The effect of environmental governance in quality improvement of urbanization —Evidence from China 2000–2017

Zhiguo Tang[1†], Yanping Tian[2†] and Shuyi Yu[3*]

[1]School of Marxism, Lanzhou University, Lanzhou, China, [2]School of Economics, Lanzhou University, Lanzhou, China, [3]School of Law, Lanzhou University, Lanzhou, China

Introduction: The promotion effect of environmental governance on improving the quality of urbanization is yet to be fully understood. No consensus exists on the concept of urbanization quality, and the exploration of the promotion effect of` environmental governance focuses on the economic dimension. Since 2000, high-quality and distinctive urbanization has been an important part of China's social development, and environmental governance has been a primary aspect of this pursuit. Therefore, Chinese practice is a suitable research object to help enrich the exploration of the academic community.

Material and Methods: This paper constructs an evaluation index system for urbanization quality based on a new development philosophy by the Chinese government and adopts the entropy value method to investigate the effect of environmental governance using provincial panel data from 2000 to 2017.

Results: Firstly, the overall effect of environmental governance on improving the quality of urbanization is significant, however, among the environmental governance effects of the five dimensions of urbanization quality, it is conducive to innovation and coordinated development but not conducive to shared development. Secondly, the role of the three governance mechanisms in the environmental governance system is not balanced. The contributions of market governance are much higher than that of government governance and public governance, And there is a large room for improvement in the effectiveness of collaborative governance. In terms of the improvement of specific dimensions of urbanization quality, government governance contributes significantly to innovative development but restricts open and shared development; market governance promotes green and shared development but inhibits open development; public governance plays a positive role in coordinated and open development but hinders innovative, green and shared development. Thirdly, the role of environmental governance has significant regional differences. The eastern region is high, the northeast and central regions are second, and the western region is a negative effect. Within the environmental governance system, government governance has a significant promoting effect on all regions, market governance has a significant promoting effect on eastern, western, and northeastern regions. And public governance has the largest promoting effect on eastern and central regions, while it has an inhibiting effect on western and northeastern regions.

Discussion: It is necessary to build an environmental governance system adapted to the regional reality, play the leading role of government environmental regulation, and optimize the collaborative mechanism of the government, enterprises and the public in the environmental governance system with the guidance of market governance.

1 Introduction

Since the middle of the 20th century, the relationship between environmental protection and urbanization quality improvement has entered the field of theoretical research. Subsequently, with the global outbreak of environmental problems and the introduction of the concept of urbanization quality, the issue has evolved into an academic hot topic, that is, the effect of environmental governance on the improvement of urbanization quality. In different time and space conditions, the effects of environmental governance in the process of urbanization have their commonalities, but there are also differences. What's more, this issue is not only related to the formulation of environmental governance policies, but also the power mechanism of urbanization quality improvement. This has meant the problem was hotly debated by scholars.

In the study of environmental governance effects on the improvement of urbanization quality, China should be one of the key research objects. Because, since 2000, China has been actively exploring the urbanization road with Chinese characteristics. Urbanization is used as an important space carrier for economic growth (Binglian and Junfeng, 2019). At the same time, China's overall environmental governance has basically developed simultaneously. In 2000, air pollution in urban cities across the country was very serious. Only one-third of the city's currency with air quality reached national secondary standards; the surface water pollution was generally polluted, especially the urban section flowing through the city. Organic pollution is heavy. The lake eutrophication problem is prominent. The groundwater is polluted by dot or facial pollution, the water level decreases, the contradiction between supply and demand of water resources has intensified, and ecological destruction is serious (State Council of the People's Republic of China, 2002). In the face of this situation, the Chinese government has formulated the "National Environmental Protection" Tenth Five-Year Plan "and decided to start the national action of ecological environmental protection. It is clearly proposed that "effectively strengthen environmental protection work, strictly implement the control plan of total pollutant emissions, ensure that environmental pollution will be reduced by 2005 (State Council of the People's Republic of China, 2002). The trend of ecological environment worsening will be initially curbed. Environmental quality in urban and rural areas, especially in large and medium-sized cities, is improving." Since then, the issue of environmental governance and urbanization has become the content of continuous attention of the Chinese government. In terms of urbanization development, at the 2012 National Economic Work Conference, the Chinese government has proposed to actively promote the policy of urbanization and strive to improve the quality of urbanization. In the same year, the Chinese

government proposed a new type of urbanization road with Chinese characteristics that should be further developed. In 2017, the Chinese government further put forward the policy of urbanization and high-quality development and urban agglomeration. In terms of environmental governance, during the past two decades, the content and means of China's environmental governance have changed significantly. After experiencing two stages including environmentally friendly strategies (2001–2012) and ecological Civilization Strategy (2013-present). The former controlled total pollutant emissions and promoted the establishment of ecological environmental demonstrations. The latter improved environmental quality and built a "Beautiful China." A relatively complete environmental strategic policy system in line with national conditions has basically formed. Looking back over the past decades, China has developed into a heavy town of global urbanization. It has not only achieved the "Chinese miracle" of rapid economic growth, but also made great achievements in environmental governance (Wang et al., 2019). This makes China a better object of research on the improvement of urbanization quality improvement.

It is of great significance to study the effects of environmental governance on the process of urbanization in China. On the one hand, it is the content that the academic circle should pay attention to in promoting environmental governance within the quality of urbanization improving. On the other hand, in the construction of Chinese ecological civilization countries, It will also be related to the issue of new urbanization and high quality development actions that are coordinated with new development concepts. In other words, whether the research and formulation of related policies in urbanization in China in the future, or providing experience for countries and regions similar to China, or promoting the theory itself, it has great value.

There are many results on this problem. From the perspective of time dimension, this study can be traced back to the 1990's, and generally focuses on two theories including " compliance cost theory" (Gray, 1987) and "innovative compensation theory" (Porter, 1991). The former posits that under the government's environmental regulation, enterprises pay additional costs to meet environmental standards, thus increasing the cost burden on enterprises and weakening their motivation to promote economic growth. The latter stresses that the government's environmental governance could stimulate green technology innovation in enterprises, and that the benefits of innovation would sufficiently compensate for the costs of environmental regulation. Different scholars look for evidence for these two hypotheses from using different data and different perspectives. Some scholars used the panel data of 30 provinces (cities, autonomous regions) in mainland China from 2004 to 2010 for empirical inspection. It was found that the cost-oriented

environmental regulations had no significant impact on economic growth, and the investment-based environmental regulations significantly promoted economic growth (Yuan and Liu, 2013). Taking 283 prefecture-level cities in China as samples, some scholars proved through empirical research that environmental governance promotes urban productivity (Kong et al., 2019). Using the panel data of 282 cities in China from 2005 to 2016 to explore the relationship between environmental regulation and resource endowment on urban industrial transformation, some scholars showed that environmental governance rationalizes and upgrades the industrial structure of cities (Hong and Zou, 2018). Using the spatial panel data of 285 cities at prefecture level and above in China from 2003 to 2016, some scholars analyzed the impact of environmental regulation on the level of new urbanization and its spatial spillover effect (Li and Shen, 2019). The research shows that process-based and effect-based environmental governance improves the quality of a city and has positive spillover effects on surrounding cities. Generally speaking, the research of scholars supports the promotion of environmental governance in the process of urbanization in China. In addition, these studies also show a common theoretical trend. It proved that different environmental control policy tools bring different environmental governance effects, at the same time, exist for regional heterogeneous and timely-not-linear evolution characteristics.

Looking back on existing research, these studies have undoubtedly contributed to the revelation of the effects of environmental governance on improving the quality of urbanization in China. However, we believe that there is still room for questioning.

First, China has promoted the expansion and enrichment of urbanization in time. But most of the research focused on improving production efficiency and optimizing industrial structures, as well as other economic effects. These focus areas are narrow in the broad sense of urbanization development quality. There are some differences with the urbanization quality theory of the international community. No comprehensive scientific understanding exists for what the development of high-quality urbanization means in the context of China (Wang and Fang, 2012; Chen et al., 2014). However, international academic circles have a more comprehensive understanding of the connotation of urbanization quality, indicated by such terms as eco-city (Yanni, 1984; Register, 1987), sustainable development city (Walter and Walter Betal, 1992; Oetal, 1993), quality of life of residents (Boyer and Savageau, 1985) and measurable urban sustainability model (May et al., 1997). Chinese scholars also have some responses to the deficiencies in this aspect. Niu Wenyuan defines the quality of urbanization in China from the three aspects of developmental vitality, coordination, fairness and sustainability (Niu, 2009). Li Mingqiu and Lang Xuebin define the quality of Chinese urbanization from the quality of the development of the city, the efficiency of urbanization, and the degree of urban and rural integration (Li and Lang, 2010). Lu Dadao defines the quality of urbanization in China from the town's population employment, social security, medical care, infrastructure, the degree of protection of the environment and the degree of fairness, etc (Lu, 2013). Fang Chuanglin proposed that the high-quality development of China's new urbanization is a kind of harmonious, high-efficiency and low-carbon, ecological environmental protection, conservation of innovation, and intelligent and safe quality improvement (Fang, 2019). In addition, to analyze the quality of urbanization development in China Wang Deli and others have established 31 indicator systems including urban basic

strength, coordination of urbanization development, and urbanization development sustainable level and urbanization development quality evaluation models (Wang et al., 2010). Other scholars respectively from the population, economy, society and ecological environment, residents, urban and rural areas as a whole. They hope to build a comprehensive index system of provincial urbanization of our country quality measures (Zhou, 2017; Tian, 2018). From the economic, social, ecological protection and urban and rural infrastructure, five aspects build up the county urbanization in our country as a whole quality evaluation system (Su et al., 2011). Looking back at these studies, a clear feature can be found of strong subjectivity. There is a greater distance from the official claims of the Chinese government. In addition, a regret is that scholars only stay in the definition of the concept of quality of urbanization. They have not yet further launched the research on environmental governance effects under the new connotation.

Second, after the Chinese environmental governance model has gone through the two stages of "single control of the government" and "government supervision auxiliary public participation," it is currently moving towards a new stage of "government, enterprise, and public co-governance" (Yang, 2008). However, existing research has focused on government-led models of environmental regulation. The transformation of China's environmental governance model can be seen in some key legal and policy documents in China since the new century. The Environmental Impact Assessment Law issued in 2002 clarified the public's rights and interests in environmental governance. In 2014, the newly revised Environmental Protection Law established the public interest litigation system for environmental protection. In 2015, the public participation Measures for Environmental Protection were adopted to ensure the public's right to environmental participation and effective ways from the institutional level. In 2016, the National Development and Reform Commission and the Ministry of Environmental Protection issued the Opinions on Cultivating Market Players in Environmental Governance and Ecological Protection, which substantially promoted the process of market environmental governance. Besides, academic circles show that many literatures have expanded the connotation of environmental regulation to the environmental governance of the multi-goal, diversified subjects, and diverse tools. It is highly consistent with the inherent requirements of ecological governance modernization and the connotation of "new governance" and network governance. Research from Zhao Yumin and others divided environmental regulations as explicit environmental regulations and hidden environmental regulations (Zhao et al., 2009). The explicit environmental regulations were divided into command control-type environmental regulations, incentive environmental regulations based on markets, and voluntary environmental regulations. Peng Xing and others divide environmental regulation as command-type environmental regulation, economic incentive environmental regulation and voluntary environmental regulation. The academic community has also responded to this issue (Xing and Li, 2016). More and more scholars began to go beyond government regulation (regulation) to analyze and study high-quality development issues. They analyzed and research included high-quality development issues including urbanization from the perspective of environmental governance. Scholars have pointed out that in China, the single environmental regulation which has been dominated by the government for a long time has many obstacles such as system block segmentation, single subject and rigid means (Shen, 2014). Trading

market governance is the important means to solve the problem of environment for China's future (Tu and Chen, 2020). Public environmental awareness can effectively promote the local government pay more attention to environmental problems, Through environmental governance investment, improve the industrial structure and so on ways urban environmental pollution can be improved (Zheng et al., 2013). However, looking at these responses, the perspective in the study is either focused on a system or a governance mechanism. It is still difficult to fully reveal the promotion effects of environmental governance in the process of urbanization in China.

Third, since 2000, China has been continuously promoting urbanization development and environmental governance. However, the time span of the data used in the institute is obviously short and presents a certain degree of subjectivity. We believe that it is incomplete to reveal environmental governance effects on the improvement of the urbanization quality in China.

In summary, there are many documents that study the environmental governance effects of urbanization quality in China. However, in combination with the new stage of China's development, there are still fewer documents in China under the modernization of ecological environmental governance (Yao et al., 2014). From the reality of China's economic and social development, this article discusses the environmental governance effect on the quality of urbanization from the perspective of Chinese-style modernization. Based on the characteristics of China's development, it draws on others' research results (Sun et al., 2020; Wang, 2020). A quality evaluation system for China's urbanization has been established with the concept of "innovative, coordinated, green, open and shared" as its core contents. From the perspective of network governance and ecological governance modernization, environmental governance and environmental governance systems are defined. An empirical study has been studied on the effect of environmental governance on the improvement of the quality of China's urbanization. This paper attempts to reveal the facts, mechanism, deficiency and future improvement of the effect. In general, there are five parts in the first part of the introduction. In view of this, the second part of this paper constructs the index system of the development quality of new urbanization in accordance with the five dimensions of the new development concept, and the third part elaborates the effect and internal mechanism of environmental collaborative governance in promoting urbanization development; In the fourth part, the theoretical model of inter-provincial panel data from 2000 to 2017 was used to empiric the internal mechanism of environmental governance promoting the high-quality development of new urbanization in China, and the problems and deficiencies of the existing environmental governance system in China were discussed. On this basis, the corresponding policy suggestions were put forward.

2 Evaluation index construction and measurement of the quality of urbanization based on new development philosophy

2.1 Construction of evaluation index

The Chinese government proposed to improve the quality of urbanization at the National Economic Work Conference in December 2012. In the same year, the government proposed to take the road of new urbanization with Chinese characteristics of connotative development, but it did not specifically define what is new urbanization with Chinese characteristics. The answer to this question is now emerging as practice advances. The government later proposed to approach high-quality economic development following the new concept of development. This new concept of the development comprises five organic aspects: innovation is fundamental, coordination is endogenous, green is universal, "opening up" is inevitable, and sharing is paramount. Chinese scholars have shared a similar view that the new concept of development is not only fundamental to the high-quality development of China's economy but also critical to urbanization (Lin, 2018; Su and Houkai, 2018; Peng and Yu, 2019). This paper is based on the construction of China's high-quality development index system of urbanization (see Table 1).

2.2 Meaning and composition of indicators

2.2.1 Innovative development

Innovative development means that urbanization should be based on scientific and technological innovation, have the main content as idea and mechanism innovation, and prioritize prominent town characteristics for intensive, high-efficiency development. The basic requirements are to adhere to a people-oriented philosophy, actively build an innovation-driven urban development model, seek urban modernization in combination with the city's own conditions and comparative advantages, continuously improve the basic conditions for scientific research and development of urban innovation and development, strengthen urban human capital investment and reserves, form a scientific innovation mechanism with market competition as the core, and deliver a dynamic mechanism. Therefore, the number of full-time college teachers in universities, technology market turnover *per capita*, and the number of three invention patent grants per ten thousand people are selected to measure the talent base conditions, market transformation application scale, and innovation achievements of the new urbanization innovation development as a regional economic agglomeration area.

2.2.2 Coordinated development

Coordinated development means that urbanization should be coordinated collaboratively at different levels of scale and characteristics. The aim is to achieve coordination between man's all-round development and space according to urban–rural integration and urban–industrial integration to achieve social, economic, cultural, and ecological all-round development. Accordingly, we select non-agricultural employment ratio, non-agricultural output value as a proportion of gross domestic product (GDP), and non-agricultural output value per unit of built-up area to measure urban–rural development coordination, industrial development coordination, and urban land use efficiency.

2.2.3 Green development

Green development means urbanization should be based on economizing resources and gradually minimizing ecological and environmental damage. These objectives can fully reflect the achievements of constructing a socialist ecological civilization and

TABLE 1 Index system of high-quality development of urbanization.

First grade indexes	Second index	Basic index	Unit	Index attribute
New Type City Town Chemical Quality Quantity	Innovation development	Number of full-time teachers in Universities	person	positive indexes
		Technology market turnover *per capita*	CNY/person	positive indexes
		Number of three invention patent grants per ten thousand people	piece	positive indexes
	Coordinated development	Urban–rural coordinated development degree: non-agricultural employment ratio	%	positive indexes
		Industrial coordinated development: non-agricultural industries accounted for the gross domestic product ratio	%	positive indexes
		Urban land efficiency: non-agricultural output/built-up area	CNY/square meter	positive indexes
	Green development	Energy consumption per unit gross domestic product	Ton of standard coal/ten thousand yuan	Reverse index
		Harmless treatment rate of urban domestic waste	%	positive indexes
		Urban park green area *per capita*	Square meters/person	positive indexes
	Open development	Inbound tourist situation	Ten thousand people/per day	positive indexes
		Imports *per capita* imports	Ten thousand yuan/person	positive indexes
		Foreign direct investment *per capita*	Ten thousand yuan/person	positive indexes
	Shared development	Registered urban unemployment rate	%	Reverse index
		Number of health professionals per thousand urban population	person	positive indexes
		Urban residential building area *per capita*	Square meters/person	positive indexes

aim to meet the growing demand of urban residents for ecological products and services. Hence, we select the energy consumption per unit of GDP, the harmless treatment rate of municipal solid waste, and the area of green space in parks *per capita* to measure the level of energy consumption, the performance of eco-environmental protection, and supply of green products.

2.2.4 Open development

Open development means that urbanization should be complemented by the advantages of capital, technology, talent, natural resources, and other essential resources of foreign countries. It should also actively participate in the division of labor in the market and industrial chain, which can maximize the development of urbanization potential and power to achieve high-quality development (Cai et al., 2018). Hence, we select the tourism situation of inbound tourists, imports *per capita*, and foreign direct investment *per capita* to examine the attractiveness, level of openness, and level of utilization of foreign resources of a city, respectively. In recent years, the global phenomenon of anti-globalization has emerged. After entering the post-COVID age, this trend is more obvious. This has made the Chinese government face great challenges. However, the Chinese government is still determined to open up and develop, and has adopted a series of policies to respond (Wang, 2021).

2.2.5 Shared development

Shared development means that urbanization development should be people-oriented and inclusive to be regarded as a

modern urban civilization. Hence, the registered urban unemployment rate, number of 1,000 health professionals and technicians, and housing gross leasable area *per capita* were selected from the employment, medical, and residential services enjoyed by residents, respectively.

2.3 Measurement of urbanization development quality

The entropy method is used to measure urbanization development quality in this paper. The variables are the innovation development index (Urban1), coordinated development index (Urban2), green development index (Urban3), open development index (Urban4), shared development index (Urban5), and comprehensive index (Urban6——"HQDNU") of urbanization quality.

For the original indicators presented in Table 1, the data translation method (Zhang et al., 2017) is used to preprocess the data. On this basis the extreme value method is used for dimensionless processing. For the positive indicators, the formula used is $x_{ij} = \frac{a_{ij} - \min\{a_{ij}\}}{\max\{a_{ij}\} - \min\{a_{ij}\}}$, and the reverse indicators are processed using the formula, $x_{ij} = \frac{\max\{a_{ij}\} - a_{ij}}{\max\{a_{ij}\} - \min\{a_{ij}\}}$, where x_{ij} refers to the values obtained from standardizing the original indicator data; a_{ij} is the original index value; $\min\{a_{ij}\}$ is the minimum value of the index; $\max\{a_{ij}\}$ is the maximum value of the index, i = 1, 2,..., m; j = 1, 2,..., n.
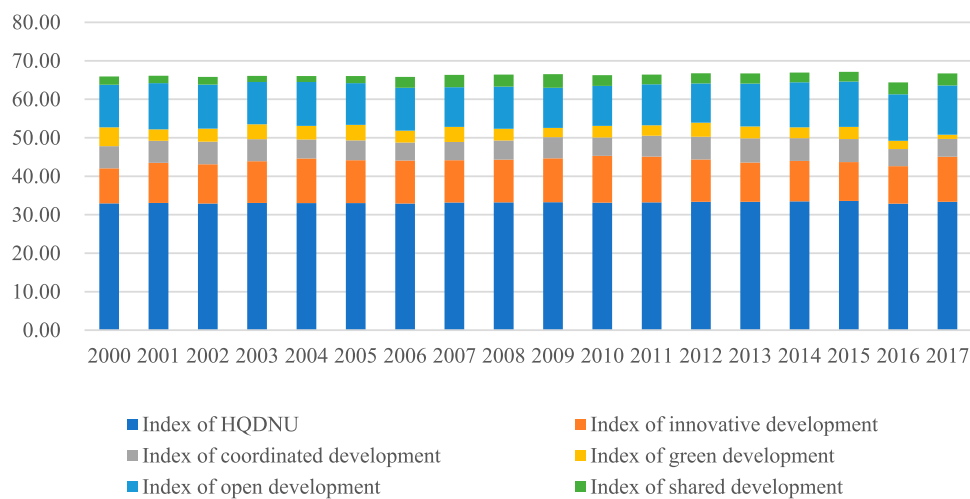
FIGURE 1
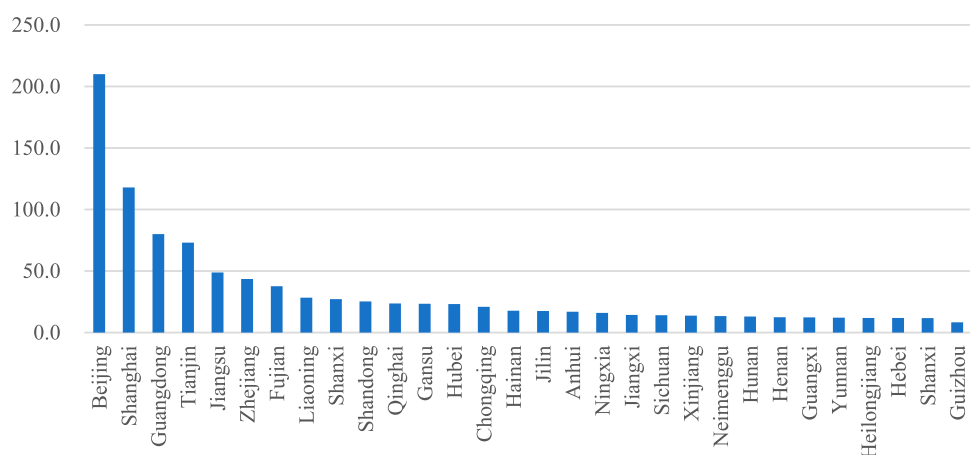Change trend of quality development index of China's urbanization from 2000 to 2017.

FIGURE 2
Quality level of urbanization development in China's provinces in 2017.

Using the entropy method, we form the comprehensive index (urban) and a five-dimensional development index of the high-quality development of new urbanization in 30 provinces, autonomous regions, and municipalities (excluding Hong Kong, Macao, Taiwan, and Tibet) from the year 2000–2017.

In terms of time (see Figure 1), China's overall urbanization quality index has maintained a slow and steady growth trend over the past 18 years; the innovation, openness, and shared development index show a slow growth trend, whereas the coordinated development and green development indices show surprisingly slow and varying declines.

From the vertical dimension, the high-quality development of urbanization in 2017 indicates more obvious regional levels and differences (Figure 2). Beijing, Shanghai, Tianjin, and Guangdong maintain a high level of development, followed by Jiangsu, Zhejiang,

and Fujian, with the rest concentrated at a lower level. Twenty-three provinces, regions, and cities are below the average level of 33.07, accounting for 76.7%. Thus, if the new development concept for measuring the quality of China's urbanization development in approximately the past decade, the overall development is relatively slow and the differences between provinces and regions.

3 Analysis of the effect and internal mechanism of environmental governance promoting urbanization quality

Environmental governance is a management system through formal or informal mechanisms for protecting natural resources, controlling environmental pollution, and resolving environmental

disputes. Under the environmental governance system, environmental protection does not simply rely on the top-down administrative mechanism of the government; the government rather provides the basic institutional framework and principles. The meaning of the internal mechanism of environmental governance includes the status, function and effect of government, market and public governance, as well as the interaction between them in the environmental governance system. Through voluntary consultation, the relevant stakeholders finally reach the public goal that conforms to the environmental interests of most people (Clarkson et al., 2008). Environmental governance is different from environmental regulation as its mechanism is embodied in the multiple subjects in various formal and informal institutional frameworks, according to their interests and preferences, as well as through voluntary trading and game to balance interests. To achieve the low-carbon and green development goal of urbanization, environmental governance should be based on material and technological progress, structural coordination, all-around social progress, rights and interests sharing, and open and inclusive development. The process of improving environmental governance and governance capacity modernization is the process of innovation, coordination, green, open, and shared development of urbanization. The effect of environmental governance manifests in the following three aspects.

First, the process of improving environmental governance efficiency is the process of the technological innovation of urbanization. The environmental governance system is compatible with the current Chinese socialist market economy system. The enterprise primarily participates in environmental governance through an interest game. Environmental governance increases the cost of corporate governance and investment in the research and development of governance technology. However, environmental technology standards set by environmental laws, regulations, and policies promulgated by the government encourage enterprises to invest in technological innovation. To obtain innovation profit, the enterprise obtains a competitive advantage through product, technology, market, management process, and system innovation (Li and Xiao, 2020). In the process of urbanization, the government provides the infrastructure and talent reserve for green technology research and development through the formulation of laws, regulations, policy measures, and implementation of planning objectives appropriate for the stage of economic and social development. This government provision effectively stimulates enterprises to innovate and contribute to the development of urbanization innovation.

Second, the process of improving the environmental governance system is also the process of the overall development of urbanization, coordination of the structure, and sharing of rights and interests (Zhan and Chen, 2020). The improvement of the environmental governance system translates to the multi-means participation of government-led enterprises and the public at various levels. At the present stage, the basic motivation of enterprises and the public to participate in environmental governance is economic interests and rights. Relatively balanced social forces, protection of the interests of enterprises, and public participation in environmental governance balance mechanisms can only be achieved by the perfection of market competition and relevant legal systems, coordination of industrial organization systems, and coordinated development of urban and rural social

structures. From the perspective of generating dynamic forces within the ecological environment, only the overall coordinated development of the urbanization of social economy and culture, as well as the equal protection and sharing mechanism of the rights and interests of various social subjects, is constantly improved (Zheng et al., 2013). The improvement molds an independent consciousness in enterprises to protect the ecological environment, take social responsibility, and encourage public participation in environmental protection, thus establishing a foundation for ecological environment governance.

Third, the modernization of environmental governance capacity will promote the green, open, and inclusive development of urbanization. The modernization of environmental governance capacity is a process of all-around social progress and an optimized combination of resources and technologies, the need to learn from foreign advanced governance concepts and mechanisms, the introduction of mature and advanced green technology, and talent. This process can promote the open development of urbanization and inclusive development.

According to the above analysis, the basic assumption in this paper is that the improvement of the environmental governance system and governance capacity is conducive to the innovative, coordinated, green, open, and shared development of urbanization.

4 Empirical analysis

4.1 Basic regression model

To study the relationship between environmental governance and the development of urbanization, we establish the following regression models:

$$Urban_{jit} = \beta_0 + \alpha egovern_{it} + \beta_1 egrow_{it} + \beta_2 public_{it} + \beta_3 struc_{it} + \beta_4 educ_{it} + \beta_5 \ln trade_{it} + \varepsilon_{it} \qquad (1)$$

$$Urban_{jit} = \beta_0 + \alpha_1 government_{it} + \alpha_2 market_{it} + \alpha_3 social_{it} + \delta_m \mathrm{inter}_k + \beta_1 egrow_{it} + \beta_2 public_{it} + \beta_3 struc_{it} + \beta_4 educ_{it} + \beta_5 \ln trade_{it} + \varepsilon_{it}, \qquad (2)$$

where i represents the cross section of 30 provinces and cities in China (except Hong Kong, Macao, Taiwan, Tibet); t represents the year from 2000 to 2017; $urban_{jit}$ represents the development level of urbanization in the period of region i (province, region, and city) during period t; $j = 1,2,3,4,5$ represent innovative, coordinated, green, open, and shared development level of urbanization, respectively; the main explanatory variables include environmental governance index ($egovern_{it}$), government environmental governance index ($government_{it}$), market environmental governance index ($market_{it}$), and public environmental governance index ($social_{it}$); and inter_k (k = 1,2,3) represent the interaction terms of government, market, and public environmental governance, respectively. The control variables include economic growth level ($egrow_{it}$), government public goods input ($public_{it}$), economic structure optimization ($struc_{it}$), human capital accumulation ($educ_{it}$), and "opening up" level ($trade_{it}$). The coefficient α represents the effect of environmental governance, β represents the effect of control variables, δ_m (m = 1,2,3) represents the effect of interaction terms and ε_{it} is a random error term following an independent identical distribution.

4.2 Variables and data source description

4.2.1 Explained variables

Learn from the definition and method of high-quality development by scholars such as Ou Jinfeng (Ou et al., 2020) and Cheng Jingjing (Cheng and Xia, 2021), the explanatory variable of high-quality development level of urbanization is represented by the comprehensive index Urban of urbanization development quality measured above, and the high-quality development of new urbanization in China is reflected from five aspects: innovation (Urban1), coordination (Urban2), green (Urban3), openness (Urban4), and sharing (Urban5).

4.2.2 Core explanatory variables

The environmental governance index ($egovern_{it}$) represents the overall level of social environmental governance. China is improving its environmental governance system, which is led by the government, dominated by market enterprises, and attracts active public participation. We use the entropy weighting method to construct the environmental governance index comprising the three dimensions of government governance, market governance, and social governance.

In this paper, the definition of the main body of the environmental governance system follows a functional principle, and government governance and market governance are divided according to the mandatory and incentive means of environmental governance. Government governance mainly involves the use of government's administrative power to achieve resource-saving utilization and ecological environment protection. We describe the government's environmental governance behavior and investment in four aspects: investment in environmental pollution control *per capita* (CNY/person), the number of environmental administrative punishment cases per 10,000 people (pieces/10,000 people), the number of environmental protection agencies per 10,000 people (person), and the number of environmental laws and regulations promulgated in the year (pieces/year). Market governance mainly refers to the use of the market as a decisive means of resource allocation, the use of interest incentive mechanisms to induce market players (mainly enterprises) to change their behavior rules, and the use of ecological environment protection and resource conservation through market transactions, such as pollution tax collection, emission rights, and emission permit trading systems. China levied sewage charges from 1978 but replaced them with environmental protection taxes in 2018 (Lu et al., 2018). The collection of sewage charges changes the production decisions and profit targets of enterprises, which is an important means of market environmental governance. With the continuous improvement in China's socialist market economic system, the connotation of market governance is constantly enriched. Because market governance involves a micro-enterprise level, it is difficult to collect relevant data. Therefore, we draw on He Xingbang's method and use three proxy variables: sewage fee collection/GDP, resource tax/GDP, and vehicle and ship tax/GDP (He, 2018). Social environmental governance mainly includes the public, news media, and public welfare social organizations. It also includes the mode of participation in addition to environmental awareness and belief under the

control of independent environmental protection. Social environmental governance actively pursues a resource-saving consumption lifestyle mainly through supervision and other social democratic participation to encourage the government and enterprises to perform environmental governance. This paper uses environmental complaints letters and visits (pieces/ten thousand people), environmental problems from people's congress recommendations and CPPCC (——Chinese People's Political Consultative Conference) proposals (pieces/ten thousand people), artificial afforestation area (square meters/ten thousand people), and water-saving irrigation area (mu/ten thousand people).

4.2.3 Control variables

In addition to our main concern of environmental governance factors, factors affecting the quality of urbanization are the level of economic growth (egrow), supply of public goods (public), quality of civic education (educ), optimization and upgrading of industrial structure (struc), and level of openness to the outside world (trade). These factors play an important role as control variables in reducing the model because of the omission of important variables arising from endogeneity problems. In the selection of indicators, the level of economic growth is expressed by GDP *per capita* (CNY/person), the supply of local government public goods is expressed by government public expenditure *per capita* (CNY/person), the optimization and upgrade of the industrial structure are expressed by the proportion of tertiary industry output value (%), the overall education quality of residents is expressed by the number of ten thousand college students (person), and the total foreign trade *per capita* (ten thousand yuan/person) indicates the level of "opening up." Economic growth continuously improves the agglomeration level, division of labor, and cooperation level of the urban population and economy by improving labor production efficiency. This growth continuously improves the efficiency of land resources and space utilization, which is the basis of the high-quality development of urbanization. Public goods, including education, healthcare, social security, and employment, are crucial to the quality of life of urban residents. The development of non-agricultural industries is the structural factor of the quality of urbanization, which is related to the employment opportunities and income levels of urban residents, as well as the sense of happiness and gain of urban residents. The level of "opening up" affects the quality of urbanization development through resource allocation optimization.

4.2.4 Data source description

The data used in this paper are derived from the 2001–2017 "China Statistical Yearbook," "China Urban Statistical Yearbook," "China Environmental Statistical Yearbook," "China Environmental Statistical Yearbook," "China Labor Statistical Yearbook," "China Energy Statistical Yearbook," "China Education Statistical Yearbook," and "China Science and Technology Statistical Yearbook," as well as regional statistical yearbooks and statistical bulletins. The missing data of individual years are supplemented by the average growth rate. The year 2000 is set as the base year for the nominal variables, and the non-exponential variables are logarithmic to reduce the heteroskedasticity of the data. The descriptive statistical results of each variable are presented in Table 2.

TABLE 2 Descriptive statistical results of variables.

	Variable	Observed value	Mean value	Standard deviation	Minimum value	Maximum value
Variable being explained	Comprehensive index of new urbanization Development quality (Urban)	540	34.727	42.910	16.1	268.9
	New urbanization innovation development index (Urban1)	540	10.855	22.457	0.2	142.03
	New urbanization innovation development index (Urban2)	540	5.352	2.628	0.99	18.3
	New urbanization innovation development index (Urban3)	540	3.160	1.250	0.51	7.68
	New urbanization innovation development index (Urban4)	540	11.190	18.403	0.22	81.91
	New urbanization innovation development index (Urban5)	540	2.533	1.457	0.23	11.91
Explanatory variables	Comprehensive environmental governance level (Govern)	540	32.987	14.204	5.99	125.49
	Government governance index (government)	540	12.873	9.657	0.91	96.62
	Market governance index (market)	540	8.266	6.610	0.35	62.03
	Social governance index (social)	540	11.847	7.294	2.06	46.32
Control variable	Economic development level (pgdp)	540	3.3908	2.250	0.41	13.49
	Public goods supply (public)	540	47.713	38.539	2.18	229.12
	Industrial structure optimization (struc)	540	41.278	8.412	28.6	80.6
	Quality of civic education (educ)	540	37.669	20.092	4.0	91.2
	Level of opening up (trade)	540	83.29	255.11	0.132	3,090

TABLE 3 Panel model test results.

Test method	Test statistic values	p-Value
Wald test for between-group heteroskedasticity correction	$\chi 2\ (30) = 548.35$	0.0000
Intergroup autocorrelation Wooldridge test	$F\ (1,29) = 14.197$	0.0070
Inter-group simultaneous correlation test	Pesaran's test: csi = 53.877	0.0000
	Friedman's test: Csi = 194.440	0.0000
	Frees' test: Csi = 5.290	0.0000

4.3 Analysis of empirical results

4.3.1 Test of model setting

To improve the effectiveness of the model estimation, the panel data are tested first, where F = 122.32 (0.0000), which rejects the null hypothesis of "the absence of individual fixed effects" by a large margin. GLS estimation is performed for the random effect model, and the Breusch and Pagan test results are provided. LR = −407.25 (0.0000), the null hypothesis "H0: σu = 0" is rejected, so the random effect model should be selected. Through the Hausman test, the p-value is 0.0000, strongly rejecting the null hypothesis "H0: ui is not correlated with Xit, Zi = 0." These panel data are suitable for the fixed effects model, and F = 51.91 is obtained through the joint significance F-test of time effects, and the year fixed effects are significant at the 1% level, so the double fixed effects model is selected.

We further test whether the random disturbance term $\{\varepsilon_{it}\}$ of the panel data model is inconsistent with the classical hypothesis to obtain more effective and consistent estimates. According to the improved Wald test results provided by Greene (2000) (Greene, 2000), $\chi 2\ (30) =$ 440.24, p = 0.0000, and heteroskedasticity exists between groups. The Wooldridge test method is used for testing, F (1,29) = 29.374, p = 0.0000, which supports the conclusion that intra-group autocorrelation exists. By testing the panel data with the three methods of xtscd (see Table 3), the p values are all less than 1%, so the null hypothesis of "no correlation between groups" is strongly rejected.

TABLE 4 Overall regression results of urbanization.

Explanatory variables	Variable being explained urban			
	①	②	③	④
Egovern	0.0740* (0.0416)	0.07248***(0.0033)		
Government			0.07215*** (0.0029)	0.1715***(0.0114)
Market			0.1579*** (0.0066)	0.2071***(0.0214)
Social			0.0087** (0.0038)	0.2314***(0.0181)
Government*market				0.0035***(0.0008)
Government*social				−0.0122***(0.0009)
market*social				−0.0080***(0.0012)
T	−1.9125***(0.5394)	−2.0474***(0.04718)	−2.0486*** (0.0457)	−1.9635***(0.04719)
_cons	−56.9044***(21.7227)	−19.036***(4.6814)	82.8957*** (3.7807)	85.3751***(3.8431)
Model overall significance test	Wald ch2 = 130,566.30	Wald ch2 = 316884.40	Wald ch2 = 1,690,279	Wald ch2 = 309066.89

Note: Values in the parentheses are standard deviations. ***, **, and * represent the statistical significance levels of 1%, 5%, and 10%, respectively (double-tailed). The values in the parentheses after the regression coefficients of each explanatory variable are z-values after heteroskedasticity adjustment (heteroskedasticity panel correction standard error in Eq. 1).

TABLE 5 Regression results of different dimensions of new urbanization and high-quality development of new urbanization.

Explanatory variables	Variable being explained: Urban1 ①		Variable being explained: Urban2 ②		Variable being explained: Urban3 ③		Variable being explained: Urban4 ④		Variable being explained: Urban5 ⑤	
egovern	0.019*** (0.002)		0.002*** (0.001)		−0.001 (0.001)		0.002 (0.001)		−0.002***(0.001)	
government		0.027*** (0.003)		0.001 (0.001)		0.001 (0.001)		−0.01*** (0.002)		−0.004** (0.001)
market		0.012 (0.010)		0.002 (0.001)		0.008*** (0.002)		−0.26*** (0.003)		0.023*** (0.003)
social		−0.001 (0.008)		0.010*** (0.001)		−0.01*** (0.002)		0.039*** (0.003)		−0.009*** (0.002)
t	−0.50*** (0.053)	−0.48*** (0.071)	0.072*** (0.012)	−0.08*** (0.012)	−0.04*** (0.009)	−0.03** (0.0124)	−0.232*** (0.021)	−0.24*** (0.036)	0.012 (0.015)	0.037** (0.016)
_cons	95.51*** (6.38)	31.37*** (5.085)	20.89*** (0.917)	20.57*** (0.915)	6.888*** (0.291)	6.250*** (0.368)	43.54*** (2.57)	69.85*** (3.078)	0.825 (0.083)	1.16 (0.805)
Overall significance test	Wald chi2 = 6951.7	Wald ch2 = 5866.6	Wald chi2 = 2588.9	Wald chi2 = 2585.3	wald chi2 = 2017.7	wald chi2 = 2339.0	wald chi2 = 13867	wald chi2 = 19336	wald chi2 = 2920.2	wald chi2 = 1323.7

Note: Values in the parentheses are standard deviations. ***, **, and * represent the statistical significance levels of 1%, 5%, and 10%, respectively (double-tailed). The values in the parentheses after the regression coefficients of each explanatory variable are z-values after heteroskedasticity adjustment (heteroskedasticity panel correction standard error in Eq. 1).

Combined with the test results, considering the individual fixed effect and time effect, this paper uses the comprehensive FGLS that can better correct the heteroscedasticity and panel correlation of panel data to estimate the model, so as to obtain a consistent and effective estimator.

4.3.2 Analysis of estimation results

Owing to space constraints, we only report the main explanatory variables related to the model, and the control variable parameter estimation results are omitted (see Tables 4–6).

First, environmental governance contributes to the high-quality development of new urbanization. To obtain more effective estimation results, we use panel corrected standard error (PCSE) and comprehensive FGLS to estimate Eq. 1, which can correct heteroskedasticity and correlation. Corresponding to ① and ② in Table 4, the comprehensive FGLS estimation results of Eq. 2 are ③ and ④. After controlling the individual and time effects, as well as influencing factors such as economic growth rate, government investment, economic structure optimization, human capital accumulation, and foreign trade; Table 4 (① and ②) shows that China's environmental

TABLE 6 Regression results of environmental governance effect in four regions.

Explanatory variables	Eastern region (10 provinces)		Central region (6 provinces)		Western region (11 provinces)		Northeast (3 provinces)	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
egovern	0.2265*** (0.0219)		0.0323** (0.0155)		−0.0669*** (0.0091)		0.0699*** (0.0262)	
government		0.2820*** (0.0269)		0.0388 (0.0263)		−0.0894** (0.0099)		0.0705*** (0.0257)
market		0.1318** (0.0614)		−0.0069 (0.0270)		0.0821*** (0.0137)		0.2981** (0.1179)
social		0.1617*** (0.0321)		0.0919** (0.0500)		−0.1225*** (0.0135)		−0.0349 (0.1057)
t	−4.0766*** (0.1453)	−4.1544*** (0.1377)	−1.4846*** (0.2364)	−1.4633*** (0.2773)	−1.0981*** (0.0871)	−1.1496*** (0.0806)	−1.3074** (0.6190)	−1.2821** (0.5816)
_cons	3.8028*** (11.5087)	4.3971 (11.0896)	−33.085*** (4.5257)	−27.171*** (5.2723)	−12.995*** (2.2978)	−14.233*** (2.2211)	−43.51*** (12.326)	−48.52*** (12.5157)
test of significance	Wald chi = 15155.75	Wald chi = 626.55	Wald chi2 = 933.06	Wald chi2 = 873.22	wald chi2 = 4927.11	wald chi2 = 5368.68	wald chi2 = 2376.11	wald chi2 = 3,378.91

Note: Values in the parentheses are standard deviations. * * *, * *, and * represent the statistical significance levels of 1%, 5%, and 10%, respectively (double-tailed). The values in the parentheses after the regression coefficients of each explanatory variable are z-values after heteroskedasticity adjustment (heteroskedasticity panel correction standard error in Eq. 1).

governance has significantly promoted the high-quality development of urbanization in the country as a whole. For every 1 point increase in the environmental governance index, the high-quality development index of urbanization increases by 0.074 and 0.072 points, which is statistically significant, reflecting that China has vigorously implemented the strategy of ecological environment protection since the new century. Additionally, the construction of a "two-oriented" society has promoted the development of new urbanization in China.

Second, the internal mechanism of environmental governance in promoting the high-quality development of new urbanization is unbalanced (see ③ in Table 4). The role of the three aspects of the internal mechanism of environmental governance is significant at 5%. The role of market environmental governance in the high-quality development of new urbanization is much higher than that of government governance and public governance. For every 1 point increase in the market environmental governance index, the high-quality development index of new urbanization increases by 0.1579 points, whereas government environmental governance only increases by 0.072 points, which is less than 50% of the role of market environmental governance. The role of public environmental governance is even lower, only increasing by 0.0087 points. To a certain extent, this result reflects that although environmental governance has been dominated by government regulation for a long time, in addition to mandatory means such as legislation and policies, the dominance is mostly related to market interest incentives. The relation has effectively promoted the formation and improvement of the market-oriented mechanism of environmental governance, and public environmental governance has begun to play a role. However, owing to the constraints of basic factors such as the level of economic and social development as well as the low awareness of environmental protection, its role in promoting the high-quality development of new urbanization remains relatively limited. From the perspective of

environmental governance, we are faced with many challenges, such as the unscientific and reasonable arrangement of the power structure of environmental governance, the poor information sharing and coordination between cross-sectoral governance entities, the insufficient authority and effectiveness of government supervision, the insufficient play of the role of corporate subjectivity, and the low effectiveness and orderly participation of social forces (Zhan and Chen, 2020).

If the interaction of the three aspects of environmental governance is further investigated, the role of government, market, and social public governance in promoting the high-quality development of new urbanization is significant at the 1% level. In the case of non-participation by the public, the synergistic effect of government and market environmental governance significantly improves the performance of government environmental governance. Every increase of 1 point promotes the high-quality development index of new urbanization. The result of 0.2004 points is much higher than that of a single function. Without considering the market, the government will promote the high-quality development index of urbanization by increasing 1 point through social public governance by 0.027 points. It can be seen that the collaborative foundation of government and public governance has not been formed. Without considering the power of the public, the excessive use of government power by the market may lead to a decline in its role in promoting the high-quality development of new urbanization in China to 0.0272. If the market actively cooperates with public environmental governance, its role in promoting the high-quality development of new urbanization will be significantly increased to 0.1123. If government intervention is lacking, the synergy between public and market forces will promote the high-quality development of new urbanization by 0.1653 points. The synergy between the public and the government will promote the high-quality development index

of new urbanization by 0.0743 points, which is much higher than the performance of the public alone.

The effect of environmental governance is mainly reflected by the estimation results (see Table 6) of the five dimensions of the new development concept. Environmental governance has a positive effect on the high-quality innovation development and coordinated development of new urbanization and is statistically significant at the 1% level. This result confirms the existence of the "Porter effect" but it is not conducive to shared development. From the perspective of the internal mechanism of environmental governance, government governance has promoted the innovation and development of new urbanization. Every 1-point increase in the index will significantly promote the innovation and development index of new urbanization by 0.027 points. However, to a certain extent, the promotion inhibits the opening and sharing of the development of new urbanization. A possible reason is that the government's environmental governance can promote the improvement of the basic conditions of innovation and development, such as basic research on innovation and the accumulation of human resources, which is conducive to the cultivation of innovative development methods. Green, open, and shared development require long-term system improvement, industrial structure, and urban and rural structure optimization and adjustment, where the role of government environmental governance is limited. Market environmental governance promotes the green and shared development of new urbanization. It can increase the green and shared development index of new urbanization by 0.08 and 0.023 points, respectively, but its contribution to open development is negative. Currently, the market mechanism of resource trading and resource allocation in environmental governance is imperfect, mainly relying on policies, laws, and administrative means to change people's interest game expectations. Enterprises promote green technology research and development innovation from their respective environmental rights and interests, achieve the goal of saving resources and protecting the environment, and promote the sharing and development of environmental rights and interests to a certain extent. However, the joint and several effects of the open development of new urbanization and the coordinated development of market environmental governance are slow. Public governance has played a positive role in coordinated development and open development. Every 1-point increase in this index can significantly promote the coordinated development and open development indexes of new urbanization by 0.01 and 0.039 points, respectively, but restricts innovative development, green development, and shared development. Currently, the public mainly participates in environmental governance through letters and visits, complaints, water conservation, and greening, which encourage enterprises to save resources, protect the environment, improve the industrial structure, and create a good environment for opening to the outside world. However, owing to the imperfect basic conditions for development and related systems, it plays a limited role in promoting innovation, promoting green technologies and production methods, and sharing the fruits of social development.

Third, obvious regional differences are observed in the effects and mechanisms of environmental governance on promoting the high-quality development of new urbanization in China. From the regression results presented in Table 6, the overall effectiveness of environmental governance in the eastern region is relatively high, and the synergy between the government, market, and public is obvious. Every 1-point increase in the environmental governance index will

effectively promote the high-quality development index of new urbanization by 0.2265 points, which is much higher than that of other regions. The northeast region comes second, and its environmental governance effect is 0.0699 points. The central region is 0.0323, less than 50% of the value of the northeast region and 14.3% of that of the eastern region. The environmental governance in the entire western region inhibits the high-quality development of new urbanization. This conclusion supports the research conclusion of Lu Weixue and others, that is, the impact of environmental regulation policy synergy on high-quality economic development has obvious heterogeneity, and the higher the level of economic development, the higher the synergy effect of environmental regulation policy (Lu et al., 2022).

From the perspective of the internal mechanism of environmental governance in promoting the high-quality development of new urbanization, the environmental governance of the government, market, and public varies considerably in different regions. The effect of government environmental governance is highly significant in the eastern and northeastern regions, which are 0.282 and 0.0705, respectively, and that of the eastern region is much higher than that of other regions. The market environmental governance effect is significant at the 5% level in the eastern, western, and northeastern regions, which are 0.1318, 0.0821, and 0.2981, respectively, and the market environmental governance effect in the northeastern region is much higher than that in other regions. A 1-point increase in the government environmental governance index will increase the new urbanization quality index by 0.2981 points. The market environmental governance effect in the central region is negative but not statistically significant. The regional differences in the effect of social public environmental governance are also large. The eastern and central regions have the largest effect of social public environmental governance, which are 0.1617 and 0.0919, respectively, and significant at the 1% and 5% levels, respectively. However, the social public governance in the western region has not promoted the high-quality development of new urbanization, and its inhibitory effect is significant at the 1% level. The northeast region also shows a consistent effect but is not statistically significant.

Obvious regional differences are observed in the internal mechanism of China's environmental governance in promoting the high-quality development of new urbanization. The main reason for the differences is that areas with good ecological environment in China are mostly distributed in the south of Hu Huanyong Line, and most areas in the western region have a fragile ecological environment. In the long-term development process, the objective of government environmental protection is first to ensure that areas with good ecological environments do not continue to deteriorate; this goal can achieve better results in the short term. The effect of promoting the high-quality development of new urbanization in China is better. The eastern, western, and northeastern regions are the key areas controlled by resource and environmental taxes and fees in China. They are also the three major regions with high market environmental governance effects. Public governance has significantly promoted the high-quality development of new urbanization in the central and eastern regions. A possible reason is that the eastern region has a good economic development foundation, and the public's awareness of

TABLE 7 Robustness test of the model.

Explain variables	①	②
Urban-1	1.089***(0.0235)	1.091***(0.0286)
Urban-2	−0.3527***(0.0213)	−0.3589***(0.0267)
egovern	0.0264***(0.0043)	
government		0.0445***(0.0095)
market		0.0545**(0.0215)
social		−0.0349***(0.0085)
Government*market		
Government*social		
Market*social		
t	−1.4001***(0.0497)	−1.3817***(0.0615)
_cons	−38.115***(3.472)	−36.845***(3.760)
Model Global Significance Test	Wald ch2 = 435104.89	Wald ch2 = 120215.78

environmental protection is high. Meanwhile, the public's participation in environmental governance through green actions and water-saving irrigation is more prominent in the main grain-producing areas in central China. Ecological environment protection in the western and northeastern regions has been the focus of the country for a long time. The strong intervention of the government has obviously inhibited the public's participation.

4.3.3 Robustness test of the model

The high-quality development of new urbanization in China is related to various factors, such as economic, social, and cultural factors. The variables involved in the model in this paper, such as environmental governance, economic growth, public investment, economic restructuring, human capital accumulation, and foreign trade, are mostly economic factors. Economic development is the most important aspect affecting the high-quality development of new urbanization in China. Social and cultural aspects also play an important role that cannot be underestimated. Therefore, the model estimation in this paper likely has an endogenous problem of missing important variables. Thus, it is necessary to perform a robustness test of the model estimation and draw on relevant research literature. The 1-period and 2-period lag terms of the explanatory variable are included as the explanatory variable, which will alleviate the endogenous problem caused by the missing variables to a certain extent. According the model (1), the FGLS estimation method is used for robustness test. The results are shown in Table 7, in which regression Eq. 1 provides the estimation results of model (1) under the premise that the explanatory variable lags behind the 1-period and 2-period. We find that environmental governance still has a significant role in promoting the high-quality development of new urbanization in China as a whole. Eq. 2 provides the estimation results of model (2), where the public governance symbol is changed. The significance and parameter size changes of government environmental governance and market environmental governance are small, which proves the robustness of the panel data model estimation presented in this paper.

5 Conclusion

Our empirical study has observed the effect of environmental governance on the quality improvement of urbanization from various angles. The results show that the hypothesis of promoting effect of environmental governance is valid in the overall perspective, but it shows significant and complex imbalance in other perspectives. First, there is an imbalance in the promotion effect of environmental governance on the five dimensions of urbanization quality. Second, the three internal governance mechanisms of environmental governance (government governance, market governance and public governance) have an unbalanced effect on the quality of urbanization. Third, the effect of environmental governance on the quality of urbanization also shows a clear regional imbalance.

The significant and complex imbalances noted above are somewhat beyond our expectations. Although the author recognizes that there must be spatio-temporal differences in the development of urbanization and environmental governance, and many empirical studies have found that different environmental control policy tools will bring different environmental governance effects, and there are regional heterogeneity and time non-linear evolution characteristics. But such complex imbalances are still bigger than expected. It also suggests that practice should not be judged solely on the basis of theory.

Compared with the existing research, our empirical results accord with the general trend of the development of the existing theory, and to some extent develop the existing theory, and put forward a series of new problems. For example, how to achieve the shared development of environmental governance and urbanization? How to explain and solve the restraining effects of environmental governance in the process of urbanization? How to better realize the synergy of government environmental governance, market environmental governance and public environmental governance in the process of urbanization? In addition, this study may point out a possible direction for future research, that is, how to realize the improvement of environmental governance and the improvement of urbanization quality with specific regions or cities as spatial objects.

At present, global development faces multiple challenges. How to achieve environmental governance and economic development in the post-epidemic era is one of the key issues. In order to meet this challenge, urban space will remain the main area for countries to meet the challenge. Because, although the current rural area is also an important field, but its economic function is still not the dominant function. Green technology is the focus of attention in many countries, but there is still a gap to achieve the goal of ecological wellbeing and economic development in the post-epidemic era. So, how to improve the quality of urbanization and environmental governance in the post-epidemic era, will undoubtedly be the goal of all countries to achieve. Although China started late, but, after decades of sustained efforts, both in the field of urbanization, and environmental governance, has become one of the international community's focus. In this context, the 17 years of experience from China (2000–2017) will at least provide a reference for how China or similar countries and regions can better manage the environment in urban space in the future. Based on the empirical study of this paper, we also put forward some suggestions for policy-making. The following positive adjustments should be made. First,

China should persist in and innovate in environmental governance to promote high-quality urbanization. As the main inhabitation area of economic and social development in China, urban areas are crucial in ecological environmental governance and socialist ecological civilization construction. In the new era of socialism with Chinese peculiarities, China should adopt the modern construction of the system and capacity of environmental governance as a goal and constantly improve the internal structure and system of environmental governance. The country should prioritize the inclusive goals of the environmental governance system with Chinese peculiarities in environmental protection, the transformation of the development model through innovation, coordination of the social and economic structure, greater openness, and realization of the benefits of development shared by the people.

Second, China should constantly improve the internal mechanism of the environmental governance system, strengthen collaborative mechanisms, and constantly improve the efficiency of environmental governance. As part of the modernization of the national governance system and governance capacity, environmental governance is insufficient in promoting innovative, coordinated, green, open, and shared development of China's new urbanization. A large gap still exists between the overall goal of the modernization of the governance system and governance capacity, and the construction of its basic system needs to constantly advance. However, the internal mechanisms of environmental governance are not coordinated, and the synergy mechanism is not fully unbalanced. China should continue improving the goal of her socialist market economy to complete the remodeling of the government's leading role in environmental governance and reduce government failure from the mechanism. Meanwhile, the country must accelerate the reconstruction of the main position of the market environment governance with resources and pollution property rights trading as the core. The market should fully optimize the allocation of resources to ensure that enterprises become the subject of environmental governance. The public should be actively encouraged to participate in the basic projects of environmental governance: channels for public participation in environmental governance should be improved through legislation and relevant systems, social publicity and education should be strengthened, and the public's awareness and ability for environmental protection should be cultivated. The positive role of big data and information governance should as well be exploited, and the public should be encouraged to participate actively in environmental governance.

Third, China should consider the imbalance in regional development conditions in constructing different environmental governance systems. As a developing country, different regional economic development levels are a basic feature of the country, which should determine the different emphases that should be placed on the environmental governance system and ability of modernization construction in different regions. The central government should further delegate power to local governments in environmental governance and strengthen supervision over local governments in environmental governance. The central government should provide more financial support to the western regions and other regions with less developed environmental governance capabilities. The western regions and other regions with less developed environmental governance capabilities should further improve their marketization level and strengthen social forces for environmental protection. Under the authorization of the central government, China would gradually establish regional and innovative governance systems in line with the concept of environmental pluralism and co-governance.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization, ZT, YT, and SY; methodology, ZT; software, ZT; validation, ZT, YT, and SY; formal analysis, ZT; investigation, ZT, YT, and SY; resources, SY; data curation, ZT and YT; writing-original draft preparation, ZT and YT; writing-review and editing, ZT; visualization, SY; supervision, SY; project administration, SY; funding acquisition, SY. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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