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Re-examination of "Pollution Haven" or "Pollution Halo" Effect on Foreign Direct Investment

—Evidence from "Two Control Zones" Policy in China

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***Abstract*—Based on panel data of prefecture-level cities from 1996 to 2017, taking account of the exogenous shock of the "Two Control Zones" (TCZ) policy, this paper investigates empirically the impact of environmental policy on Foreign Direct Investment (FDI) by using the methods of difference-in-differences (DID) and Propensity score matching method (PSM-DID). The results show that the implementation of the environmental policy does inhibit FDI and verifies the existence of "pollution haven" effect in China for a long time. While strengthening the opening up and actively introducing foreign capital, Chinese governments must keep the bottom line of environmental regulations to ensure the quality of FDI.**

Keywords—two control zones; pollution haven effect; foreign direct investment ; difference-in-differences estimation

I. INTRODUCTION AND LITERATURE REVIEW

In recent years, China has continuously accelerated the pace of opening up to the outside world and constructed a new open economic system. The utilization of foreign capital has played an important role in the 40 years of economic development of China's reform and opening up.

While pushing forward the process of opening to the outside world, Chinese government has also actively strengthened pollution prevention and ecological construction, vigorously promoted green development. Therefore, the environmental problems brought by capital introduction have to become the focus of attention. In order to alleviate the air pollution mainly caused by acid rain and sulfur dioxide, the Chinese government implemented the Two Control Zone policy of acid rain and sulfur dioxide control in 1998.

Although there are many studies on the relationship between FDI and environment regulation, they have not reached a unanimous conclusion. Copeland and Taylor(1994)[1] put forward the famous "pollution haven" hypothesis, believing that developed countries usually transfer their backward high-pollution industries to developing countries with less environmental regulations, making developing countries "pollution haven". However, some studies also believe that the "pollution haven hypothesis" is not established in emerging developing countries (Grossman and Krueger, 1991)[2]. On the contrary, the transfer of enterprises from developed countries improves the environmental quality of developing countries through technology spillover effects (Eskeland and Harrison, 2003)[3]. This view is also known as the "pollution halo hypothesis" (Frankel, 2003)[4].

Chinese scholars also have made several studies on the issue. A study by Liu and Zhao (2016)[5]find that FDI has a dual effect of "pollution halo" and "pollution haven" on urban environmental pollution in China. Zheng and Shi (2017)[6] uses China's provincial panel data to conduct research and believes that the validity of the pollution haven hypothesis is related to the types of environmental policies and industrial characteristics. Furthermore, Sun and He (2018)[7] find that FDI in labor-intensive and heavily polluting capital-intensive industries has a "pollution haven" effect on the environment, while FDI in lightly polluting capital-intensive industries has a "pollution halo" effect. Yet whether FDI affects the energy consumption of the host country in accordance with the "pollution halo" hypothesis or the "pollution refuge" hypothesis depends on the strict degree of environmental supervision by the host government, that will not only affect the local industrial structure to a certain extent, but also affect the extent to which local and foreign enterprises use advanced environmental protection technologies, thus determining the role of FDI in the host country's environmental protection (Zhang and Jiang, 2013)[8].

In the examination of "pollution haven" or "pollution halo" effect of FDI, a key problem is how to solve the endogenous problem of environmental regulation. Most of the literatures adopt the endogenous approach to environmental regulation. Liu and Wang (2016)[9], by studying endogenous environmental regulation, FDI and China's urban environmental quality, and find that FDI has improved China's environmental quality and FDI has threshold effect. Jiang and Zhao (2019)[10] study the impact of formal and informal environmental regulations on FDI, but the environmental regulation variables are still endogenous.

The TCZ policy can be used as an exogenous environmental impact to effectively solve the endogenous problem of environmental regulation. Xue et al. (2019)[11] study the impact of environmental regulation on regional economy in 287 cities above prefecture level in China from

1995 to 2010 based on the TCZ policy. Yet the study only adds the relevant indicators of FDI into the model and did not directly examine the impact of environmental regulation on FDI. Tang (2019)[12] uses the data of newly-established foreign direct investment industrial enterprises from 2003 to 2007 to find that the improvement of environmental regulation promotes the entry of FDI in the TCZ cities, and inhibits that in those non-TCZ cities. However, since the "two control zones" policy is divided into two stages, and the attitude towards foreign investment is different in different stages of China's economic development. What effects will FDI has in different stages? Tang has not given any discussions in his paper.

Lu et al. (2012)[13] use the TCZ policy as their identification with data from China City Statistical Yearbook for the period 1992-2009, and confirm the "pollution haven" effect in China. Yet is still there a pollution haven effect from 2009 up to now in China? It needs to be further investigated. Therefore, this paper takes the TCZ policy as an exogenous policy impact and uses DID and PSM-DID methods to examine the location choice of FDI against stringent environmental regulations in prefecture-level cities in China from 1996 to 2017. The time period spans the two stages of the TCZ policy, which can more directly verify whether foreign investment has a "pollution haven" or "pollution halo" effect in China.

The remainder of this paper is organized as follows. Section II describes the model construction and variables definition as well as data source. Section III empirically analyses the effect of the TCZ policy on FDI, along with robustness test and further dynamic heterogeneity discussion. Conclusions and policy recommendations are stated in Section IV.

II. Model Construction, Variables and Data

A. Model Construction

1) Model setting: In order to identify the impact of the two-zone policy on China's FDI, this paper adopts DID to conduct causal identification. The basic idea of DID method is to set the cities affected by the policy as experimental group, the cities not affected by the policy as control group, the year of policy implementation as time dummy variable, the value before policy implementation is 0, and the value after policy implementation is 1. Therefore, according to the policy of two control zones to conduct this quasi-natural experiment, this paper sets the model as follows:

$$\ln Fdi_{it} = \alpha_0 + \beta_0 TCZ_{it} \times Post_{it} + \sum_{k=1}^{k=6} \beta_k X_{kit} + \mu_i + \delta_t + \varepsilon_{it} \quad (1)$$

Where subscripts i, t and k denote the city, time and number of variables respectively; LnFdi_{it} represents our outcome variable, the logarithm of the amount of FDI indicating the level of foreign direct investment in prefecture-level cities; TCZ_{it} denotes the Two Control Zones, and if city is a TCZ city, it has a value of 1. If city is a non-TCZ city, it has a value of 0; $Post_{it}$ indicates the post-treatment period, it has a value of 0 before the policy is implemented, and a value of 1 after the policy is implemented; X_{kit} represents a series of control variables that affect foreign direct investment, μ_i and δ_t respectively represent the fixed effects of the city and the year, and ε_{it} is the error term representing random perturbations. The coefficient of $TCZ_{it} \times Post_{it}$ measures the net impact of the two control zones policy on foreign direct investment in prefecture-level cities.

Parallel trend chart: One of the preconditions of DID estimation method is that the experimental group and the control group must satisfy the same trend before the policy shocks, otherwise the conclusion cannot be guaranteed to be the difference between the two due to the policy impacts. Therefore, we have drawn the trend chart of the logarithm of the actual foreign capital utilization in the TCZ cities and non-TCZ cities. As shown in Fig. 1, the actual utilization of foreign capitals in the TCZ cities and the non-TCZ cities have the same trend before 2000, satisfying the parallelism assumption. After 2000, there is a short-term emergency response process for foreign-funded enterprises after the implementation of the TCZ policy. As a result, the difference between the two becomes smaller in 2000. However, due to the more stringent pollution control targets of the TCZ in 2010, which is the year when the second-stage targets of the TCZ in China should be realized, so the gap between the two groups does not narrow from 2000 to 2006, instead widen. Yet it becomes further narrow from 2007. Therefore, we preliminarily estimate that the implementation of the TCZ policy can significantly inhibit foreign investment, thus indirectly verifying that FDI has a "haven of pollution" effect in China, which is to be confirmed by the following empirical analyses.

B. Variables Definition

1) Dependent variable: Foreign Direct Investment ($LnFdi_{it}$)

Foreign Direct Investment is expressed in terms of the actual amount of foreign capital utilized in the current year, which is converted into investment in RMB according to the exchange rate of the current year.

2) Core explanatory variable: The implementation of the "two control zones" policy ($TCZ_{it} \times Post_{it}$)

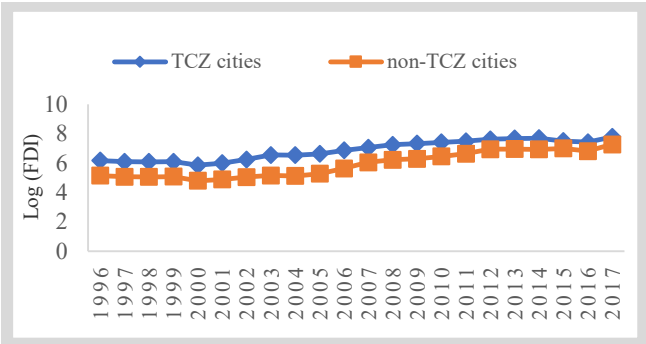

Fig. 1. Trend of total FDI inflow to TCZ cities and non-TCZ cities.

According to "The Official Reply of the State Council Concerning Acid Rain Control Areas and Sulfur Dioxide Pollution Control Areas", the list of cities implementing the TCZ policy is identified. The control zones listed in the document includes 175 cities and regions, specifically 158 prefecture-level cities, 13 regions and 4 municipalities directly under the central government. The value of cities implementing the two control zones policy is 1, whereas the value of cities implementing the two control zones is 0. Considering there is a certain time lag between the implementation of central government and the prefecture-level cities, we use the practices of Shi et al. (2017)[14] and Li et al. (2019)[15] for reference and take the second year (2000) after the policy is formulated as the actual shock time of the policy, i.e. the value is 1 in 2000 and later, and 0 before 2000.

3) Control variables: The industrial structure (Str) is expressed by the proportion of the added value of the tertiary industry to that of the secondary industry; Population density (PI) is expressed as the number of person per square kilometer, the higher the population density, the higher the land cost; Investment in fixed assets (LnInvest) is logarithmic representation of annual investment in fixed assets; Human Capital (Edu) is measured by the proportion of college students in the total population at the end of the year; The level of economic development (LnPgdp) is expressed by the logarithm of GDP per capita; Passenger traffic(LnPassenger) is expressed by the logarithm of the total passenger traffic.

C. Data Sources

All the data including 281 prefecture-level cities in China from 1996 to 2017 in this study come from CEIC database and China City Statistics Yearbook. The state document, "The Official Reply of the State Council Concerning Acid Rain Control Areas and Sulfur Dioxide Pollution Control Areas" provides a detailed name list of cities designated as TCZ, including 158 prefecture-level cities.

III. EMPIRICAL ANALYSES

A. Basic Regression and Robustness Test

In order to estimate the impact of the TCZ policy on FDI and examine whether FDI has "pollution haven" or "pollution halo" effect in China, this study adopts a two-way fixed effect model to regress (1). the baseline DID estimation results are reported in columns (1) and (2) of Table I.

As shown in Column (1) without control variables, the coefficient of *TCZ×Post* is significantly negative at the level of 1%, and after adding the control variables in column (2), although the significant level drops, it is still significantly negative at the level of 10%, indicating that cities with tougher environmental regulations attract less FDI in China.

TABLE I. BASELINE RESULTS AND ROBUSTNESS TESTS

	DID		PSM-DID	Counterfactual Test
	(1)	(2)	(3)	(4)
TCZ × Post	-0.3274***	-1.0860*	-1.7152***	-0.4569
	(-4.62)	(-1.74)	(-2.79)	(-0.64)
Str		-0.0000	0.0002	-0.0000
		(-0.03)	(0.26)	(-0.03)
PI		-0.0001	-0.0008***	-0.0001
		(-0.82)	(-3.15)	(-0.82)
LnInvest		0.6027***	0.6288***	0.6027***
		(10.58)	(10.69)	(10.58)
Edu		-1.0898	-2.7455	-1.0898
		(-0.44)	(-0.92)	(-0.44)
LnPgdp		0.5793***	0.5393***	0.5793***
		(5.32)	(4.73)	(5.32)
LnPassenger		0.0234	0.0076	0.0234
		(0.66)	(0.20)	(0.66)
Constant	5.4519***	-5.7987***	-5.1784***	-5.0884***
	(86.67)	(-5.40)	(-4.50)	(-5.21)
City fixed effects	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes
Observations	5607	3742	3578	3742
R^2-Adjusted	0.4489	0.4654	0.4623	0.4654
F	196.2748	110.7210	104.1587	110.7210

[a.] Note: *, ** and *** represent statistical significance at the 10%, 5% and 1% level respectively.

In order to eliminate the bias caused by endogenous selection, we further use PSM-DID method to conduct robustness test. The specific process of tendency score matching is as follows: TCZ is taken as dependent variable, GDP per capita, industrial structure and other factors are taken as independent variables, Logit model is used to calculate tendency score value, then by which using radius matching method to find similar non-TCZ city samples for cities implementing the TCZ policy, and afterwards delete the unmatched non-TCZ city samples and use DID method to estimate. The empirical results are reported in column (3) of Table I. From the matched regression coefficient of *TCZ×Post,* it can be seen that the implementation of the TCZ policy still reduces FDI, indicating that the basic empirical results are stable.

We further conduct a counterfactual test by changing the policy impact time to check its robustness. If the coefficient is still significantly negative on this condition, then FDI does not have the "pollution haven" effect in China. Column (4) of Table 1. reports the empirical result of adjusting the policy impact time to 1997. The coefficient of *TCZ×Post* is not significant, which shows that the baseline results based on DID method are stable. Since the TCZ policy has a strong binding force on highly polluting industries, it can be verified that FDI does have a "pollution haven" effect in China, and foreign investment location choices are constrained by the implementation of environmental policies.

B. Further Discussions—Dynamic Heterogeneity Analysis

Since the baseline regression can only examine the average effect of the TCZ policy on FDI, this study uses the practice of Li et al. (2019)[15] for reference to construct the annual time dummy variable (Postt) from 2000 onwards, and multiplies the time dummy variable with the dummy variable of the TCZ grouping to obtain the long-term dynamic effect of the TCZ policy on FDI so as to analyze the continuous effect of the policy and further verify whether FDI has the behavior of evading the environmental policy. The results are reported in Table II. It can be seen that the coefficient was significantly negative in 2000, while it was still negative but not significant from 2001 to 2006, indicating that foreign-funded enterprises investing in China will make a short-term emergency response to the policy implementation at the initial stage. Moreover, the government explicitly emphasizes that the TCZ policy should basically control the worsening trend of environmental pollution and ecological destruction by the year 2000. However, the Ninth Five-Year Plan of the national environmental protection and the Long-Term Target for 2010 emphasize the realization of higher pollution control targets. From the dynamic coefficient point of view, the coefficients have become significant since 2007, indicating that the closer the pollution control policy targets are to the realization stage, the greater the pollution prevention and control efforts may be, and thus the more FDI can be inhibited.

IV. Conclusions and Policy Recommendations

Based on the TCZ policy as an exogenous shock to control for the potential endogeneity of environmental regulations, this paper examines the impact of environmental policies on FDI in the prefecture-level cities from 1996 to 2017 by using DID and PSM-DID methods. The empirical results show that the TCZ policy significantly and negatively affect inflow of FDI, and from the dynamic time effect, it can be drawn that the closer to the realization year of the environmental policy target, the more significant the inhibitory effect on FDI is, indicating that foreign investors respond to environmental regulations by reallocating their production to places with less stringent regulations. FDI does have "pollution haven" effect in China for a long time. which is consistent with and complements the study of Lu et al. (2012)[13].

TABLE II. Dynamic Impact Analysis of TCZ Policy on FDI

	Coefficient	Standard Error		Coefficient	Standard Error
Y2000	-1.5063*.	-1.95	Y2009	-1.2043*	-1.71
Y2001	-1.0476	-1.48	Y2010	-1.2962*	-1.84
Y2002	-0.9339	-1.32	Y2011	-1.3772*	-1.95
Y2003	-1.0130	-1.43	Y2012	-1.5914**	-2.26
Y2004	-0.9679	-1.37	Y2013	-1.4966**	-2.12
Y2005	-1.0190	-1.44	Y2014	-1.4584**	-2.06
Y2006	-1.1021	-1.56	Y2015	-2.0537***	-2.85
Y2007	-1.3832*	-1.96	Y2016	-1.9364***	-2.68
Y2008	-1.3194*	-1.87	Y2017	-1.4164**	-2.20

b. Note: The above regression controls the control variables as well as year and city fixed effects, of which the sample size is 3742 and the adjusted R-square is 48.06%.

According to the research conclusion, several corresponding policy suggestions are put forward to promote the healthy and sustainable development of our economy. Since foreign investors respond to environmental regulations by reallocating their production to places with less stringent regulations, the government and industrial associations should formulate reasonable investment promotion plans according to the differences in regional economic development and strictly control the quality of foreign investment. In terms of foreign investment industrial structure, relevant government departments should actively guide foreign investors to invest in the tertiary industry according to the development needs and especially increase foreign investment in tourism services.

Secondly, in terms of environmental regulation, the government and relevant departments should start from the source, encourage the development of green and clean technologies and industries, and provide policy support to guide foreign investors to actively participate in them.

Finally, from the perspective of enterprises, local enterprises should actively deal with environmental regulation, take the initiative to carry out technological transformation and upgrading of enterprises, develop environment friendly and efficient production technologies, and strive to improve their technological innovation capabilities and their comparative advantages so as to enhance their attractiveness to foreign investment.

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