Economic Development and Water Pollution: Evidence from 287 Cities in China

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contents

Introduction

■ Economic Development and water pollution in China

Growth of China‘s Economic Development from 1978 to 2022

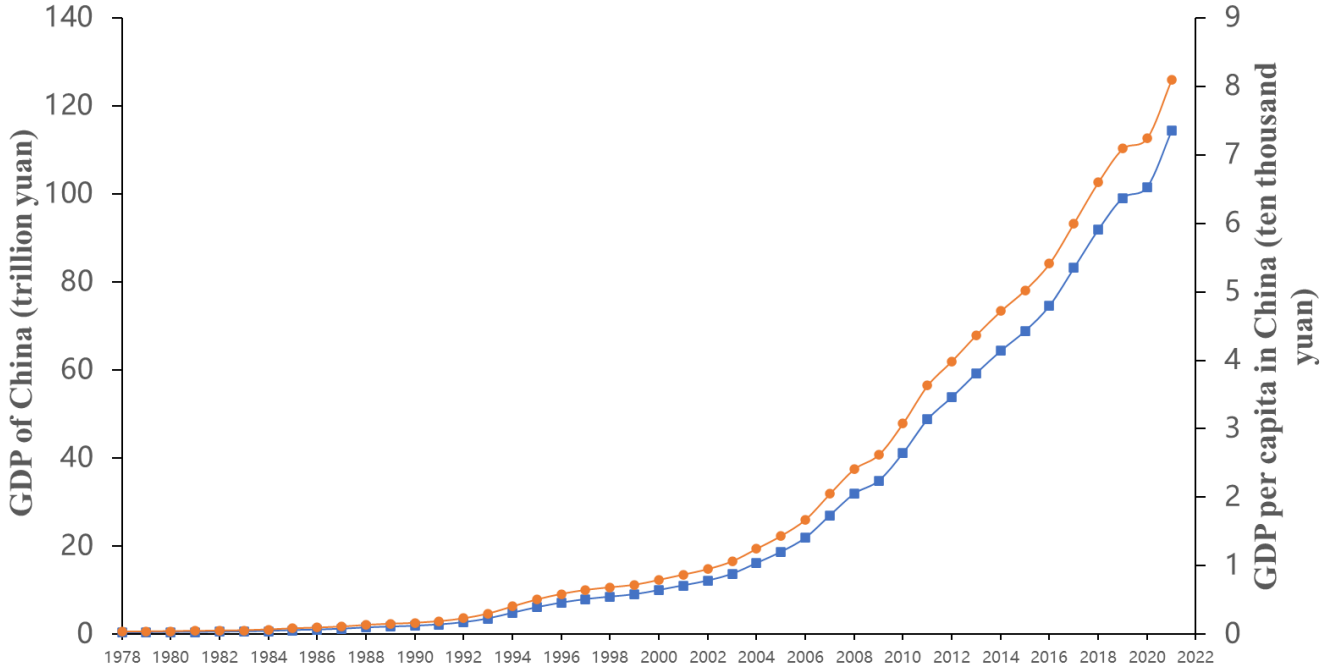


Fig.1
Source: China’ s statistic yearbook

Percentage Change of Water Quality Class over Time

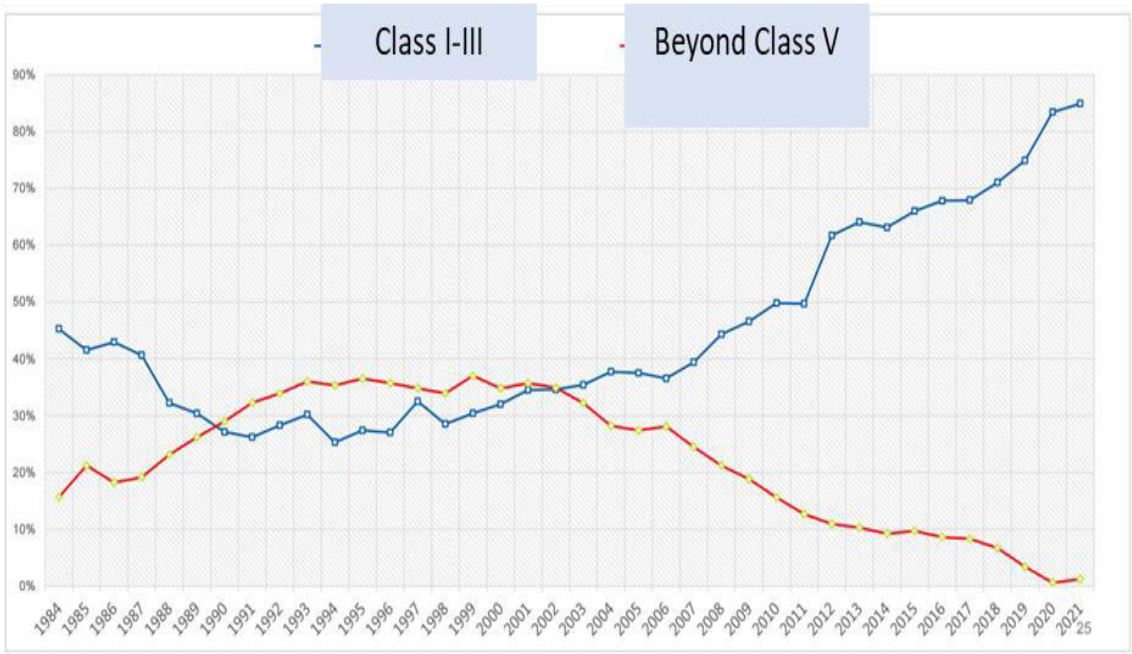


Fig.2
Source: China’s environmental statistic yearbook
According to China’s water quality standard, Class I-III refers water safe for swimming while class v refers to water very polluted

Introduction

■ Protection of ecological environment in river basins

- In recent years, China has made numerous attempts and achieved significant results in protecting the water environment of river basins.
- In 2022, out of 3641 national surface water assessment sections, the proportion of sections with excellent water quality (Class I-III) was 87.9%, an increase of 3 percentage points year-on-year; The proportion of inferior Class V sections is 0.7%, a year-on-year decrease of 0.5 percentage points.

Toolkit for water pollution control in China

- Macro level: Mainstream, integration, planning, IRBM
- Comand and Control(C&Cs): Environmental inspection
- Building urban wasterwater treatment infrastructue
- Market Based Instrument(MBIs)
- Voluntary approach

Introduction

Water pollution in cities over development

- With the rapid development of China's economy, country's water quality has been continuously deteriorating, with an amount of waste water discharge of over 70Gt and a roughly average annual increase amount of 200kt.
- The problem of water pollution in cities' rivers is particularly serious. Extensive human behavior has led to declining phytoplankton downstream and gradual deterioration of downstream water quality (Hu et al., 2020).
- There is a need to explore a sustainable path for harmonizing water pollution and economic growth at the city level.

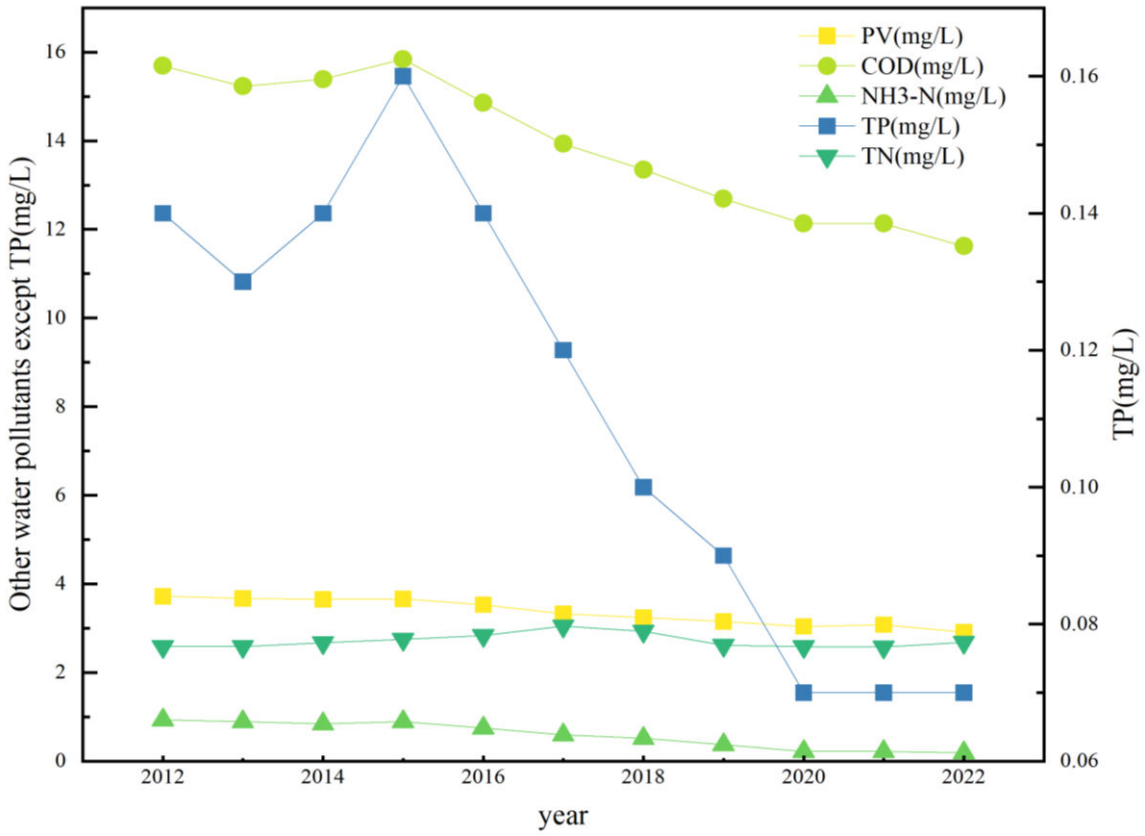
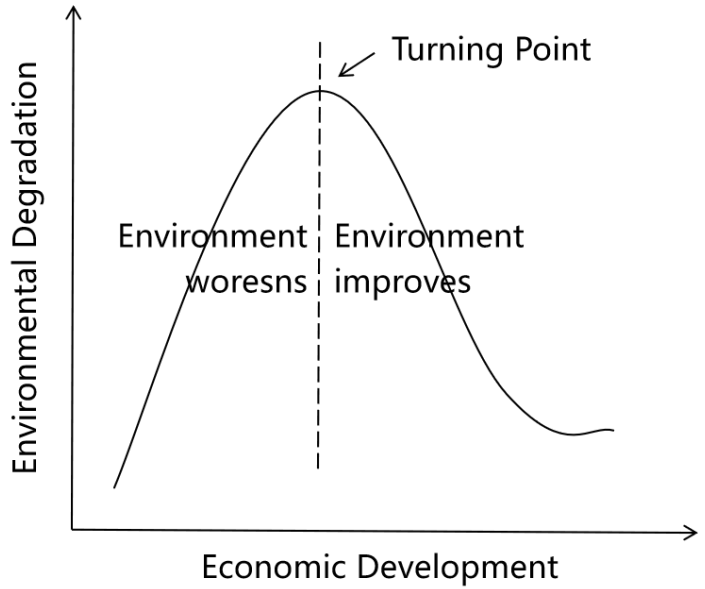


Fig.3 Annual average concentrations of five criteria pollutants in 287 cities of China, 2012-2022
(Data source: Collected at the water quality monitoring section)

Introduction

EKC hypothesis

- The EKC is a critical method of analyzing the relationship be tween environmental deterioration and economic development (Sarkodie and Strezov, 2019).
- Based on the EKC hypothesis, there exists an inverse U-shaped curve between environmental pollution and per capita income, whereby environmental pollution worsens and then improves as per capita income increases.
- By combing through the literature, it can be seen that there are still the following limitations:



There are fewer special studies on water pollution and economic growth.

Most of the data are based on the national and provincial levels.

Most have not yet focused on the differences in EKC patterns in heterogeneous cities and the dynamics of the changes generated by EKC's inflection points.

Methodology and data

The empirical model

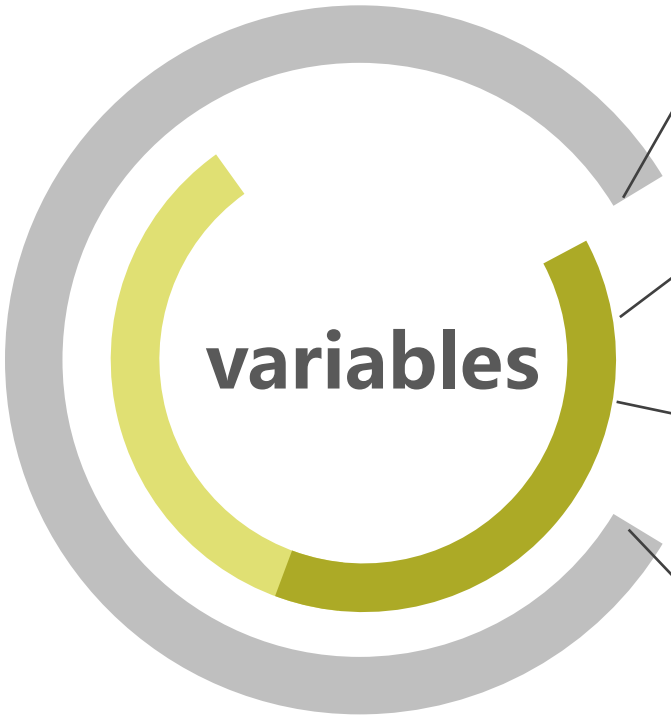
- In this paper, a log-quadratic equation with water environmental quality as the dependent variable and GDP as the independent variable is used to investigate the relationship between water pollution and economic growth, and the significance of the regression coefficients is used to determine whether the EKC meets the "Inverted U-shaped" characteristics.
- The specific form of the econometric model is as follows.

$$E_{it} = \alpha_0 + \varphi E_{it-1} + \alpha_1 lny_{it} + \alpha_2 ln^2(y_{it}) + \alpha_3 \bar{y}_{it-} + \alpha_4 X_{it} + \beta_i + \mu_t + \gamma t + \varepsilon_{it}$$

- ✓ E_{it}: concentration of water pollutants in city *i* in year *t*.
- ✓ lny_{it}: the logarithm of GDP in city *i* in year *t*.
- ✓ $\bar{y}_{it-}$: the average of the previous three years' GDP, representing the impact of "permanent income".
- ✓ X_{it}: a vector composed of a set of control variables, including environmental regulatory intensity ($regu_{it}$), technological progress (tec_{it}), industrial structure (ISU_{it}), and urbanization rate (RU_{it}).
- ✓ α_0: constant term, α_1, α_2, α_3, α_4 denote the coefficients of regression.
- ✓ β_i and μ_t: the city fixed effect and the year fixed effect.
- ✓ γt: the time trend term.
- ✓ ε_{it}: the random disturbance term.

Methodology and data

Variables description



Dependent variable: Permanganate Value (PV_{it}), NH_3-N (NN_{it}), Biochemical Oxygen Demand (COD_{it}), Total Nitrogen (TN_{it}), Total Phosphorous (TP_{it}).

Independent variable: the logarithm of GDP (y_{it}).

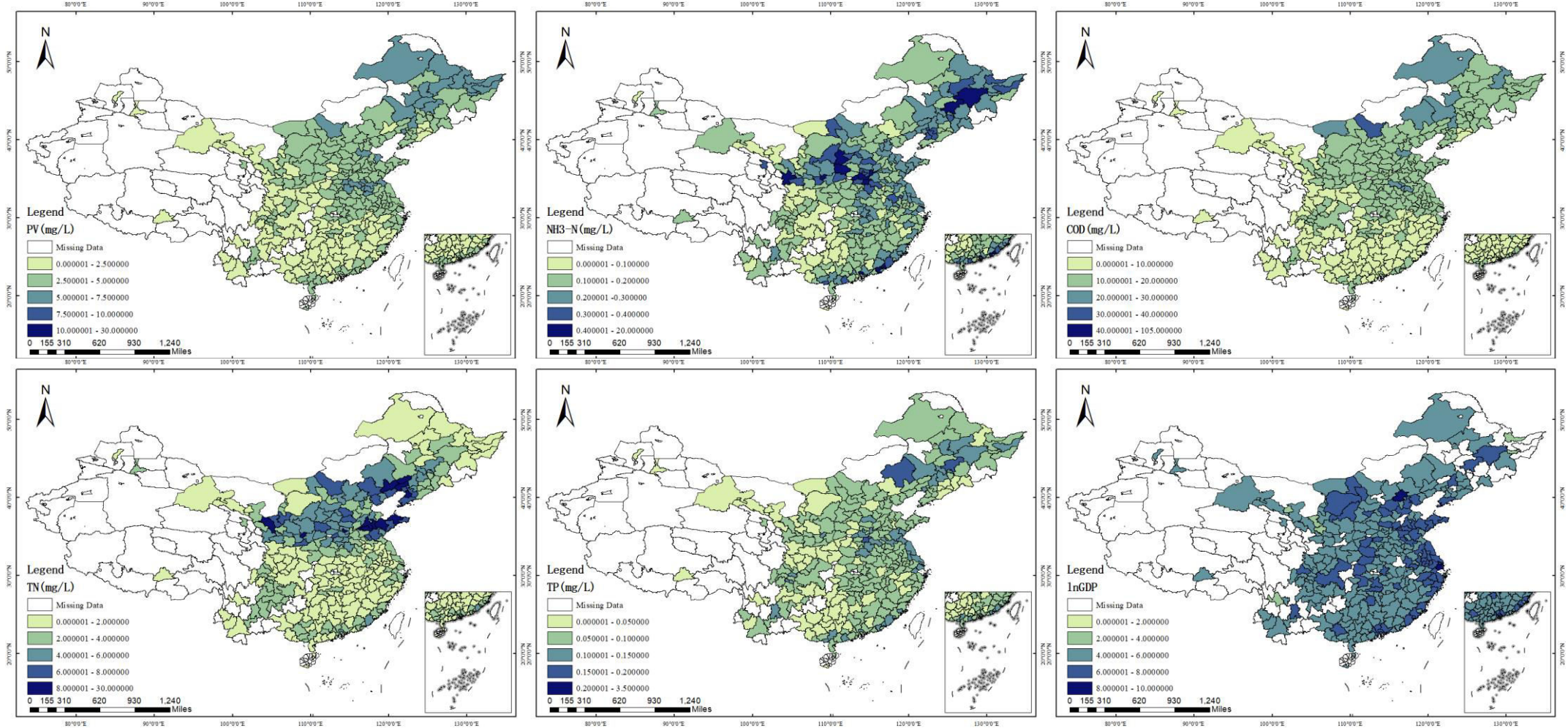
Control variables: environmental regulatory intensity ($regu_{it}$), technological progress (tec_{it}), industrial structure (ISU_{it}), and urbanization rate (RU_{it}).

Data sources: Collected in "China Urban Statistical Yearbook", "China Statistical Yearbook", etc.

Empirical results and discussion

Basic statistical analysis

- In 2022, the concentrations of PV, NH_3-N, COD, TN and TP are higher in the cities of Northeast China, and the concentrations of PV, NH_3-N and TN are higher in North China.
- Water pollution is more serious in Northeast China and North China.



Empirical results and discussion

Empirical results

- The concentrations of PV, NH_3-N, TN and TP have an "Inverted U-shape" relationship with economic development, i.e., as long as the economy can continue to grow, the concentrations of PV, NH_3-N, TN and TP will ultimately tend to decline.
- EKC's inflection points for the concentrations of PV, NH_3-N, TN and TP are 1.986, 3.783, 4.591 and 4.375 respectively.

Variables	PV	NH_3-N	COD	TN	TP
y	0.425	1.687	0.945	2.222	0.245*
	[0.795]	[1.050]	[3.615]	[1.505]	[0.133]
y^2	-0.107**	-0.223***	-0.420	-0.242***	-0.028***
	[0.048]	[0.081]	[0.286]	[0.091]	[0.010]
cons	-1.368	-7.154***	-0.927	-12.840**	-0.609*
	[2.929]	[2.662]	[10.141]	[5.739]	[0.356]
Controls	Yes	Yes	Yes	Yes	Yes
City_FE	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes
N	2080	2080	2080	1872	2079
R^2	0.850	0.725	0.829	0.848	0.757

Empirical results and discussion

■ Heterogeneity analysis——Heihe-Tengchong Line

- The concentrations of PV, NH_3-N, and TP in cities east of the Heihe-Tengchong Line have significant "Inverted U-shape" relationships with economic development, and the EKC's inflection points of PV, NH_3-N, and TP are 1.077, 3.617, and 4.321, respectively.
- For the cities west of the Heihe-Tengchong Line, only COD has a significant "Inverted U-shape" relationship with economic development, and its inflection point is 4.034.

Variables	West of Line	East of Line	West of Line	East of Line	West of Line	East of Line	West of Line	East of Line	West of Line	East of Line
	PV		NH_3-N		COD		TN		TP	
y	3.308*	0.209	3.192	1.483	17.797*	0.086	7.970**	2.24	0.318	0.242
	[1.853]	[0.891]	[3.211]	[1.123]	[9.171]	[4.100]	[3.404]	[1.614]	[0.316]	[0.149]
y^2	-0.251	-0.097*	-0.434	-0.205**	-2.206**	-0.334	-0.510*	-0.243**	-0.028	-0.028**
	[0.165]	[0.053]	[0.444]	[0.085]	[0.788]	[0.317]	[0.291]	[0.097]	[0.026]	[0.011]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	157	1923	157	1923	157	1923	132	1740	157	1922
R^2	0.825	0.849	0.244	0.748	0.809	0.824	0.870	0.836	0.435	0.765

Empirical results and discussion

Heterogeneity analysis——Resource-based vs. Non-resource-based cities

- There is a significant "Inverted U-shape" relationship between PV, NH_3-N, COD and TP and economic development in non-resource-based cities, and the inflection points of EKC are 5.563, 4.772, 3.364 and 4.260, respectively.
- For resource cities, only TP has a significant "Inverted U-shape" relationship with economic development, with an inflection point of 3.714.
- This may be due to the distorted structure of energy consumption and factor endowment in resource-based-cities, which has led to serious overexploitation.

Variables	non-resource-based cities	resource-based city	non-resource-based cities	resource-based city	non-resource-based cities	resource-based city	non-resource-based cities	resource-based city	non-resource-based cities	resource-based city
	PV		NH_3-N		COD		TN		TP	
y	0.879	1.157	2.09	0.861	4.003	-7.974	3.314*	1.899	0.213	0.104
	[1.350]	[1.375]	[1.437]	[1.584]	[5.262]	[5.936]	[1.987]	[2.480]	[0.204]	[0.098]
y^2	-0.079**	-0.079	-0.219**	-0.162	-0.595**	0.468	-0.170	-0.254	-0.025**	-0.014*
	[0.071]	[0.098]	[0.100]	[0.144]	[0.371]	[0.484]	[0.114]	[0.171]	[0.012]	[0.008]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1235	845	1235	845	1235	845	1129	743	1235	844
R^2	0.864	0.887	0.773	0.716	0.855	0.837	0.847	0.882	0.755	0.838

Empirical results and discussion

Heterogeneity analysis——Yellow River Basin

- Selected 41 cities in the Yellow River Basin, including Taiyuan, Hohhot, Bayannur, Jinan, etc.
- There is a significant "Inverted U-shaped" relationship between NH_3-N and TP and economic development in the Yellow River Basin cities, and the EKC's inflection points of NH_3-N and TP are 7.924 and 6.421, respectively.
- For NH_3-N, Dezhou, Xi'an, and Dingxi crossed the EKC's inflection point in 2022; For TP, Baotou, Erdos, Jinan, Zibo, Jining, Dezhou, Zhengzhou, Xi'an, and Dingxi crossed the EKC's inflection point in 2022.

Variables	PV	NH_3-N	COD	TN	TP
y	3.197	5.230*	13.469	5.364	0.488**
	[3.083]	[2.594]	[11.795]	[5.546]	[0.237]
y^2	-0.177	-0.330**	-0.529	-0.073	-0.038*
	[0.229]	[0.155]	[0.861]	[0.407]	[0.020]
cons	-12.725	-28.481***	-80.466	-46.471*	-1.813
	[20.509]	[8.884]	[60.597]	[23.245]	[1.538]
Controls	Yes	Yes	Yes	Yes	Yes
City_FE	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes
N	303	303	303	261	303
R^2	0.712	0.741	0.759	0.855	0.647

Empirical results and discussion

■ Heterogeneity analysis——Yangtze River Basin

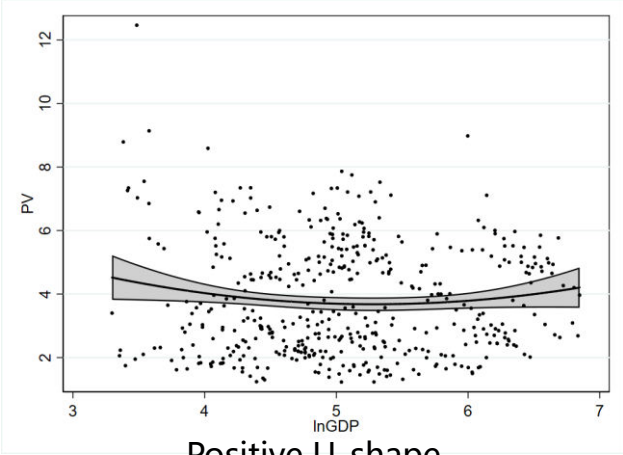
- Selected 66 cities in the Yellow River Basin, including Shanghai, Nanjing, Wuxi, Changzhou, etc.
- There is a significant "Inverted U-shape" relationship between NH_3-N and TN and economic development in cities in the Yangtze River basin, and the EKC's inflection points are 5.769 and 3.223.
- For NH_3-N, 25 cities, including Shanghai, Nanjing, Wuxi, Changzhou, Suzhou, Nantong, Yangzhou, Zhenjiang, Taizhou and Wuhu, crossed the EKC's inflection point in 2022; For TN, 66 cities in the Yangtze River Basin crossed the EKC's inflection point in 2022.

Variables	PV	NH_3-N	COD	TN	TP
y	-0.136	0.773**	0.354	1.818***	0.027
	[0.645]	[0.354]	[3.653]	[0.577]	[0.046]
y^2	-0.033	-0.067***	-0.366	-0.282***	-0.006
	[0.054]	[0.025]	[0.272]	[0.049]	[0.004]
cons	-0.961	-2.252	6.46	-3.184	0.016
	[5.489]	[1.953]	[26.754]	[4.008]	[0.226]
Controls	Yes	Yes	Yes	Yes	Yes
City_FE	Yes	Yes	Yes	Yes	Yes
Year_FE	Yes	Yes	Yes	Yes	Yes
N	499	499	499	480	499
R^2	0.891	0.784	0.865	0.869	0.87

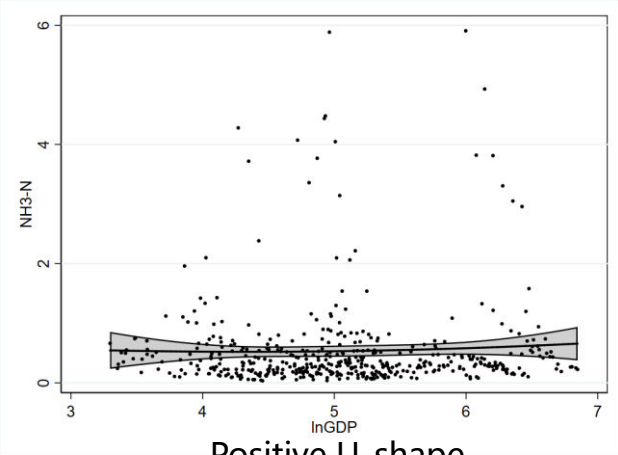
Empirical results and discussion

■ Driving factors of EKC's inflection point

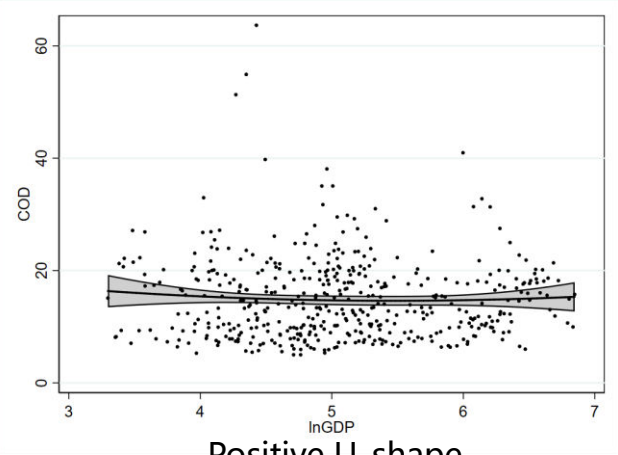
- Cities with **low water environmental concerns**: With the exception of TP, there is a "Positive U-shaped" relationship between water pollution and economic development.



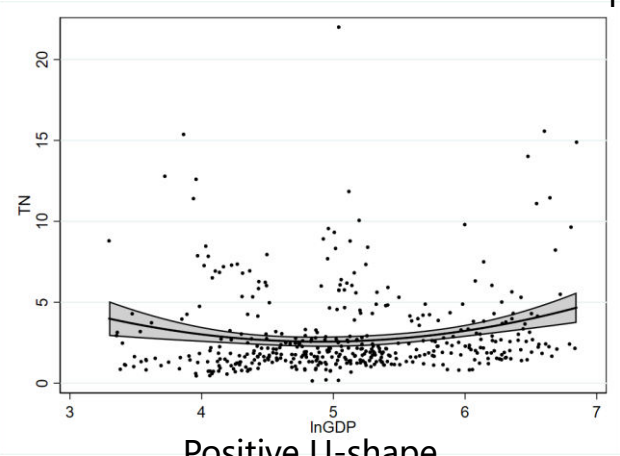
Positive U-shape
inflection point：lnGDP=5.281



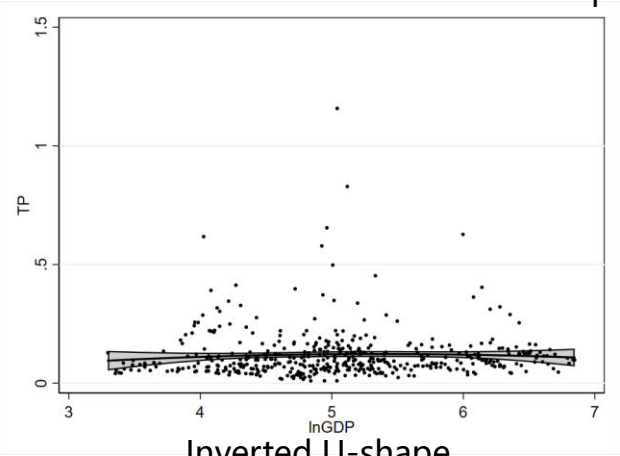
Positive U-shape
inflection point：lnGDP=4.344



Positive U-shape
inflection point：lnGDP=5.466



Positive U-shape
inflection point：lnGDP=4.901

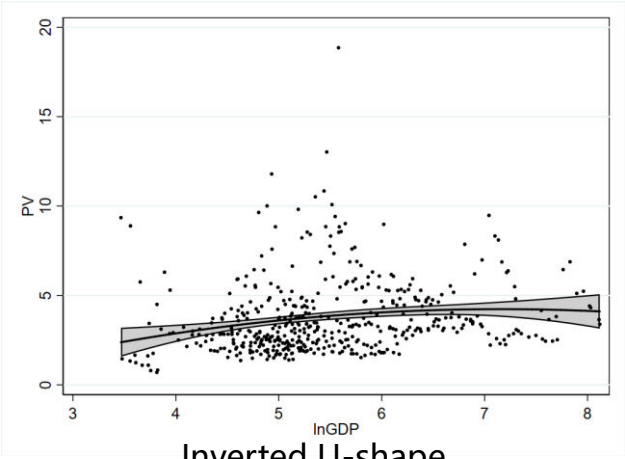


Inverted U-shape
inflection point：lnGDP=8.975

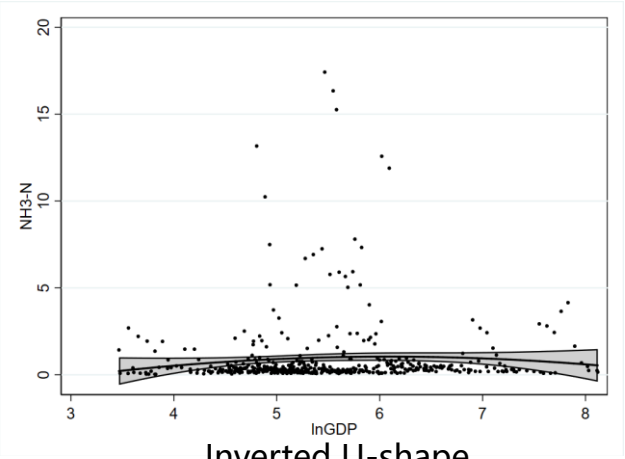
Empirical results and discussion

■ Driving factors of EKC's inflection point

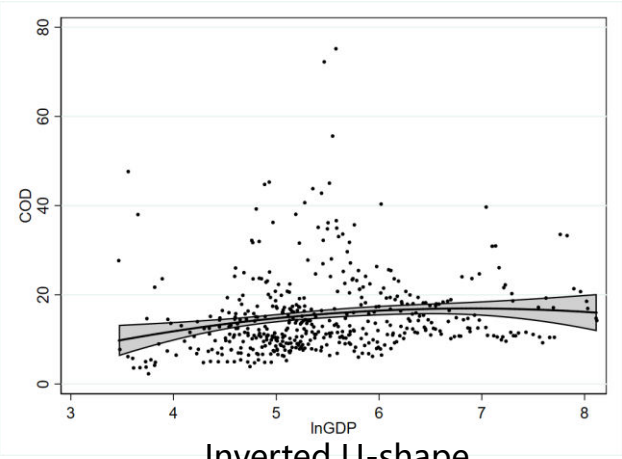
- Cities **with high water environmental concerns**: Five types of water pollution and economic development have "Inverted U-shaped" relationship.



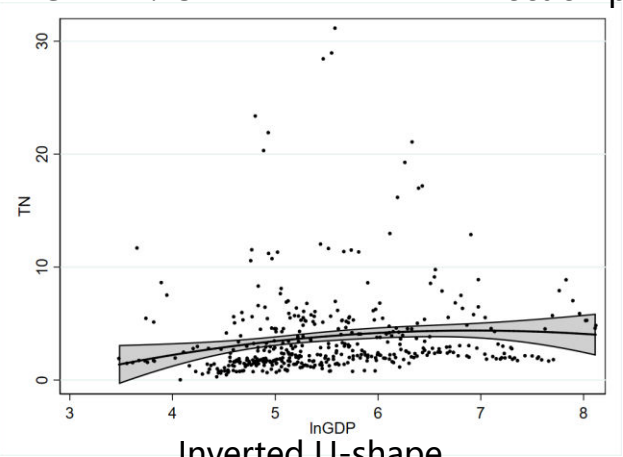
Inverted U-shape
inflection point：lnGDP=7.157



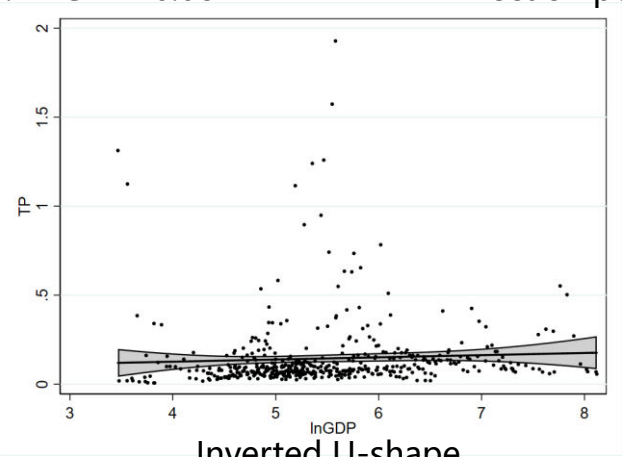
Inverted U-shape
inflection point：lnGDP=6.082



Inverted U-shape
inflection point：lnGDP=6.888



Inverted U-shape
inflection point：lnGDP=6.921



Inverted U-shape
inflection point：lnGDP=6.921

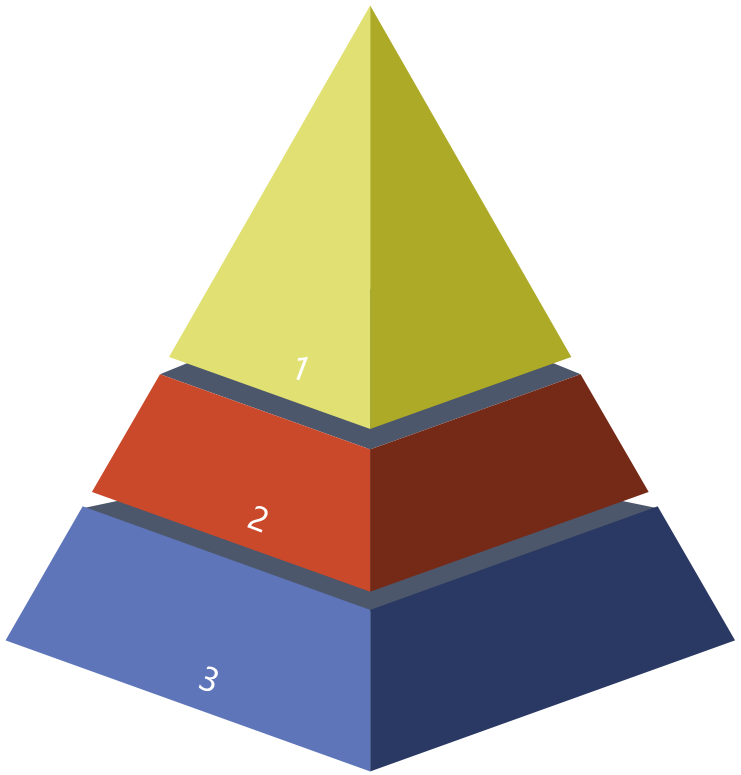
Conclusions and implications

Conclusions

- The concentrations of PV, NH_3-N, COD and TP in 287 cities are in **a decreasing trend**, with the concentrations decreasing by 22.103%, 80.803%, 26.328% and 54.957%, respectively, in 2022 compared with those in 2012. The concentration of TN is in a fluctuating trend.
- Dynamic panel regression results show that PV, NH_3-N, TN and TP have **an "Inverted U-shaped" relationship** with economic development, except for COD.
- The heterogeneity results show that cities east of **the Heihe-Tengchong Line and the non-resource-based cities have a significant "Inverted U-shape" relationship**. For the Yellow River Basin cities, there is **a significant "Inverted U-shape" relationship between NH_3-N and TP and economic development**, while there is **significant "Inverted U-shape" relationship between NH_3-N and TN for the Yangtze River Basin cities**.
- In cities with **low water environment concern**, there is **a "Positive U-shaped" relationship** between water pollution and economic development, whereas for cities with high water environment concern, there is an "Inverted U-shaped" relationship between all five types of water pollution and economic development.

Conclusions and implications

Implications



1 **Increased focus on prevention and treatment** of water pollution and further enhancement of environmental awareness among residents of various watersheds.

2 Resource-based cities should **change their traditional economic development mode**l, focus on solving the contradiction between economic development and water pollution.

3 Establish **a mechanism for cooperation and coordination** of the interests of the three regions of the Yellow River and the upper, middle and lower reaches of the Yangtze River, so as to form a situation of common development in the whole basin.

Conclusions and implications

Future prospects

- China has made every effort to promote ecological environmental protection in key river basins, and has achieved remarkable results, there is **still rooms for further improvement**.
- Its successful experience is that it has comprehensively integrated the left and right coasts, upstream and downstream, above and below the ground, land and sea areas, pollution prevention and ecological protection with **a toolkit of wide range of policies** applied.
- **Not only water pollution, but also water quality and water ecology** should be concerned, managed and Improved in an integrated pattern of water ecosystems in the river basins, given play to the role of cross-sectoral and cross-regional coordinating mechanisms
- **Priority should be given comprehensively** to the management of water pollution, water ecological restoration, monitoring and early warning of the quality of water ecosystems and environmental quality, the formulation of water quality standards, and the construction of compensation mechanisms for protection, and has strengthened the conservation and intensive utilization of water resources.

Thanks for listening

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