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Article

Decentralization and Transboundary Pollution: Evidence from the Change of Water Pollution Levels in China

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Abstract: Pollution spillover is an important issue to improve the water environment of transboundary rivers, which has been aggravated by the decentralization of China's pollution control and promotion system.This paper analyzes the evolution of the pollution reduction mandates and the possible change of water environment in China which are tested with the water quality data of state key monitoring sections in 2004-2014 .In terms of research methods, this paper mainly uses Propensity Score Matching reference with group difference test and OLS. Empirical findings support the association between decentralization and pollution levels. The pollution levels of the monitoring points located at the boundary are significantly higher than that of interior counties. The pollution of tributary is more serious than trunk stream，which quickly reversed after the system changed. Water pollution levels rapidly changes when we compare the monitoring site in front of jurisdictional boundaries with that after the jurisdictional boundaries. We draw the following conclusions that local goverments may manipulate pollution within their jurisdictions and total pollutant control system will exacerbate border pollution, while water quality inspection can reduce marginal pollution.

Keywords: Boundary effect; Transboundary pollution; Propensity Score Matching

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1. Introduction

Pollution spillovers of trans-boundary river is one of the most important research questions in environmental economics, Because the negative externalities of pollution are amplified by the flow of water. The emissions from the upstream area exceed the capacity of the river's self-purification which causes the pollution levels of downstream to be more serious than that of upstream. Rivers across jurisdictional boundaries are more polluted because of non-coherence because of the decentralization of regional finance and environmental management, which leads to the more serious transboundary pollution phenomenon. Sigman[1] find that the pollution in the upstream of jurisdictional boundaries will be serious 40%. A great deal of research have found that decentralization of environmental governance leads to more serious transboundary pollution Inverted U-shaped curve[2]. Sigman [3] study the impact of decentralization on water quality by studying pollution in rivers around the world. The closer the border is, the more serious the pollution is. The harm of transboundary pollution is very serious, because it seriously damages the health of border residents[4],such as diarrheal diseases and digestive system cancers. The poor living in the border are disproportionately affected by transboundary pollution.

Pollution across the jurisdictional boundaries of the river basin can also cause environmental inequality which has been particularly serious over the past few years [5]. The total pollutant control system, which environmental protection department develop based on environmental carrying capacity, is weakened. This is a threat to ecosystem security.

China is one of the countries with the lowest per capita freshwater resources, but water quality has deteriorated over the past 30 years. 75 percent of the lake water can’t be used as drinking water. The deterioration of water quality is an important cause of the high incidence of cancer in China [6].

Ebenstein[7] find that a deterioration in water quality will increase the incidence of gastrointestinal cancer 9.7%. Cai et al.[8] have studied China 's Water Pollution Reduction Policy from 1998 to 2008 which actually led to more pollution on the downstream of the provinces with more levied sewage charges levy. The existence of transboundary pollution problems has made the issue of local government governance more complex. What is more serious is that it affects the residents' environmental attitudes. He et al. [9]have studied the impact of transboundary water pollution on people's WTP and found that WTP is negatively affected the water quality from the upstream. This phenomenon is more pronounced when the downstream has a weak negotiation capability. More and more studies have found that fiscal decentralization and decentralization of environmental governance seriously affects pollution abatement in China.

Due to the deteriorating water quality, the Chinese government began to control the total amount of pollutants in major basin from the "Tenth Five-Year Plan", but river water quality has not improved significantly. Regulatory system is the most important systems of water pollution control and is the basis of the incentive system and participatory system in China. The central government has incorporated the emission reduction targets into the scope of official assessment from the "Eleventh Five-Year", which lead to a decline in pollutant emissions from various regions. The question is that border pollution disputes and environmental group events have increased dramatically at this period. The first reason for this matter may be people's awareness of environmental protection gradually awakened with the improvement of living standards. On the other hand these things also show that environmental management is not able to meet the needs of the public environment and exactly the current environmental system is ineffective. Cat et al. shows that total water pollution control system may increase the total emissions of pollution in China. The formal implementation of water quality assessment is the period of "12th Five-Year plan", of which emission reduction effect has not been sufficiently studied. In view of the harm of boundary pollution, it is necessary to further study the effect of regulation on water quality improvement and boundary pollution. In particular, we need to pay attention to the change of boundary pollution in the process of institutional evolution.

The existing studies have verified the existence of tranboundary pollution from different aspects and the effect of decentralization on border pollution, but little attention has been paid to the changes of pollution levels in watershed border of China. China is in the economic transition period and the tolerance to treat water pollution of the whole society is declining. Pollution reduction mandate is being perfected to take into account the public environmental rights, environmental justice and justice. Study on the relationship between pollution reduction mandate and river basin boundary pollution will improve the water pollution control system, at the same time the ongoing practice of pollution abatement to provide reference.

2. Evolution of China 's Water Pollution Regulation

2.1. Decentralization of environmental management

China firstly proposed to carry out the control of total pollutants in the "Ninth Five-Year Plan" which is also the first five-year plan for environmental protection, but there are no specific measures and objectives. "Tenth Five-Year Plan" clearly requires local governments to reduce pollutant emissions with the by 10% of expected target. For a long time, local officials in China have been mainly motivated by the promotion of GDP growth and tax revenue, so the main pressure facing local governments is economic development. An important reason for the rapid development of China's economy is the fast rise in the volume of foreign trade in industrial products which is accompanied by a large amount of pollutant emissions. Local economic growth causes large amounts of pollutants, but local governments are reluctant to bear the costs of dealing with pollution because the cost of pollution control is high. Due to the concealment of pollution emissions and the persistence of damage, there is the phenomenon of excessive pollution emissions across the country. The pollution reduction mandate is a typical localized pollution control, mainly relying on local environmental protection departments which take orders from the local

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government. The regulatory agency of environmental protection was the Bureau of Environmental Protection(BEP) in China before 2008, it was promoted to the Ministry of Environmental Protection (MEP). MEPs at each level are in charge of enforcing the environmental protection regulations in the localities, but local MEPs are controlled by the same-level local governments. MEPs justly decomposed the targets of pollution reduction, and did not mention how local governments meet these targets. The emission reduction targets of "10th five-year plan" is expected with no coercive force. Local officials may ignore environmental issues and pay attention to economic development by promoting incentives. Wu et al.[10] find out that local government officials use high-pollution technologies just for cost savings.

Under the decentralization of financial and environmental management, the total emissions of local pollutants will exceed expectations. Localization of environmental governance may also create pollution spillover in space, which will create tranboundary pollution. Local government leaders must also minimize environmental emergencies and environmental petitions because it reduces the probability of their promotion, so local governments still need to control the total amount of pollutant emissions. Local governments have the incentive to concentrate pollutant emissions in downstream of the river across the area, especially at the jurisdictional junction. In this way the GDP growth are the performance of local officials, while the costs of pollution control and the loss caused require the downstream area to bear. This has resulted in higher pollution in the border areas than in the region. Duvivier and Xiong [11] contrasted polluting firms' location choices in Hebei province and found out that polluting firms are more likely to set up in border counties than in interior ones, which they think is the result of decentralization. Zhang [12] found that local MEPs are often encouraged by local government officials to turn a blind eye to environmental pollution. The existence of transboundary pollution makes the border areas pollution paradise, which damage the whole community especially the nearby residents. Excessive pollutant emissions and border pollution is the situation of local pollution control in China before 2006. COD is only reduced by 2% and other pollutants even increased at the end of the "Tenth Five-Year plan".

H1: decentralization of Fiscal and environmental management will form transboundary pollution.

2.2 Total pollutant discharge assessment

For the gradual increase in pollution, the central government for the first time set the binding indicator to reduce COD emissions by 10% in the period of "Eleventh Five-Year plan". Local governments were asked to reduce emissions at least not below this target. The binding index has the legal effect, and the result is the reference for the promotion of local officials. The leading cadres of local government and state-owned enterprises, who may face punishment or dismissal if the target can't be completed, are responsible for the implementation in the "one vote veto" system. Total pollutant discharge assessment has played a significant role in reducing local pollutant emissions and COD emissions decreased by 12.45 percent from 2006 to 2010. The scope of this environmental improvement may be limited because the higher authorities only assess COD. Zheng et al. [13] find out that the mayors have reduced the total amount of pollution emissions under the pressure of the central government and the public in this period. Kahn et al.[14] use difference in difference to study water quality change in key river basins in China from 2004 to 2010.They find out that COD emissions fell by 54% but other pollutants which are not included in assessment content did not show a significant decline.

Although the assessment of pollutant discharge has improved the water quality, the effect on the boundary pollution has not been unanimous. The pollution levels of transboundary rivers may occur in two cases which are opposing each other. The first case is that the boundary pollution of the river basin will be reduced because the total amount of pollutant emissions from the local government will be reduced under the pressure of total pollutant discharge assessment with increasing the investment in pollution control. In the condition of environmental carrying capacity and self-purification capacity, pollutant that flows downstream decrease, which improve the whole basin water quality accompanied by improvement in boundary area. Kahn et al. has proved that the water quality in the border areas is improving faster, and that the newly built heavy polluting enterprises are less likely to choose the border area in this period.

The other situation is that transboundary pollution may be more serious, which implies that the pollution of the border area is higher than that of the internal area. Local governments want to achieve better emission reduction at lower cost to minimize the impact on economic growth. In order to meet the higher levels of government assessment and public pressure, local government officials may be achieved by reducing the total emissions, or through the downstream areas of the border row. Local governments may relax regulation of polluting enterprises near jurisdictional boundaries and acquiesced in the jurisdictional boundaries secretly sewage. Local environmental protection departments may also be more direct transfer of heavily polluting enterprises to the downstream areas. The total amount of pollutants in the assessment is helpful to reduce the pollutant emission, but the phenomenon of transboundary pollution has not been reduced, even in some areas worse. Cai et al. use pollution source census data of China to study the behavior of wastewater pollution enterprises, which showed that 20 percent more polluting activities in the downstream county of a province. The assessment of "11th Five-Year plan" is mainly for the total COD emissions and emission reduction project progress lack of specific requirements for water quality improvement. Local governments may only reduce total pollution emissions due to higher government assessment and public pressure and will discharge pollutants in the downstream areas in order to reduce the impact on economic development. It is an environmentally free ride.

H2: Pollutant emissions from local places have been reduced under total pollutant discharge assessment.

H3：The total amount of pollutant emissions assessment will exacerbate the phenomenon of transboundary pollution.

2.3 Total pollutant discharge assessment and water quality assessment

People continue to complain about poor water quality and border pollution because of the Chinese people's income level and the popularity of the network. "Twelfth Five-Year Plan" requires local governments to reduce COD emissions by 8% and ammonia emissions by 10% from 2011 to 2015, which is more stringent and wider range compared to the previous five years. The main content of water quality assessment system is to check the water quality of the local water quality monitoring points that are directly managed by the central environmental protection department. 30 percent of monitoring points are near the provincial jurisdictional boundaries. Water quality assessment system was first appeared in the river basin pollution control plan in 2006, The constraints of which are weak and there is lack of action. Six ministries jointly formulated and issued the specific assessment approach in april 2009, which did not play a rigid constraint until the first assessment came out in June 2011. Failure of water quality targets will affect the promotion of local officials since then[15]. Total Emission Reduction and river cross section water quality assessment does improve water quality because local officials are subject to promotion incentives. Water quality cross-section assessment may has brought about a decrease in the degree of transboundary pollution. The strengthening of the total pollutant emission reduction system requires local governments to reduce total emissions of pollutants while cross sectional water quality assessment makes the cost of local pollution emissions internalization.

Water quality assessment not only prompted the local government to focus on improving the domestic water quality, and may weaken the cross-border river boundary pollution phenomenon. There may be two cases for the river basin water quality assessment as a rigid constraint in the process of reducing border pollution. The first is that the governments of all regions should seriously reduce pollution emissions and increase the input of pollutants treatment, which will undoubtedly improve the water quality throughout the region. The second case is that the water quality cross-section assessment may lead to strategic polluting of local government speculation. Water quality monitoring data may have been improved for inspection, but in fact the transboundary pollution is not much reduced. Water quality cross-section assessment stipulates that exit water quality must be higher than entry water quality for a region if the goal of improving water quality can't be done. Upstream may discharge of sewage behind the monitoring points near the border, so the water quality of the site data is normal although the upstream excessive discharge of pollutants. Downstream may discharge of sewage before the monitoring points near the border, so the water quality of the site data is poor although the upstream do not excessive discharge of pollutants. Local government may appear strategic polluting with the water quality assessment into practice. Polluting the neighbor give rise to destructive competition between jurisdictions, which might cause an association between pollution level and decentralization.

H4：The implementation of water quality cross-section assessment will reduce the observed transboundary pollution

H5：Local governments will engage in strategic polluting in the pollution reduction in the context of decentralization.

3. Empirical strategy

The location of monitoring points is an important explanatory variable in order to study the existence and change of transboundary pollution. Although the monitoring site is widely distributed but the total is not large, the comparability between sites is the key to the conclusion. OLS estimates can overcome the defects of inter-group discrepancy test by considering other control variables, but the independent assumptions of the explanatory variables are often not satisfied. The selection of monitoring sites was not random in this study, so OLS estimates are not suitable. Propensity score matching (PSM) is more appropriate for this study, in which the explanatory variable is independent of the explanatory variable in the case where the negligible assumption holds. The validity of propensity score matching is based on the absence of missing important variables, which means taking into account all the important factors that might affect the explanatory variables [16]. The massive data and sufficient covariates can meet the needs in this study, so this paper uses PSM to estimate Average Treatment Effect (ATE) and Average Treatment Effect on the Treated (ATT). Although many studies have reported ATE, policy makers may be more interested in ATT for it is the net effect. We use the most commonly used logit method to estimate the score of monitoring site with replacement. The matching method can be divided into K-nearest neighbor matching, caliper matching, spline matching and kernel matching. Which method is best has not yet been unanimously agreed, so It is generally believed that the most robust results of the different methods are the most credible.

We consider a range of socioeconomic, water resources, environment, demographic, seasonal effect and other characteristics to mitigate selection based on unobservable variables. The degree of regional economic development determines its industry ,there is close relationship between per capita income and pollution emission according to the Environmental Kuznets curve. Industrial wastewater discharge is one of the main causes of water pollution and regional industrial structure determines the amount of sewage discharge. The degree of openness is closely related to the regional economic development model and A large number of studies have examined the existence of pollution heaven hypothesis in China. The total amount of water resources will affect the industrial structure of the region. The amount of surface water resources has a decisive effect on the self-purification capacity of water environment. The higher the intensity of environmental regulation is, the better the water quality improvement. Environmental inspectors are directly supervising corporate emissions and environmental improvements. River water flow changes vary widely in different months. The main research object of this paper is the change of these four indexes, and we use NpH to represent the absolute value of the difference between PH and 7.

4. Data

Water quality data come from water quality automatic monitoring weekly report on major river basin from 2004 to 2014, which can be obtained from the Ministry of Environmental Protection data center. The monitoring site is located in the stream of the important rivers, the entrance of the important tributaries and the river mouth, the important lakes and reservoirs, the national border rivers, major water conservancy projects in China. The monitoring sites studied in this paper include all sites considering the possible bias caused by the artificial selection of the site. China's water quality automatic monitoring system is constantly improving with the monitoring site changes. There are 73 monitoring points at the beginning of 2004, the number increased to 82 in the eighth week of 2005. An increase of 2 monitoring points in the forty-eighth week of 2006, monitoring points reached 100 in the twenty-second week of 2007, 115 in the twenty-third week of 2011, 131 in the twenty-third week of 2012 and up to 145 in 2014 at the twenty-third week. The monitoring station adopts the method of on-line continuous monitoring, and the monitoring frequency is once every 4 hours. The monitoring data is transmitted to the provincial monitoring center and the China Environmental Monitoring Station at the same time. Monitoring site management and data release is responsible for the Ministry of environmental protection, which can avoid the problem of self-reported water quality in some degree. The authenticity of the monitoring data is essential, which has been emphasized by Bernauer and Kuhn[17]. Weekly report is a summary of the data for the week including 4 pollution indicators such as hydrogen ion concentration(pH), dissolved oxygen(DO), chemical oxygen demand(COD) and ammoniacal nitrogen(NH3-N). Monitoring data may be missing due to power supply, flood, or disconnection, so the data set is unbalanced panel data. Overview of the water quality data is in Table 1. And Figure 1.

Table 1. Water quality data of monitoring sites

	pH		DO		COD		NH3-N	
year	number	mean	number	mean	number	mean	number	mean
2004	3397	7.682	3363	7.202	3397	5.672	3384	1.303
2005	4072	7.672	4010	7.243	4060	5.84	4049	1.154
2006	4121	7.664	4067	7.349	4116	5.753	4041	1.172
2007	4789	7.723	4734	7.191	4766	5.864	4763	1.24
2008	5015	7.791	4972	7.458	4961	5.682	5013	1.188
2009	4926	7.758	4900	7.514	4914	4.856	4911	1.068
2010	5048	7.745	5030	7.596	5045	4.758	5037	0.868
2011	5576	7.811	5558	7.845	5567	4.6	5569	0.777
2012	6272	7.703	6249	7.922	6263	4.113	6258	0.587
2013	6641	7.66	6639	7.866	6630	4.097	6632	0.589
2014	6855	7.673	6848	7.959	6857	4.09	6852	0.55
Total	56712	7.717	56370	7.613	56576	4.9	56509	0.902
Min		6.54		0.53		0.6		0.02
Max		8.98		14.2		44.5		14.6

We construct a range of socioeconomic, water resources, environment, demographic, seasonal effect and other characteristics to mitigate selection based on unobservable variables.
Specific indicators and data sources of characteristic variables are listed below as Table 2.

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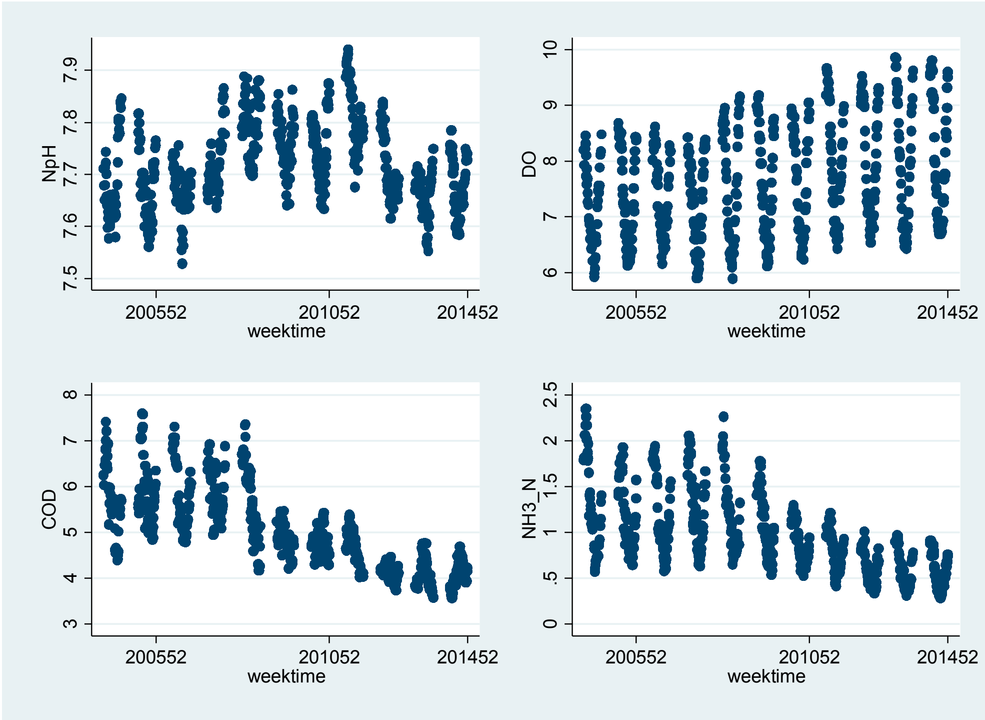

Figure 1. Average weekly water quality

Table 2. Covariant form

Classification	Index	Sources
Regional economic development	Natural logarithm of annual Prefecture level city per capita GDP	Statistical yearbook of China regional economy
	Natural logarithm of quarterly provincial per capita GDP	National Bureau of Statistics website
industrial structure	Annual city level industrial added value accounted for the proportion of GDP	Statistical yearbook of China regional economy
Opening degree	Annual city level FDI accounted for the proportion of GDP	Statistical yearbook of China regional economy
	Monthly provincial export and import ratio	National Bureau of Statistics website
Environment and resource endowment	Natural logarithm of annual provincial per capita water resources	China Environmental Statistics Yearbook
	Natural logarithm of annual provincial surface water per capita	
	Annual runoff of the river Mean annual runoff of the river River length	China Water Resources Statistical Yearbook
Environmental protection	Natural logarithm of sewage charges	China Environmental Statistics Yearbook
	The proportion of environmental Supervisors in provincial environmental protection institutions	
	The proportion of environmental supervisors in county environmental protection institutions	
time factor	Annual dummy variable	
	Monthly dummy variables	

Notes: 1. All monetary variables are deflated to 2005 yuan using provincial GDP deflators.2. The aggregate data is processed by natural logarithm, which is comparable to different dimensions.

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5. The evolution of transboundary pollution

5.1. The existence of boundary pollution

Table 3. Boundary pollution existence test

	NpH		DO		COD		NH3-N	
	OLS	Diff	OLS	Diff	OLS	Diff	OLS	Diff
Total sample	0.24***	-0.26***	-0.33***	0.18***	3.01***	-2.82***	0.94***	-1.04***
2004-2005	0.09***	-0.15***	-0.48***	0.22***	3.92***	-4.52***	0.90***	-1.21***
2006-2010	0.25***	-0.25***	-0.41***	0.27***	3.48***	-3.40***	1.12***	-1.33***
2011-2014	0.24***	-0.30***	-0.22***	0.12***	2.18***	-2.17***	0.71***	-0.79***

Notes:1. In order to report the information as much as possible, this paper only reports the regression results of the dummy variables omitting the other control variables and the constant term. 2. The Diff test is a significant measure of the difference between the non-provincial monitoring points and the provincial boundary points.3. * Significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

OLS is used to test the impact of monitoring stations near the provincial boundary on water quality in consideration of all the case of control variables to control for confounding factors. This paper set up a virtual variable which is 1 when the monitoring points are located near the border. The results of the inter-group difference test and OLS estimation for the presence of boundary pollution are shown in Table 3, from which we can get that the water quality of the monitoring site at the provincial boundary is worse than that of non-provincial boundary monitoring site. The deviation of the PH value from the normal value in the water at the provincial boundary monitoring site is greater than that of the non-provincial monitoring site and the trend is increasing. The DO value in the water at the provincial boundary monitoring site is lower than that of the non-provincial monitoring site as a whole, which has been strengthened by 2011 and will begin to weaken after 2011. The COD value of the water at the provincial monitoring site is higher than that of the non-provincial monitoring sites, but the difference of COD value is decreasing during the 11th Five-Year Plan and the 12th Five-Year Plan period. The NH3-N value in the water at the provincial monitoring sites is higher than that of the non-provincial monitoring sites and the difference of NH3-N value is increasing before 2011 but decreasing during the 12th Five-Year Plan period.

Table 4. The propensity score matching results

		NpH		DO		COD		NH3-N	
		ATT	ATE	ATT	ATE	ATT	ATE	ATT	ATE
(1)	nearest neighbor	0.22***	0.20***	0.09	-0.08	3.57***	1.56***	0.77***	0.63***
	matching	(15.45)	(15.07)	(1.02)	(-1.13)	(33.74)	(14.66)	(11.54)	(14.67)
(2)	caliper matching	0.01***	0.21***	0.08*	0.03	3.59***	1.51***	0.78***	0.60***
		(19.24)	(16.47)	(1.82)	(0.63)	(37.29)	(15.02)	(12.18)	(14.31)
(3)	spline matching	0.22***	0.19***	0.02	0.03	3.80***	1.57***	0.87***	0.54***
		(32.36)	(35.02)	(0.5)	(0.98)	(47.5)	(25.25)	(21.95)	(21.28)
(4)	kernel matching	0.22***	0.17***	0.02	0.03	3.80***	1.61***	0.86***	0.55***
		(35.85)	(39.96)	(0.47)	(0.97)	(48.05)	(25.73)	(19.61)	(22.22)
(5)	nearest neighbor	0.23***	0.21***	0.15***	0.06*	3.58***	1.47***	0.78***	0.59***
	matching with AI	(39.94)	(43.25)	(5.02)	(1.68)	(88.21)	(41.17)	(36.18)	(42.53)
(6)	Mahalanobis	0.21***	0.25***	-0.08***	-0.02	3.96***	2.06***	1.05***	0.75***
	matching with AI	(42.15)	(68.64)	(-3.20)	(-1.13)	(130.09)	(68.97)	(70.59)	(63.96)
(7)	2004-2005	0.10***	0.09***	0.08	0.24***	5.71***	1.92***	1.00***	0.37***
		(7.33)	(5.05)	(1.34)	(5.96)	(48.62)	(18.01)	(22.28)	(12.29)

(8)	2006-2010	0.25***	0.21***	0.15***	-0.08***	6.10***	2.18***	1.90***	0.83***
		(31.02)	(30.7)	(3.01)	(2.71)	(61.97)	(30.45)	(27.11)	(33.10)
(9)	2011-2014	0.18***	0.22***	-0.09	0.11***	2.40***	1.01***	0.61***	0.50***
		(21.55)	(28.26)	(-1.24)	(3.05)	(45.83)	(18.98)	(20.63)	(24.1)

Notes:1. First row is the 1 order nearest neighbor and we choose the 4 order caliper matching for Row (2). 2. Nearest neighbor matching with AI choose the 4-nearest neighbor matching.3. Row (1)-(4) use bootstrap and the following brackets are the Z values that are repeated 300 times because of the method.4. Row (5)-(9) use heteroskedasticity robust standard error and the following brackets are the t values. The results of the 4 order nearest neighbor matching are considered to be the most robust by comparing different matching methods, so this method is used in the study for different time periods. 5. * Significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

The smoothness test of the results showed that the majority of the variables were smaller in standard deviation, and most of the observed values were within the common range of the matching score, which proved that the results were stable after matching. This section mainly studies the differences between the provincial boundary monitoring stations and the others. Here we focus on ATE with the ATT as reference. It can be found that the results of several matching method is robust and water quality of provincial boundary monitoring points is significantly worse than that of non-provincial boundary monitoring points in Table 4. The deviation of the PH value from the normal value in the water at the provincial boundary monitoring site is greater than that of the non-provincial monitoring site. This phenomenon continues to deteriorate until the period of "12th Five-Year Plan". The COD value of the water at the provincial monitoring site is higher than that of the non-provincial monitoring sites, the gap of which is widening during the period of "11th Five-Year Plan" but narrowing from the period of "12th Five-Year Plan". This phenomenon also exists in NH3-N that the pollutions near provincial boundaries increase at first and then decrease. In addition to DO values, these phenomena are consistent with those found in table 2. This may be because the Do value is an important index to measure the self-purification capacity of water body, and the increasing of DO value indicates that the water body is in a state of continuous improvement.

Although the pH of the water has improved since 2011, the PH value of the provincial boundary continues to deteriorate. PH is not included in the current pollutant emission reduction system and the binding to PH is weak in cross-section assessment program. The pH value of water will improve due to the overall improvement of the water environment at the same time, for example, NH3-N itself is alkaline. According to the previous study we can get that all indexes have boundary pollution in the period of "10th Five-Year Plan". During the period of "11th Five-Year Plan", the overall COD and NH3-N has been reduced under the pressure of total emission reduction. The phenomenon of boundary pollution not only did not reduce, but strengthened. It was not until the period of "12th Five-Year Plan" that the phenomenon of boundary pollution was reduced under the dual pressure of total pollutant emission reduction and water quality assessment. Upstream concentrate water-polluting activities in the downstream to shift the burden of pollution to their downstream neighbor. This confirms the hypothesis mentioned above that total pollutant control can improve water quality but will bring transboundary pollution which requires water quality assessment system.

5.2. Trunk and tributary

The result may be not accurate if we directly compare the sites on province boundary and others which include 17 lake monitoring points and 6 national border monitoring points just in 2007. Lakes and reservoirs are protected by urban centralized drinking water source protection plan and the water quality is obviously better than other areas. The water quality of the national border monitoring points, especially the entry point, is significantly better than the domestic monitoring points. This leads to an unmatched question comparing water quality of the province boundary site

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with that of non-province boundary site. One solution to this problem is to consider the trunk and tributary monitoring points separately.

Table 5. Differences of pollution levels between trunk and tributary

	NpH		DO		COD		NH3-N	
	Diff	OLS	Diff	OLS	Diff	OLS	Diff	OLS
Trunk	-0.11***	0.10***	-0.52***	0.45***	1.33***	-0.79***	0.13***	-0.11***
Tributary	-0.40***	0.27***	0.39***	-0.75***	-5.35***	5.22***	-1.60***	1.28***
	ATE	ATT	ATE	ATT	ATE	ATT	ATE	ATT
Trunk	0.11***	-0.01	0.25***	0.74***	-0.55***	-0.45***	0.03***	-0.12***
	(12.59)	(-0.83)	(7.11)	(9.34)	(-13.01)	(-10.04)	(2.86)	(-8.14)
tributary	0.24***	0.24***	0.44***	0.44***	4.96***	4.96***	0.72***	0.72***
	(22.53)	(22.53)	(7.64)	(7.64)	(89.35)	(89.35)	(16.94)	(16.94)

Notes: 1. All results use 4 order nearest neighbor matching and heteroskedasticity robust standard error, which the following brackets of are the t values. 2. All control variables and theconstant term are included but not reported in OLS, the dummy variable of which is 1 if the monitor station is on the tributary. 3. * Significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

As can be seen from Table 5, there is a significant difference between the trunk and tributary in the border pollution. The four indicators all show that the observation points at the tributaries are basically the same as the total samples, that is, the monitoring sites at the province boundary are more polluting. Transboundary pollution of tributaries is more obvious in some degree. The water quality of the observation points located at the trunk is quite different from the overall. Although some indicators such as NpH and NH3-N support the existence of boundary pollution, the phenomenon become very weak in economic and statistical sense. Water quality of province monitoring points in trunk have higher DO and lower COD ,which means that water quality of province boundary point is better. The reasons for the differences in the performance of the main and tributary monitoring points are multifaceted and the following two aspects may be most significant. On the one hand is an objective reason that the trunk flow from a number of tributaries and continue to have a new tributary inflow, so the water self-purification ability is stronger. At the same time the trunk is subject to more supervision. While the tributary pollution control faces higher regulatory cost which lead to polluting enterprises concentrated in the tributaries. The water quality monitoring point is set up from the trunk, which leads to the weak binding of the pollution control system to the grass roots government. On the other hand, the phenomenon is caused by the implementation of the pollution control system from top to bottom. The central government and the provincial government signed water environmental objectives responsibility and the province government and the city government signed later. Local governments do not have the incentive to fully implement the current emission reduction policies, especially if they are also an important source of local revenue because of the difficulty of the transformation and upgrading of sewage companies. Local governments need to raise their pollution control funds, but the local government revenue sources are very limited. These verify the hypothesis five that the implementation cost of water pollution control system implemented from top to down is high and local governments may focus on detected values rather than actual emissions.

5.3 The changes of pollution levels between upstream and downstream

In this section, we use the objective provincial boundaries to divide the stations located near the provincial boundaries into two groups, which can help us avoid the irreversibility of monitoring sites from another perspective. According to the direction of the flow, the provincial boundary monitoring points can be divided into the upstream and downstream points with the provincial boundary line. There is no monitoring site across the two provinces at the same time. From the ATE of Table 6, the difference between the upstream monitoring point and the downstream monitoring point is significant and the upper monitoring point has a better water environment on the whole. But the relationship between water quality of upstream and downstream has changed dramatically over time. The DO value of the downstream point is higher in the fifteen five and eleventh five period, but this phenomenon reversed during the period of "12th Five-Year Plan". The COD value of the downstream point was significantly lower than the upstream in the fifteen five and eleventh five period , but the value of the downstream point was higher during the period of "12th Five-Year Plan". The NH3-N value of the downstream point gradually become worse In contrast to upstream during the fifteen five and eleventh five period , but get better during the period of "12th Five-Year Plan". Similar trends can be found in OLS and difference tests as a reference. The water quality of upstream monitoring point is worse than that of downstream monitoring point, and this phenomenon is deteriorating in the fifteen five and eleventh five period. The water quality of the downstream monitoring point is worse than the upstream monitoring point during the period of "12th Five-Year Plan".

Table 6. The changes of pollution levels between upstream and downstream

	NpH		DO		COD		NH3_N	
	Diff	OLS	Diff	OLS	Diff	OLS	Diff	OLS
Total sample	0.11***	-0.02**	1.04***	-1.53***	0.56***	2.87***	-0.27***	1.294***
2004-2005	0.27***	-0.25***	0.41***	0.78***	4.25***	-1.64**	0.65***	-0.39**
2006-2010	0.12***	-0.02*	1.13***	1.97***	2.88***	-1.88***	0.25***	-1.63***
2011-2014	0.04***	-0.08***	0.97***	-2.12***	-0.60***	3.69***	-0.43***	1.72***
	ATE	ATT	ATE	ATT	ATE	ATT	ATE	ATT
Total sample	-0.11***	-0.22***	-2.04***	-1.33***	5.32***	1.79***	1.57***	1.2***
	(-10.73)	(-21.50)	(-42.36)	(-37.16)	(18.33)	(37.25)	(31.93)	(63.37)
2004-2005	-0.26***	-0.29***	0.19**	0.6***	-2.49***	-3.98***	-0.08	-0.01
	(-11.68)	(-10.11)	(1.97)	(5.31)	(-7.8)	(-10.45)	(-0.77)	(-0.1)
2006-2010	-0.16***	-0.30***	2.14***	1.79***	-3.75***	-1.72***	-1.99***	-1.47***
	(-16.86)	(-24.47)	(39.97)	(31.19)	(-31.62)	(-25.04)	(-24.22)	(-55.34)
2011-2014	-0.08***	-0.19***	-2.65***	-2.29***	4.01***	3.22***	2.21***	2.09***
	(-7.85)	(-16.33)	(-28.47)	(-17.17)	(47.6)	(22.66)	(30.12)	(42.94)

Notes: 1. All results use 4 order nearest neighbor matching and heteroskedasticity robust standard error, which the following brackets of are the t values.2. All control variables and theconstant term are included but not reported in OLS, the dummy variable of which is 1 if the monitor station is on the upstream. 3. * Significant at 10 percent, ** significant at 5 percent, *** significant at 1 percent.

In the period of "10th Five-Year Plan" the water quality of upstream is worse than that of downstream, which can be understood as the upsteam discharge of pollutants at downstream of the river. This causes the phenomenon of tranboundary pollution. The phenomenon of border pollution in strengthening in the period of "11th Five-Year Plan", which may be due to the impact of pollutant emission reduction assessment system. Local government leaders want to achieve both GDP growth and total emissions of pollution reduction targets. The pollutant discharged downward is not included in the total emissions. The water quality was better than that of upstream point in the period of "12th Five-Year Plan", which may be caused by two reasons. On the one hand, it is possible that the upper reaches of the region reduce pollution emissions, even eliminating the pollution emissions near the border. On the other hand, this may this may be speculation of the local government, because the change in water quality is not continuous. Upstream areas may emit more pollutants between monitoring points and provincial boundaries.

Water quality of monitoring site in the upper reaches is acceptable, although excessive pollutants are emitted. Downstream areas also have incentives to emit contaminants between provincial boundaries and monitoring sites. In this way, the water quality flowing into the downstream along the river is not up to standard, so the water quality which this area outflow does not need to meet the standards. There are dramatic changes comparing the water quality of upstream and that of

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downstream as time goes on, which can be explained by the introduction of total amount of pollutants emission reduction system and water quality assessment system. From the above we can see that the total pollution assessment lead to stronger border pollution. Under the pressure of water quality assessment, local governments may be opportunistic in reducing pollution emissions.

6. Conclusions and Recommendations

This paper identify the transboundary pollution and the empirical effects of decentralization on water quality in China, which provide strong evidence of strategic polluting in the main basin of local goverments. we verifies the existence of boundary pollution in China's transboundary rivers from the period of "10th five-year plan". The water quality has been improved in the total pollutant discharge assessment system, but border pollution is more serious in the period of "11th five-year plan". We believe that this is caused by local governments under the pressure of the environment to take low cost sewage way. The water quality assessment section makes local government work hard to improve water quality, especially the water quality of monitoring points near provincial boundary, and weaken the boundary pollution phenomenon in the period of "12th Five-Year Plan". The implication of the pollution reduction mandate since 2001 is twofold. The tranboundary pollution of the trunk is consistent with the whole basin, while tributary is the opposite in some degree. This may be caused by objective reasons that purification capacity of the trunk is stronger. Another possible reason for this phenomenon is the poor implementation of the government's emission reduction policy. The implementation of pollutant emission control and water quality assessment was accompanied by the sharp change of water quality between the front and rear monitoring stations of provincial boundary. The boundary pollution will increase with the environmental pressure of local government and be weakened with the water quality assessment system. There may be speculation in the process of local government's pollution control. The ultimate cause of all these phenomenon is the financial decentralization and environmental management decentralization of China.

Supplementary Materials: No

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Appendix A Median and standard deviation of water qulaity

	PH		DO		COD		NH3_N	
year	P50	SD	P50	SD	P50	SD	P50	SD
2004	7.68	0.541	7.28	2.615	3.8	7.088	0.36	2.704
2005	7.66	0.564	7.39	2.795	3.6	8.049	0.29	2.566
2006	7.67	0.54	7.47	2.721	3.6	7.754	0.31	2.461
2007	7.73	0.521	7.38	2.781	3.6	7.596	0.32	2.66
2008	7.79	0.519	7.57	2.703	3.6	7.191	0.34	2.681
2009	7.74	0.51	7.56	2.559	3.5	5.247	0.33	2.321
2010	7.74	0.53	7.6	2.503	3.6	4.825	0.29	2.023
2011	7.81	0.522	7.73	2.463	3.4	4.736	0.29	1.75
2012	7.69	0.529	7.89	2.55	3.2	3.963	0.24	1.365
2013	7.65	0.531	7.75	2.408	3.3	3.256	0.23	1.434

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2014	7.64	0.535	7.9	2.387	3.3	3.213	0.23	1.455
Total	7.71	0.533	7.64	2.587	3.4	5.732	0.28	2.12

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