}$, SO_2, and NO_x decreased around 8%, 9% and 6%, respectively. Additionally, we find that it also causes a considerable tax loss, 1,282.7 billion CNY (equivalent to 189 billion USD), to local governments mandated to implement the environmental policy or regulation by the central government.

It is important to note that the tax loss estimation is conservative. This is because we merely take VAT into account, while many other types of tax, such as corporate income tax, can contribute to the reduction as well. Moreover, we identify two potential mechanisms for this tax loss. Environmental policy adversely affects tax revenue by negatively influencing potential and existing companies. Specifically, after the policy was introduced, the number of new companies in regulated sectors dropped by approximately 12%, and the profit of existing companies declined by about 25%.

Our research has explicit policy implications. Firstly, for local governments to voluntarily impose more stringent environmental policies or regulations, they must consider this potential tax loss when determining a threshold that safeguards their fiscal health. Secondly, concerning regional policies imposed by the central government, additional financial support from the central government to target cities and industries is imperative in the short run to uphold fair environmental competition for both local governments and manufacturing industries.

Appendix

Table A1. The effect of CC on air pollution (time window: 2016-2021)

	(1) $PM_{2.5}$	(2) SO_2	(3) NO_x
Channel	-0.058***	-0.108***	-0.042**
	(-2.795)	(-2.872)	(-2.135)
Constant	2.295***	2.911**	2.775***
	(3.382)	(2.337)	(4.620)
Control Variables	Yes	Yes	Yes
City Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Province-Year Fixed Effects	Yes	Yes	Yes
Observations	1,710	1,710	1,710
R-squared	0.946	0.928	0.956

Note: This table shows the estimation results of specification (1) with data from 2016 to 2019, which align with the timeframe in specification (2). The dependent variables are the concentration of logarithm of $PM_{2.5}$, SO_2, and NO_x, respectively.

References

Amendolagine, V., De Pascale, G., & Faccilongo, N. (2021). International capital mobility and corporate tax revenues: How do controlled foreign company rules and innovation shape this relationship?. Economic Modelling, 101, 105543.

Andreoni, J., & Levinson, A. (2001). The simple analytics of the environmental Kuznets curve. Journal of public economics, 80(2), 269-286.

Bai, C., Liu, H., Zhang, R., & Feng, C. (2023). Blessing or curse? Market-driven environmental regulation and enterprises' total factor productivity: Evidence from China's carbon market pilots. Energy Economics, 117, 106432.

Beer, S., De Mooij, R., & Liu, L. (2020). International corporate tax avoidance: A review of the channels, magnitudes, and blind spots. Journal of economic surveys, 34(3), 660-688.

Brandt, L., Van Biesebroeck, J., & Zhang, Y. (2012). Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. Journal of development economics, 97(2), 339-351.

Cai, X., Lu, Y., Wu, M., & Yu, L. (2016). Does environmental regulation drive away inbound foreign direct investment? Evidence from a quasi-natural experiment in China. Journal of development economics, 123, 73-85.

Carosi, A. (2016). Do local causations matter? The effect of firm location on the relations of ROE, R&D, and firm SIZE with MARKET-TO-BOOK. Journal of Corporate Finance, 41, 388-409.

Castells-Quintana, D., Dienesch, E., & Krause, M. (2021). Air pollution in an urban world: A global view on density, cities and emissions. Ecological Economics, 189, 107153.

Chen, S., Oliva, P., & Zhang, P. (2022). The effect of air pollution on migration: Evidence from China. Journal of Development Economics, 156, 102833.

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. Ecological economics, 48(1), 71-81.
Cui, C., & Li, L. S. Z. (2023). Trade policy uncertainty and new firm entry: Evidence from China. Journal of Development Economics, 163, 103093.
De Beule, F., Schoubben, F., & Struyfs, K. (2022). The pollution haven effect and investment leakage: The case of the EU-ETS. Economics Letters, 215, 110536.
Fuest, C., Hugger, F., & Neumeier, F. (2022). Corporate profit shifting and the role of tax havens: Evidence from German country-by-country reporting data. Journal of Economic Behavior & Organization, 194, 454-477.
Gurdal, T., Aydin, M., & Inal, V. (2021). The relationship between tax revenue, government expenditure, and economic growth in G7 countries: new evidence from time and frequency domain approaches. Economic Change and Restructuring, 54, 305-337.
Hancevic, P. I. (2016). Environmental regulation and productivity: The case of electricity generation under the CAAA-1990. Energy Economics, 60, 131-143.
He, G., Wang, S., & Zhang, B. (2020). Watering down environmental regulation in China. The Quarterly Journal of Economics, 135(4), 2135-2185.
Hering, L., & Poncet, S. (2014). Environmental policy and exports: Evidence from Chinese cities. Journal of Environmental Economics and Management, 68(2), 296-318.
Jindal, A., Nilakantan, R., & Sinha, A. (2024). CO2 emissions abatement costs and drivers for Indian thermal power industry. Energy Policy, 184, 113865.
Keiser, D. A., & Shapiro, J. S. (2019). Consequences of the Clean Water Act and the demand for water quality. The Quarterly Journal of Economics, 134(1), 349-396.
Kong, D., & Liu, C. (2024). Centralization and regulatory enforcement: Evidence from personnel authority reform in China. Journal of Public Economics, 229, 105030.
Liu, M., Tan, R., & Zhang, B. (2021). The costs of "blue sky": Environmental regulation, technology upgrading, and labor demand in China. Journal of Development Economics, 150, 102610.
Mardan, M., & Stimmelmayr, M. (2018). Tax revenue losses through cross-border loss offset: An insurmountable hurdle for formula apportionment?. European Economic Review, 102, 188-210.
Meyer, A., & Raff, Z. (2023). The effect of water pollution regulation on prices: Evidence from Wisconsin's phosphorus rule and sewer utility bills. Journal of Environmental Economics and Management, 124, 102914.
Nerudova, D., Dobranschi, M., Solilová, V., & Litzman, M. (2023). Onshore and offshore profit shifting and tax revenue losses in the European Union. Economic Modelling, 119, 106111.
Riedl, N., & Becker, J. Multinational Firms Mitigate Tax Competition. Economics Letters.
Song, M., Xie, Q., & Chen, J. (2022). Effects of government competition on land prices under opening up conditions: A case study of the Huaihe River ecological economic belt. Land Use Policy, 113, 105875.
Walker, W. R. (2013). The transitional costs of sectoral reallocation: Evidence from the clean air act and the workforce. The Quarterly journal of economics, 128(4), 1787-1835.
Wang, C., Wu, J., & Zhang, B. (2018). Environmental regulation, emissions and productivity: Evidence from Chinese COD-emitting manufacturers. Journal of Environmental Economics and Management, 92, 54-73.

Wang, X., & Ye, Y. (2023). Environmental protection tax and firms' ESG investment: Evidence from China. Economic Modelling, 106621.

Wu, J., Segerson, K., & Wang, C. (2023). Is environmental regulation the answer to pollution problems in urbanizing economies?. Journal of Environmental Economics and Management, 117, 102754.

Wu, J., Segerson, K., & Wang, C. (2023). Is environmental regulation the answer to pollution problems in urbanizing economies?. Journal of Environmental Economics and Management, 117, 102754.

Xie, T., & Yuan, Y. (2023). Go with the wind: Spatial impacts of environmental regulations on economic activities in China. Journal of Development Economics, 103139.

Zhang, B., & Zhao, D. (2023). Emission leakage and the effectiveness of regional environmental regulation in China. Journal of Environmental Economics and Management, 121, 102869.