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Agglomeration, Environmental Policies and Surface Water Quality in China: A Study Based on a Quasi-Natural Experiment

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Abstract: This paper investigates the relationship between agglomeration and water pollution, and the effect of environment policies on water pollution reduction. The study employs a quasi-natural experimental method by coupling river water monitoring sites and development zones (DZs). We found that DZs were associated with water quality deterioration in their surrounding areas. However, the “Water Ten Plan”, which was released in 2015 and requires DZs to install water treatment facilities, effectively reduced water pollution, especially for those DZs with more polluting industries. Our findings provide evidence that agglomeration can facilitate efficient processing of wastewater by enabling its centralized treatment. The paper provides quantitative evidence for the effect of agglomeration and environmental policies from a micro point of view.

Keywords: agglomeration; development zones; environmental policies; pollution; quasi-natural experiment

1. Introduction

Development zones (DZs) are regarded as one of the most important forms of agglomeration, and an engine of regional economic development [1]. With more than two decades of development, DZs have become modern agglomerated industrial parks with attractive investment environments and advanced technology. However, are DZs environmental friendly? Researchers have been controversial on the agglomeration effect raised by Chinese development zones, given many DZs are extensively developed and land consuming [1,2]. DZs have also been criticized for their pollution emissions into the environment [3–5]. Various environmental regulations and policies have been issued and implemented by central and local authorities, but the effects of environmental policies have rarely been quantitatively explored because measurement is quite difficult [6].

The results of research on whether agglomeration affects the environment are mixed. Some studies hold the view that it degrades the environment through concentrated discharges of polluted water and air into the neighborhood [7,8]. Others argue that agglomeration can alleviate pollution for the following reasons: (1) Spillovers of clean technology among enterprises can lead to diffusion of clean production and bring about pollution reduction [9]; (2) agglomeration can reduce the cost of governance through scale effects [10,11]; and (3) the recycling effect can be achieved in clusters and therefore bring about pollution reduction [12].

Extant studies have advanced our understanding of the effects of agglomeration on the environment. However, there are still some deficiencies. First, existing studies typically take a

macro perspective by using provincial, regional or industrial level data. These studies neglect the heterogeneity of the local districts and therefore cannot arrive at accurate results. Second, existing studies neglect endogenous defects, in that ordinary least squares (OLS) and panel regression may have the weakness of missing variables, which could lead to biased results. Models that are more reliable should be considered for estimations. Third, previous quantitative studies focus less on the perspective of pollutant governance due to data limitations. Whether environmental policies which target agglomeration are effective or whether they are more effective in agglomerated districts deserves to be investigated quantitatively. Finally, most studies use the volume of waste emissions, rather than the degree of pollution in water or air, as the proxy for the pollution level. However, the volume of waste emissions is not strictly equivalent to the pollution level, because processing infrastructures differ among different places. Water or air quality is preferable for representing pollution levels in environmental research.

A DZ is a proper micro-level unit for an environmental study. Moreover, China released the “Water Ten Plan” in 2015, demanding that all DZs construct centralized sewage treatment facilities and install automatic online monitoring devices by the end of 2017. We explore two issues, addressing them in the context of DZs, environmental policies, and water quality at water monitoring sites. The first issue we consider is how agglomeration affects water quality in the vicinity of DZs. Second, we explore whether “Water Ten Plan” policy can effectively improve DZ water quality. We conducted a quasi-natural experiment on DZs by matching the geographical information from water quality monitoring sites and DZs. Such a method can address the issues mentioned above and provide relatively reliable results.

The following parts are structured as follows. Section 2 reviews policies linked to agglomeration, environmental policies, and pollution reduction, as well as the pertinent literature. Section 3 presents data sources and methodology. Section 4 describes Chinese DZs and water quality monitoring sites. Section 5 provides the results of econometric models, while the final section consists of conclusions and policy discussions.

2. Literature Review

2.1. Agglomeration and Pollution

Agglomeration is one factor affecting the environment. Krugman [13] proposed a core-periphery model to explain spatial agglomeration, based on increasing returns to scale and transport costs, according to which an urban system is formed by both centripetal forces (agglomeration forces) and centrifugal forces [14]. Diversity preference, home market effect, and increasing returns are considered agglomeration forces, while crowding effects, increasing cost of living, and pollution are centrifugal forces. Environmental pollution is often regarded as a force that retards agglomeration [15–18]. However, given that pollutant emission abatement governance may have scale economies, agglomeration does not have to inevitably lead to increased pollution; spatial concentration of potential polluters can facilitate controlling or processing pollutant emissions [19].

However, agglomeration can lead to more pollutant emissions and worsen the environment [16,20]. If abatement policy is targeted at the level of the district, it may induce polluting industries to move to under-developed regions [21], as is predicted by the “pollution haven hypothesis” [22]. On the other hand, when pollution abatement policy is aimed at strengthening environmental regulations—such as setting up a levy system or environment standards—agglomeration may help reduce pollutant emissions.

First, agglomeration can reduce the cost of pollution abatement through the establishment of centralized recycling facilities. Zeng and Zhao [10] argued that processing costs could be reduced in an agglomerated area. Agglomeration can also create a circular economy by combining waste treatment and pollution treatment systems [23].

Second, agglomeration can promote mutual learning among firms and promote technological upgrading. Knowledge, talent and technology more frequently circulate in denser clusters [24,25].

Clean technology is also developed and diffused more rapidly in agglomerated regions, and firms in denser regions have more opportunities to employ green technologies [9]. Mutual learning and matching between firms may promote efficiency, boost productivity, and reduce environmental detriment [20,26].

Third, the governance cost of dealing with agglomerated pollution emissions is lower. The difficulty of enforcing environmental regulations increases when firms are dispersed in space [11]. In sum, the unit cost of fixed assets, technology related with pollution processing, and regulatory costs all have scale economies, which means costs are lower in agglomerated regions.

2.2. Environmental Policies and Pollution Reduction in China

Agglomeration does not necessarily lead to automatic pollution abatement. Enterprises are not motivated to adopt clean technologies or enhance pollution abatement processing under unregulated market forces [27]. Proper environmental policies are necessary to propel such a transformation. Environmental policies can be designed to foster technological invention, innovation, and diffusion [28,29]. Environmental policy instruments may be divided into market-based approaches and command and control approaches [27,29]. The former includes pollution charges and subsidies, which can encourage firms to pursue pollution control efforts. Command and control regulations tend to force firms to take on pollution control responsibility by setting uniform standards to reduce pollution. Some researchers hold the view that market-based policy instruments are more effective with respect to the invention, innovation and diffusion of desirable clean technologies [27,29], but Popp [30], having explored the effect of the Clean Air Act in the U.S., supported the superiority of command and control instruments with regard to innovation. Command and control regulations drive diffusion of technologies [31] and are important for end-of-pipe solutions [32].

By implementing command and control regulations, efficient environmental policies can encourage regions to shift to clean production, restructure economic structure, and retrofit existing facilities to meet newly imposed environmental standards [33–36]. They also propel the technology diffusion process. More firms adopting a certain technology lowers the marginal costs of pollution abatement, which has a fixed cost associated with it [29].

After decades of swift economic development accompanied by environment degradation [37], the Chinese central government has shifted from a pro-growth to a pro-environment orientation [38–40]. As a result, numerous policy instruments have been implemented to reduce pollution. One of the most concerned policies to date is the “Water Pollution Prevention Action Plan”, issued by the State Council in 2015. It includes ten articles, and has been referred to as the “Water Ten Plan.” The Plan proposed to improve water quality by means of very stringent regulations, and served as the guideline for the promotion of water sustainability in China [41]. Strengthened pollution controls were implemented in industrial agglomerations, such as economic and technological DZs, high-tech industrial DZs, industrial parks, and export processing zones. DZs are required to construct centralized sewage treatment facilities and install automatic online monitoring devices by the end of 2017. According to the plan, industrial wastewater in DZs must be pretreated to meet a centralized treatment requirement before entering sewage treatment facilities. DZs that cannot meet the standard will have their development zone qualifications revoked. The “Water Ten Plan” has received a positive response. China’s Environment Protection Bureau reported in 2018 that 93% of provincial and national DZs had built sewage treatment facilities by the end of 2017. China’s increasingly stringent environment policy on wastewater stimulated the diffusion of wastewater treatment facilities and adoption of clean technology. It is expected to have a positive effect on water qualities in the neighborhood of DZs. DZs with highly polluting industries are anticipated to benefit more from the Plan because of the scale economies of pollution processing.

A limited number of studies have explored the relations between agglomeration, policies, and pollution reduction in connection with DZs. Wang and Nie [42] matched the geography of river water quality and provincial DZs in 2006, and found that DZs caused local water quality to deteriorate. But

they did not take into account the effects of policies on the environment. Zhu et al. [43] conducted a case study on how firms in development zones responded to increasingly demanding environmental regulations. Hu et al. [44] explored the development of centralized wastewater treatment plants in Chinese national industrial parks and pointed out that 92% of treatment plants met the required discharge standards. Long et al. [45] analyzed pollution control and the cost of wastewater treatment at Taihu and Haihe industrial parks. Zhang et al. [4] explored particulate pollution in the Kunshan high-tech zone. These studies advanced our understanding of both industrial parks and pollution reduction. However, most of the aforementioned studies were qualitative; quantitative studies based on the whole country are lacking, while qualitative studies on the influence of environmental policies are even rarer because of the difficulty in measuring environmental policies [46].

In this study, China's "Water Ten Plan"—which was mainly directed towards wastewater treatment in DZs—and detailed water quality information gathered from monitoring sites and published by the Environmental Protection Bureau, provided ideal conditions for exploring whether and how environmental policy effectively reduced pollution. This was achieved through empirical study, coupling DZs and the water quality information of monitoring sites from main river systems. Here, we aimed to provide empirical evidence on the controversial issue of whether agglomeration helps to reduce pollution emissions through agglomerated regulations. We anticipated that agglomerations would help to reduce pollution more efficiently through centralized environmental governance, although they were also predicted to contribute to deterioration of the surrounding environment. Such findings would change the view that pollution is an adverse force of agglomeration, which is a common belief in urban geography and among environmental researchers.

3. Data and Methodology

The purpose of this paper was to identify the effect of agglomerations and the "Water Ten Plan" policies on surface water quality. Existing studies mostly use multiple linear regression to explore such an effect. However, they could not eliminate endogenous problems, such as missing variables and time trend disturbances. A quasi-experiment based on a difference-in-difference (DID) method can address such problems by coupling geographical information of DZs and water quality monitoring sites [42,47]. DID is a quasi-experimental design that makes use of longitudinal data from treatment and control groups to obtain an appropriate counterfactual to estimate a causal effect and is widely used in social sciences [47,48]. In this study, we identified the experimental and treatment groups based on the distance between the DZs and the river water quality monitoring sites. The experimental group consisted of the water monitoring sites near the DZs, while the treatment group consisted of the sites located away from the DZs. We then used the change of values at the monitoring sites in the treatment group as the base to estimate the trend of the experimental group, and therefore eliminated disturbances in the short-term trend and missing values.

The names of the water quality monitoring sites were obtained from the website of the China National Environmental Monitoring Center (CNEMC: www.cnemc.cn), which also provided water quality monitoring data for 145 sites each week since 2014. Geographical information concerning the monitoring sites was found on Baidu Map, and included the province, city, and river name that the site was located on, as well as the latitude and longitude. Geographical information about the national and provincial DZs was found in the China Development Zone Audit Bulletin Directory (2018 edition), wherein 552 national DZs and 1991 provincial DZs were summarized. Most of them were set up before 2010. We obtained addresses of management councils of the DZs through official websites or online maps, and then obtained the latitude and longitude coordinates of the DZs using GIS. Finally, we calculated the straight-line distance between the monitoring sites and the nearest DZs. There were 16 monitoring sites with DZs within 3 km, and 29 monitoring sites with DZs within 5 km. Given that 3 km was too short compared with the area of the DZs, we considered the monitoring sites with DZs within 5 km the experimental group and the others as part of the treatment group.

The most important premise of a DID is that the experimental sample is independent from the policies. This paper satisfies this premise; although DZs are established by the government, the decision to establish a DZ is not affected by the presence or absence of water quality monitoring sites nearby.

We aimed to address two issues: (1) Whether the river monitoring sites near the DZs were more polluted than others and (2) whether the “Water Ten Plan’s” stipulation that required DZs to be equipped with a centralized wastewater treatment system between 2015 and 2017 effectively reduced the pollution level. We set the model as follows:

$$y_i = \alpha DZ_i + \beta X_{ct} + \varepsilon_i \quad (1)$$

$$y_{it} = \delta DZ_i * Policy_t + \beta X_{ct} + \gamma_c + \varepsilon_i \quad (2)$$

where, y_i is the water quality value of monitoring site i . DZ_i is a dummy variable representing whether or not the neighborhood of the monitoring site i has DZs. X_{ct} is the control variables, representing the attributes of prefecture-level administrative regions to which the monitoring sites belong. Previous studies showed that surface water quality is affected by natural and social-economic factors, like precipitation, agriculture, and industry development [47]. In this study, the variables included the gross domestic product (GDP), population, gross industrial output value (IndustryValue), whether the site was located in an urban district (Urban), and whether the site was located in direct controlled municipalities or provincial capitals (Capital). We also controlled the number of wastewater treatment plants (TreatmentPlant), precipitation, fertilizer consumption per area (Fertilizer), and discharge volume of industrial wastewater (CityWastewater) of the city.

Policy t , where t is time, is a dummy variable representing whether the “Water Ten Plan” had been implemented. As the implementation of the Plan lasted through 2015–2017, we deleted water quality data from 2015 to 2017 to estimate the effect of the policy. As the monitoring data is released every week, we were able to use the average water quality data for each of ten weeks in 2014, 2015 and 2018. It was hard to obtain data in 2018 for the control variables, and thus we used data from 2016 and extrapolated to 2018 using the trend between 2014 and 2016. α and β are coefficient variables. ε_i is an error term. γ_c represents regional dummy variables which control the factors that have not changed with time. We were primarily interested in the coefficients α and δ , which represent the average effect of the DZs on water quality and the average effect of the policy on water quality.

The urban attributes data, including GDP, population, gross industrial output value, and discharge of industrial wastewater, came from the China Urban Statistical Yearbook, while information on the wastewater treatment plants and precipitation came from the China Urban Construction Statistical Yearbook and the Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences (<http://www.resdc.cn>), respectively. Fertilizer information came from the China Statistical Yearbook for Regional Economy.

$$DZ_i = \begin{cases} 1 & \text{one or more DZs are within 5 km radius of the monitoring site } i \\ 0 & \text{no DZs is within 5 km radius of the monitoring site } i \end{cases}$$

$$Policy_t = \begin{cases} 1 & \text{time after the Water Ten Plan has been implemented} \\ 0 & \text{time before the Water Ten Plan has been implemented} \end{cases}$$

4. Descriptions of DZs and Water Monitoring Sites

Although China has set up DZs since the 1980s, relatively few were established before 1992, when over a hundred DZs were set up in a year (Figure 1). There was another peak in the establishment of provincial DZs in 2006, when over 600 were set up in a single year. Many researchers refer to this as “DZ fever” [1,2]. The rate of establishment of national and provincial DZs rose in 2010, but has slowed since 2014. There were 552 national DZs and 1991 provincial DZs in 2018. Most of these DZs are distributed in the southern and eastern regions of China (Figure 2), which is in line with the

distribution of population. Many provincial and national DZs have been upgraded from lower level DZs. DZs that were set up after 2014 were excluded from this study.

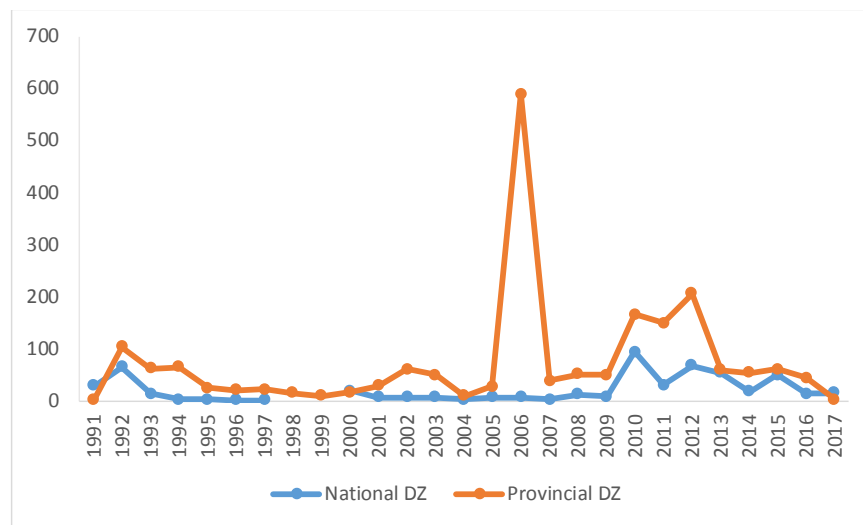


Figure 1. Number of new national and provincial development zones (DZs) established. Data source: China Development Zone Audit Bulletin Directory (2018 edition).

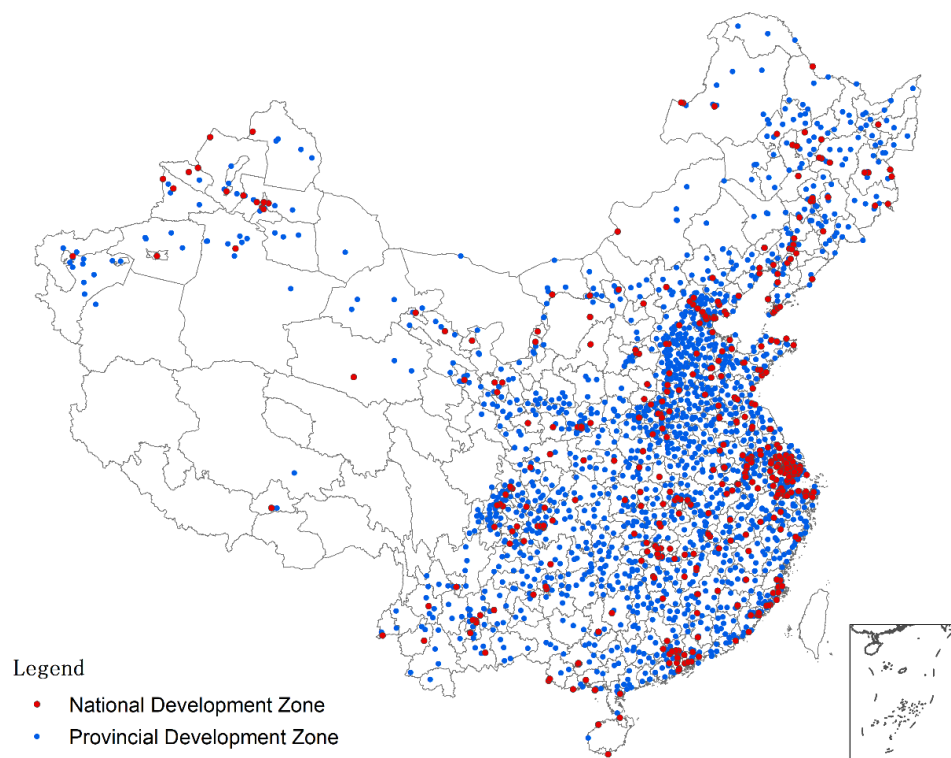


Figure 2. Distribution of China's national and provincial development zones (2017). Data source: China Development Zone Audit Bulletin Directory (2018 edition).

The water quality data of monitoring sites came from the CNEMC. There are 145 sites distributed across 29 provinces, 101 prefecture level cities, and 15 river systems (Figure 3). There are 29 monitoring sites that have one or more DZs within a 5 km distance; they are distributed in 17 provinces, in 10 river systems, and have total of 37 DZs located nearby.

CNEMC breaks down water pollution into six levels, which we refer to as 1–6. The higher the value, the greater the pollution. Water quality is estimated according to the environmental quality standard for surface water GB3838-2002, published by the Ministry of Environmental Protection of China. The average water quality in 2014, 2015, and 2018 was 2.79, 2.81, and 2.90, respectively. In 2018, the rivers with the best water quality were the Southwest River system, Yangtze River system, and Pearl River system, with an average monitored water quality of 2.04, 2.04, and 2.13, respectively. The worst water system was the Dian Lake in Yunnan province, with an average water quality of 4.75 (Table 1).

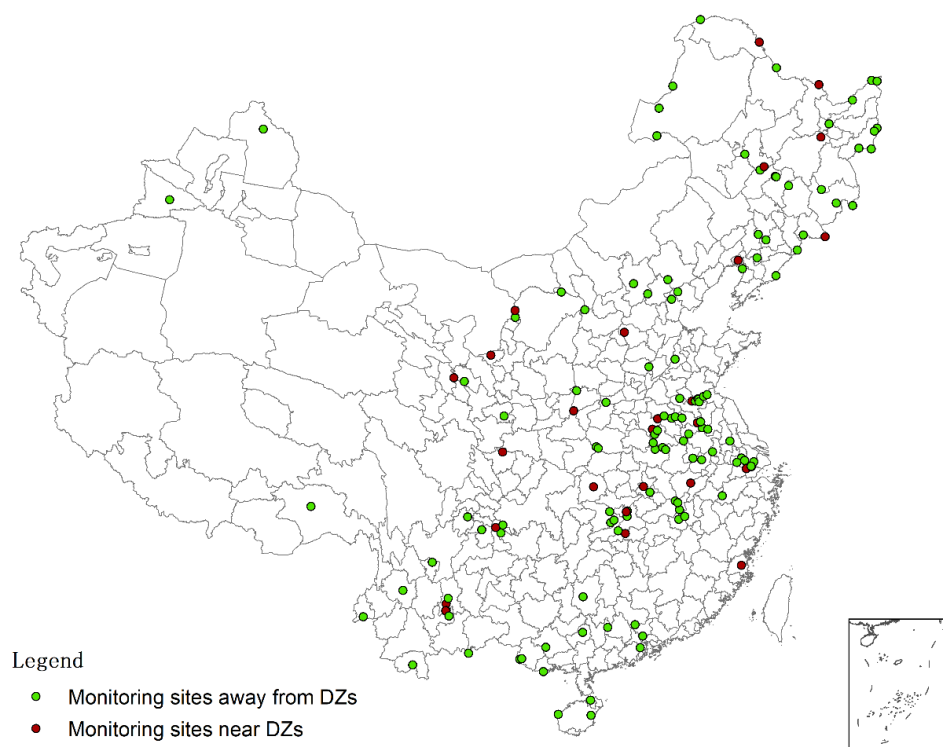


Figure 3. The distribution of water monitoring sites in China (2017). Note: ‘Monitoring site near DZs’ indicates that there are one or more development zones within 5 km of the monitoring site, while ‘Monitoring sites away from DZs’ indicates that there are no development zones within the radius of 5 km. Data source: China National Environmental Monitoring Center (CNEMC).

Table 1. Average water quality of the main river systems in 2018.

River System	Average Water Quality
Dianchi Lake Basin	4.75
Songhua River Basin	3.27
Chaohu Basin	3.13
Huaihe River Basin	3.06
Yellow River Basin	2.81
Taihu Basin	2.81
Liaohe River Basin	2.51
Haihe River Basin	2.36
Zhejiang-Fujian River	2.25
River on Hainan Island	2.25
Pearl River Basin	2.13
Yangtze River Basin	2.04
Southwestern rivers	2.04

Data source: CNEMC; Note: There are six levels of quality value ranging from 1 to 6. A higher value indicates more pollution.

5. Results of the Quasi-Natural Experiment

5.1. The Effect of DZs and Environmental Policy on Water Quality

The results of the estimation are shown in Table 2. The first two columns estimate the effect of DZs on neighboring water quality, while the last two columns estimate the effect of the “Water Ten Plan” on water quality. Columns 1 and 3 do not include any control variables except for river system dummies, while columns 2 and 4 include all economic and natural attribute variables. The R-squared values are between 0.39 and 0.43, relatively low compared with other environmental studies, and the controlled variables in columns 2 and 4 do not seem to distinctly improve the goodness of fit. The reason for this may be that there were natural factors like surface runoff and river aquatic organisms that affected the water quality but could not be obtained. Besides, we could not obtain the detailed social-economic data of the water quality monitoring sites, instead using prefecture-level administration data, which may have decreased the goodness of fit of our models. However, compared with other policy studies using DID [47], the R-squared values were not low and could explain the models well.

From our results, one can conclude that DZs significantly degrade nearby water quality. DZs within 5 km accounted for a water quality deterioration of 0.09 to 0.1, which is consistent with previous studies that argue that agglomeration brings about more water pollution [16,42]. As shown in Table 2, the coefficient of interaction terms are significantly negative at the 10% level in the last two columns, demonstrating that the “Water Ten Policy” effectively reduced water pollution. When the “Water Ten Policy” was implemented by DZs, the nearby water pollution levels decreased by roughly 0.16. Such relations are reflected in Figure 4. Additionally, the water quality of the water monitoring sites in the treatment group were dirtier than that of the control group in 2015, but in 2018—when the “Water Ten Plan” was implemented—the water quality of the treatment group experienced faster improvement compared to the control group. The policy effect was the quality improvement of the treatment group compared with the treatment group when it experienced the same trend as the control group if no policy was introduced.

The coefficients of other variables were as expected. For example, districts with higher GDP had lower water pollution, and a large population degraded water quality. Monitoring sites in urban districts had better water quality records compared with other sites, indicating better sewage processing facilities and less industrial pollution than non-urban areas. Fertilizer consumption and city industrial wastewater discharge also appeared to significantly degrade surface water quality. Capital location, number of wastewater treatment plants in the city, and precipitation did not significantly affect water quality in the district.

Table 2. Estimate results of difference-in-difference (DID) model.

	(1)	(2)	(3)	(4)
DZ*Policy			−0.164 ** (0.038)	−0.164 ** (0.036)
DZ	0.096 ** (0.045)	0.087 * (0.091)	0.167 *** (0.009)	0.158 ** (0.015)
Policy	−0.101 ** (0.021)	−0.060 (0.205)	−0.046 (0.399)	−0.003 (0.962)
lnGDP		−0.027 (0.130)		−0.026 (0.142)
lnPopulation		0.158 *** (0.001)		0.160 *** (0.000)
lnIndustryValue		−0.109 *** (0.002)		−0.112 *** (0.001)
Urban		−0.114 ** (0.044)		−0.115 ** (0.043)

Table 2. Cont.

	(1)	(2)	(3)	(4)
Capital		0.094 (0.328)		0.093 (0.331)
TreatmentPlant		−0.003 (0.324)		−0.003 (0.318)
lnPrecipitation		−0.059 (0.238)		−0.051 (0.307)
lnFertilizer		0.099 *** (0.001)		0.098 *** (0.001)
lnCityWastewater		0.086 ** (0.014)		0.088 ** (0.012)
River system dummy	Included	Included	Included	Included
Constant	2.911 *** (0.000)	3.808 *** (0.000)	2.886 *** (0.000)	3.745 *** (0.000)
Observations	1994	1994	1994	1994
R-squared	0.392	0.429	0.393	0.430

Note: p value in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

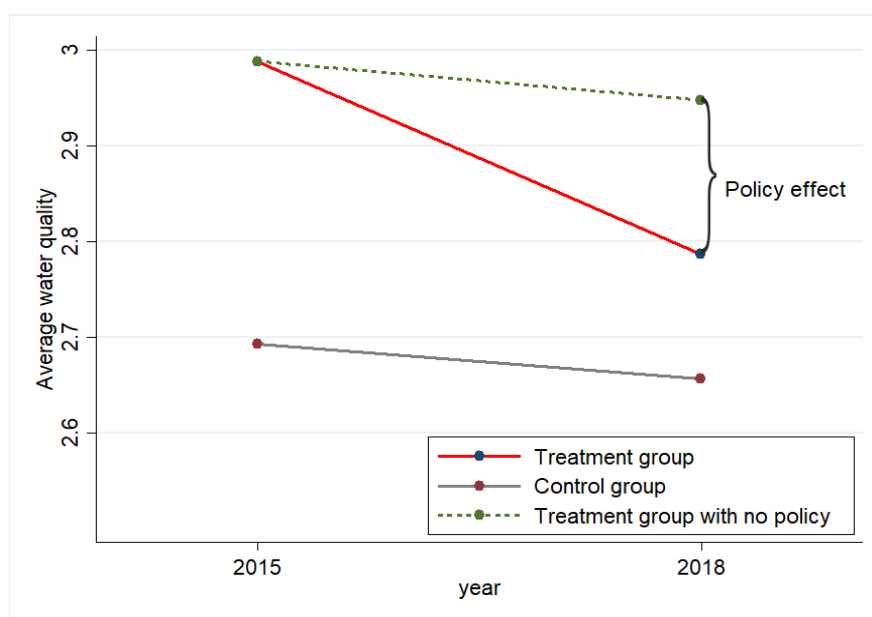


Figure 4. The average water quality of the treatment group and control group before and after the “Water Ten Plan”. Note: 1. The treatment group is water monitoring sites with development zones in a 5 km radius, while the control group is water monitoring sites with no development zones nearby. 2. There are six levels of quality value ranging from 1 to 6. A higher value indicates more pollution.

5.2. The Moderate Effect of Polluting Industries

We also investigated what kind of DZs were affected by the “Water Ten Plan”: Are DZs with industries that produce a high volume of pollutants more likely to experience improved water quality by following the “Water Ten Plan”? The interaction terms of DZ, environmental policy and value of polluting industries were introduced into a regression to solve this problem. It is difficult to obtain high polluting industry data at the scale of the DZ; thus, we instead used the polluting industry data of the district or county in which monitoring sites were located by matching the monitoring site location and the latest industrial output value from the China Industry Business Performance Database. We used the industrial output value data from the Database in 2013, which was the most recent information we were able to obtain. As it is unlikely that the industrial location changed dramatically during

the study period, the polluting industries' location in 2013 may be used to roughly reflect the actual distribution of the polluting industries. The latest database includes all state-owned enterprises and private enterprises with a sales value over 20 million Yuan. The index includes a detailed address code and industry code, as well as a total industrial output value.

Following Wang and Nie [42], we considered that the following industries were relatively heavy polluters: manufacture of foods, manufacture of beverages, manufacture of textile, manufacture of leather, fur, feather and related products, manufacture of paper and paper products, processing of petroleum, coking, processing of nuclear fuel, manufacture of raw chemical materials and chemical products, and manufacture of medicines.

We obtained the total polluting industrial output value (PollutingValue) by aggregating each firm's data at the district and county levels. We then introduced the variable and interaction terms of DZ, Policy and PollutingValue into the previous model. The results are shown in Table 3. The interaction terms are consistently negative and significant, suggesting that the "Water Ten Plan" is more efficient in improving water quality in DZs with industries that are relatively heavy polluters. The results satisfy our expectations that heavily polluted agglomerations can be efficiently governed under the "Water Ten Plan".

Table 3. The effect of polluting industries.

	(1)	(2)
DZ*Policy*PollutingValue	−0.018 *** (0.006)	−0.018 *** (0.007)
DZ	0.187 *** (0.001)	0.158 *** (0.007)
Policy	−0.052 (0.270)	−0.013 (0.798)
PollutingValue	0.008 ** (0.023)	0.001 (0.862)
lnGDP		−0.022 (0.227)
lnPopulation		0.162 *** (0.000)
lnIndustryValue		−0.109 *** (0.002)
Urban		−0.139 (0.150)
Capital		0.080 (0.409)
TreatmentPlant		−0.003 (0.277)
lnPrecipitation		−0.055 (0.271)
lnFertilizer		0.100 *** (0.001)
lnCityWastewater		0.087 ** (0.015)
Constant	2.818 *** (0.000)	3.638 *** (0.000)
River system dummy	Included	Included
Observations	1994	1994
R-squared	0.396	0.431

Note: *p* value in parentheses; *** *p* < 0.01, ** *p* < 0.05.

5.3. Robust Check

Given that the results may have been affected by systems with extreme values, we first deleted the record of the most polluted river system sample (Dianchi Lake) to check the robustness of the results in column 1 of Table 4, and found that the coefficient remained roughly the same. Similarly, we deleted the record of the sample with the cleanest river system in column 2 and deleted the sample located in municipalities and provincial capital cities (column 3), which also did not change the results. Finally, we replaced the dependent variable with regional GDP or population for a null test, and the results showed that the interaction term of DZ and Policy was insignificant, thereby proving the robustness of the original estimate.

In summary, the empirical test suggested that industrial agglomerations in DZs accounted for water deterioration in the district, but also provided opportunities for establishing centralized pollution treatment under proper environmental policies. Our results indicate that environmental policy targeting DZs can effectively reduce water pollution levels compared with other districts.

Table 4. Estimate results of robust checks.

	(1)	(2)	(3)
	Delete the most polluted river system	Delete the least polluted river system	Delete the municipalities and provincial capital cities
DZ*Policy	−0.165 ** (0.040)	−0.168 ** (0.044)	−0.200 ** (0.020)
DZ	0.162 ** (0.015)	0.160 ** (0.016)	0.209 *** (0.002)
Policy	0.003 (0.966)	−0.006 (0.922)	0.039 (0.496)
Urban characteristics	Included	Included	Included
River system dummy	Included	Included	Included
Observations	1938	1938	1646
R-squared	0.231	0.300	0.301

Note: *p* value in parentheses; *** *p* < 0.01, ** *p* < 0.05.

6. Conclusions

Many studies have explored the relationship between agglomeration and pollution, and the effect of environment policies on pollution reduction, but most of them are based at the scale of the city or industry, or they are qualitative studies. As the effects of environmental policy are hard to quantify, research based on development zones is scarce. This paper investigated the issues using a quasi-natural experimental method by matching water monitoring sites and DZs. We found that DZs can lead to water-quality deterioration, but the “Water Ten Plan”—which was released in 2015 and has required DZs to possess wastewater treatment facilities since 2017—can effectively reduce water pollution. DZs within 5 km accounted for a water quality deterioration of 0.09–0.1. When the “Water Ten Policy” was implemented by DZs, the nearby water-pollution levels decreased by roughly 0.16. The “Water Ten Plan” was more effective in improving water quality in DZs with more polluting industries. The findings provide evidence that agglomeration can facilitate efficient wastewater processing by centralized treatment, thereby reducing water pollution intensity in the long run.

This paper provides new insight into environmental issues. Local governments tend to attract enterprises to DZs for economic and political reasons, but DZs are also associated with heavy pollution problems. Most commonly, the method employed to reduce local pollution is to transfer polluting industries to less developed regions, as has been carried out with respect to developed cities in coastal areas. Such a practice simply transfers pollution, rather than reducing it. We would like to echo

the debated issue of whether agglomeration is beneficial or detrimental to the environment. Some studies have suggested that agglomeration is harmful to the environment, and our empirical studies on water quality appear to confirm this idea. However, we also found that environmental policies could efficiently control pollution in agglomerated areas, such as development zones. Pollutant processing for an agglomeration has scale economies that lower the marginal cost of pollution processing, and environmental policies can help propel such a process. Our findings partially support the idea of Porter's Hypothesis; that environmental regulation can help improve the environment through innovative activities of enterprises and organizations.

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