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Dynamics in green governance in China: Exploring the relationship between carbon emissions, water consumption and economic planning

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ABSTRACT

Environmental planning under government control plays a crucial role in shaping national environmental outcomes. This study examines how China's five-year economic planning cycles influence carbon emissions and water consumption. Using data from 240 Chinese cities (2007–2022), our analysis reveals that fiscal pressures significantly constrain resource use, reducing emissions and water consumption. However, as the planning cycle nears its conclusion, local governments ramp up industrial and infrastructure activities to meet policy targets, leading to a notable surge in carbon emissions and water usage. Quantile regression analysis further shows that these effects vary across different levels of urban development, with cities at different economic stages experiencing divergent environmental impacts. These findings underscore the complex trade-offs between economic growth, fiscal management, and environmental sustainability in a centrally planned economy. While fiscal constraints can limit resource use, the cyclical nature of planning introduces short-term environmental strains that may undermine long-term sustainability goals. This suggests a need for adaptive policy mechanisms that distribute economic activity more evenly throughout the planning cycle, rather than allowing for late-stage surges. Additionally, strengthening environmental regulations and incentivizing long-term green investments could mitigate the adverse effects of economic planning cycles on resource consumption. These insights provide implications for policymakers seeking to balance economic development with environmental stewardship, particularly in economies where centralized planning remains a dominant governance tool.

1. Introduction

Economic planning plays a fundamental role in shaping national environmental and economic outcomes. The relationship between economic cycles and environmental governance has been widely studied, particularly in democratic systems where political and economic decisions are often shaped by electoral incentives. Influential studies by Nordhaus [1] and Alesina et al. [2] have shown that governments in Western democracies tend to adjust environmental policies in response to electoral cycles, prioritizing short-term economic growth in ways that can either accelerate or delay sustainability efforts. In these systems, policymakers may introduce expansionary environmental measures to appeal to voters before elections and then tighten regulations post-election to control fiscal deficits. As a result, environmental governance in democracies often follows cyclical patterns tied to political turnover.

However, China presents a starkly different case. Unlike Western democracies, where voter-driven political cycles influence environmental policy [3], China's centralized governance structure follows a quinquennial (five-year) planning model, which defines the trajectory of economic and environmental policy in a top-down manner [4]. While these long-term planning cycles provide stability and continuity, their

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implications for environmental management, particularly concerning carbon emissions and water consumption, remain poorly understood. Existing research has explored China's political-economic cycles, highlighting their effects on fiscal expenditures, financial lending, and urban development [5-7], but relatively little attention has been paid to their direct environmental consequences.

This study seeks to address a critical research gap by systematically examining the influence of China's five-year economic planning cycles on urban carbon emissions and water consumption. While previous research has primarily focused on electoral cycles in Western economies, this study offers new empirical insights into how centralized economic planning shapes environmental resource management. Specifically, it investigates whether economic planning cycles introduce systematic variations in resource consumption and emissions and how fiscal pressures interact with these cycles to influence environmental outcomes.

This research advances the existing literature in several key ways. First, it contributes to the understanding of political-economic cycles and environmental governance in non-democratic contexts, where long-term planning mechanisms replace voter-driven decision-making processes. Second, it integrates perspectives from economic planning and environmental management studies by analyzing the evolution of urban resource consumption patterns across successive five-year planning periods in China. Third, it extends prior research on the Environmental Kuznets Curve hypothesis [8–12], assessing whether economic planning mitigates or exacerbates environmental pressures over time.

The findings of this study have significant implications for economic planning, fiscal governance, and sustainability policymaking in China and other centrally planned economies. By providing empirical evidence on the cyclical nature of carbon emissions and water consumption in urban China, this research underscores the need for adaptive governance strategies that better align economic growth with environmental sustainability objectives. Moreover, the study offers valuable insights for policymakers tasked with designing environmental policies within structured economic planning frameworks, where balancing economic development priorities with sustainability imperatives remains an ongoing challenge.

2. Literature review

The scholarly literature underscores the significant political costs that enterprises face during economic planning and political-economic cycles. Caldara et al., and Wieland [13,14] highlight how strict supervision and control, especially related to accounting data, impact business operations and development. This scrutiny often correlates with financial results that deviate from set benchmarks, leading to stringent policy constraints as noted by Andreoni et al. [15] and Nußholz et al. [16]. These constraints can negatively affect stable production and operations, aspects crucial for maintaining energy efficiency and managing carbon emissions in urban settings. Alesina et al. [2], in their study of 18 OECD countries, identified significant cyclical changes, indicating a broader global trend that also affects environmental policy and management. Yang et al. [17] specifically pointed to the Chinese government's role in exacerbating economic fluctuations, which in turn impacts the stability of supply and demand. The financial system, driven by central banks, plays a pivotal role in this dynamic, necessitating a separation from political authorities to ensure consistent management. Chen and Miao [18] conducted an empirical analysis on China's data from 1953 to 2008, revealing a strong positive correlation between changes in the central government and economic fluctuation cycles. These fluctuations, driven by local government exchanges and performance appraisals, often lead to amplified fiscal and monetary policies, directly influencing energy projects, budget allocations, and credit mechanisms. Liu and Abu Hatab [19], Wang and Nayak [20], and Wang et al. [21] demonstrated that policy instability, due to official changes, restrains economic growth, which can have a cascading effect on energy sectors. Miao [22] explored the domestic financial cycle's response to government changes, concluding that domestic political cycles significantly affect this cycle, with implications for energy financing and investments. Mei and Sun [23] used a fixed effect model to analyse data from 31 Chinese provinces, finding that economic public service supply, which includes energy-related services, exhibits clear political cycles, whereas non-economic public service supply does not. Frigerio et al. [24] and Koetter et al. [25] analysed the impact of political cycles on bank loans in Europe and Germany, respectively, noting that political friction influences lending activities, which could affect financing available for energy projects. Faraji et al. [26], through an analysis of Iranian companies, linked political cycles and connections to company returns, which can indirectly influence investment in energy sectors.

However, the relationship between political-economic cycles and resource management is not always straightforward. For example, Wang and Chou [5], Liu et al. [6], Shao and Chou [7] Three papers have successively discovered the existence of political cycles in China. Around the time of the five-year Party Congress, China's urban financial industry lending, the sale of public land, and urban air pollution all undergo cyclical changes. In short, in the year before each Party Congress, lending and sales of public land would drop significantly, and pollution would improve. But after the Party Congress is held, the scale of lending and the sale of public land will increase significantly, and pollution will become serious. By comparing the conclusions of various literatures, it can be found that China's urban changes are actually related to the cyclical nature of policies, but the overall representation is not as direct as it seems. The complexity of these cycles, compounded by the diverse interests of various stakeholders, can lead to inconsistent or short-term policies that undermine long-term environmental sustainability goals. In particular, the political volatility within these cycles often results in policy shifts that prioritize immediate economic growth over sustainable resource management, thus aggravating environmental challenges such as carbon emissions and water scarcity. This inconsistency can pose significant challenges for urban planners and managers, who must navigate these changing political landscapes while striving to meet energy efficiency targets and reduce carbon emissions. The need for a more stable and consistent policy environment becomes apparent, one that can balance economic development with long-term environmental sustainability. Furthermore, the international dimension of these cycles cannot be ignored. Global political-economic trends, such as shifts in oil prices or international environmental agreements, also play a significant role in shaping domestic environmental policies and practices. These external factors can influence the availability of energy and water resources, the cost of energy production, and the competitiveness of different technologies. Understanding these global influences on local policy implementation can help bridge the gap between national economic planning and international sustainability frameworks. In light of these complexities, this study's focus on the impact of China's five-year economic planning cycles on urban carbon emissions and water consumption is timely and pertinent. By employing a regression model, this research aims to unravel the intricate relationship between economic planning, political cycles, and resource management in urban China. This analysis is crucial for policymakers and stakeholders, providing valuable insights that can inform more effective and sustainable environmental policies. Ultimately, understanding these dynamics can help mitigate the environmental impact of urban development, contributing to the global efforts in combating climate change and promoting sustainable urban living.

In summary, while extensive literature explores the impact of political and economic planning on industrial development, there is a gap in discussions about how these cycles specifically affect urban carbon emissions and power generation. This study, by setting up a regression model within the framework of China's five-year economic planning, aims to fill this gap. It seeks to explore the impact of these cycles on urban carbon emissions and water consumption, thereby contributing to a more comprehensive understanding of the interplay between economic planning, political cycles, and resource management in urban environments. Additionally, this study will provide a deeper understanding of how these cyclical dynamics in China's unique political and economic context may offer lessons for other developing economies striving for sustainable urban development.

3. Methods

Building on the model proposed by Wang and Chou [5], Liu et al. [6], and Shao and Chou [7], previous studies have primarily framed urban economic activities as dynamic processes that consume energy and water. These studies emphasize the role of electric heating consumption as a driver of economic activities while also acknowledging its environmental impact. However, unlike Chou's prior work, which focused on the broad relationship between energy use and urban economic growth, this study takes a more nuanced approach by specifically examining the trade-offs involved in balancing electric heating consumption with economic productivity and environmental sustainability. Rather than treating energy consumption as a linear driver of economic output [8,9,27], our framework introduces a more integrated perspective, considering both the constraints imposed by environmental factors and the policy mechanisms needed to mitigate pollution. This refined conceptualization is reflected in the study structure outlined in Fig. 1.

If the capital stock (K_t) and investment (I_t) of economic activity to the local urban development to bring the following benefits:

$$Y_t = AK_t \tag{1}$$

Among which, the Y_t is the local economic output; A is a constant greater than 0, representing the contribution of investment to GDP growth. If to assume that the t-th stage investment is I_t, as investment I_t need to pay the interest cost, cost function can be written as $C(I_t)$, $C'(\bullet) > 0$, $C''(\bullet) > 0$. Because fixed assets have problems such as depreciation, if δ represents the capital depreciation rate, the capital stock in period $t+1$ is:

$$K_{t+1} = (1-\delta)K_t + I_t \tag{2}$$

Meanwhile, after transferring investment to industrial production, it will bring electric heating consumption and other environmental problems. Under the same environmental treatment technology, 1 unit of investment will produce the corresponding q unit of consumption. The economic income generated by the capital stock K_t therefore can be recorded as $V(K_t)$:

$$V(K_t) = \max_{I_t}\{AK_t - C(I_t) + \beta V[K_{t+1}(1-q)]\}, \quad 0 < \beta < 1 \tag{3}$$

According to the formula (3), the optimal dynamic condition can be obtained in maximizing formula (3), the optimal I_t level will then generate electric consumption $I_t q$.

However, it is needed to account for the cyclical nature of economic planning in our models. In China, the economic planning activities carried out every five years can be regarded as a cycle of change. The parameter β in formula (3) represents the impacts of economic planning on benefits during this economic planning period. The smaller β indicates a lower evaluation of future benefits. The β therefore changes with the economic planning. We use β^0, β^1, β^2 to represent the investment power level of a city in the year when the Chinese government propose economic planning, the middle year of two economic planning agendas, and the next economic planning year respectively. Then, Euler equation can be obtained by dynamic optimum:

$$\dot{C}(I_t) = \beta^i\left[\dot{C}(I_{t+1}) + A\right] \tag{4}$$

Among which, $I = 0, 1, 2$. The left-hand side represents the marginal cost of investment in period t, and the right-hand side represents the marginal revenue. According to the Euler equation solution, the following formulas can be obtained:

$$\dot{C}(I^0) = \frac{\beta^0(1+\beta^1+\beta^1\beta^2)}{(1-\beta^0\beta^1\beta^2)}A \tag{5}$$

$$\dot{C}(I^1) = \frac{\beta^1(1+\beta^2+\beta^0\beta^2)}{(1-\beta^0\beta^1\beta^2)}A \tag{6}$$

$$\dot{C}(I^2) = \frac{\beta^2(1+\beta^1+\beta^0\beta^1)}{(1-\beta^0\beta^1\beta^2)}A \tag{7}$$

Eqs. (5) to (7) represent the correlations among economic planning, electric heating consumption and urban carbon emissions. Since the above estimation formula is a linear form, we can conduct empirical discussion through OLS.

To ensure the integrity and reliability of statistical data, this study

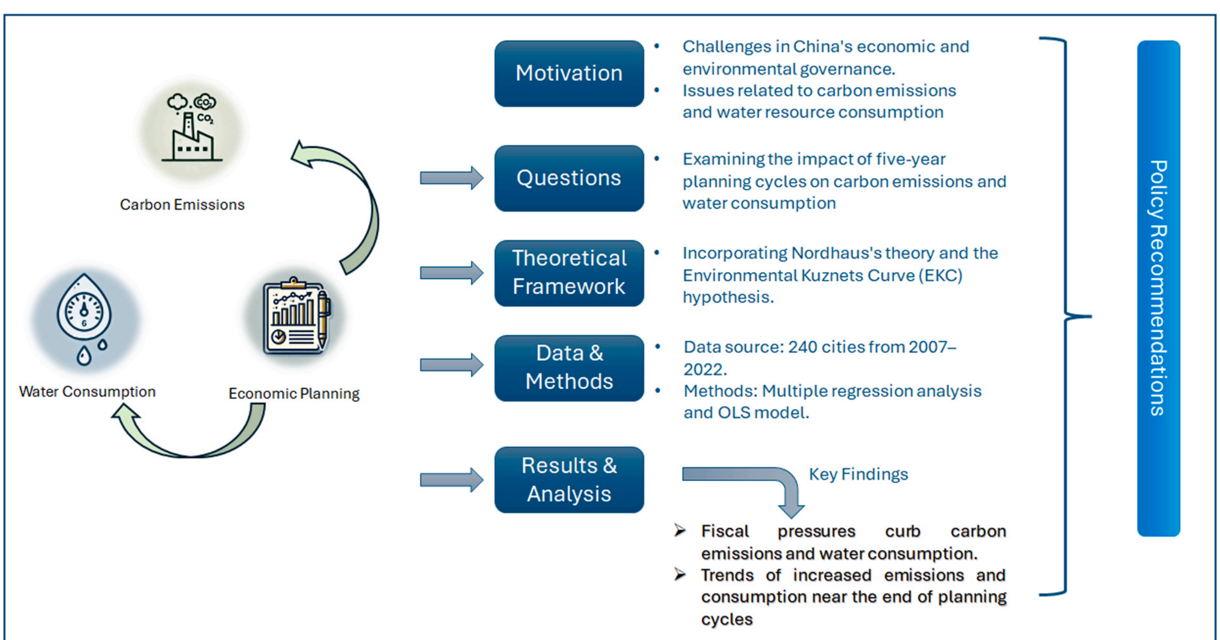

Fig. 1. Study Framework.

utilized data from 240 Chinese cities spanning the period from 2007 to 2022, as reported in the *China City Statistical Yearbook*. Initially, data for all Chinese cities included in the yearbook were gathered. Subsequently, rigorous data cleaning procedures were implemented, including the identification and exclusion of outliers in the explanatory variables to enhance result robustness.

In addition to economic and environmental data, information regarding government economic planning events (Plan) was derived from two primary sources. First, records of government economic planning were obtained from publicly available archives, including Baidu Encyclopedia, Wikipedia, and the Communist Party of China News Network (http://cpc.people.com.cn/index.html). These sources provided historical records of policy announcements and governmental planning decisions. Second, supplementary data were collected from *China City Statistical Yearbook* and *Chinese Provincial Statistical Yearbook*, ensuring consistency and completeness in tracking planning-related variables.

Following Wang and Chou [5], a multiple regression model as follows was employed to assess the impact of economic planning on carbon emissions and water consumption. The analysis proceeded in three stages. First, an ordinary least squares (OLS) model was used to estimate the relationship between economic planning cycles and resource consumption, controlling for relevant economic and fiscal variables. Second, statistical significance tests were conducted to verify the robustness of the explanatory variables. Finally, the estimated coefficients were interpreted in the context of urban environmental management, providing insights into the mechanisms through which economic planning influences emissions and water usage.

$$\log(Y_{it}) = \alpha + \beta_1 \log(Capita_{it}) + \beta_2 Finance\ Pressure_{it} + \sum \beta_j Plan + e_{it} \quad (8)$$

Where Y_{it} is the carbon emission or water consumption of city i in year t, $Capita_{it}$ is the i-th city's output per capita; $Finance\ Pressure_{it}$ is the i-th city's financial burden in year t. *Plan* represents China's five-year economic planning period (i.e. the j-th year into the economic planning period). In the process of empirical estimation, first we set the carbon emission or water consumption of city i in year t as the dependent variable, and then estimate the coefficient of independent variables (i.e., $Capita_{it}$, $Finance\ Pressure_{it}$, and other variables) with OLS model. Second, we measure whether the variables are statistical significant or not. Finally, we explain the intuition of independent variables.

To ensure the integrity of the statistical data, we collected data from 240 Chinese cities for the period 2007–2022. The data were sourced from the China City Statistical Yearbook. Initially, we gathered data for all cities listed in the yearbook, after which we excluded outliers in the explanatory variables to ensure the robustness of the results. Table 1 presents the descriptive statistics. From Table 1, we observe that in 17.6 % of the time periods, the sample cities experienced the economic planning cycle. Additionally, the variable Finance Pressure reflects the financial burden faced by cities, with an average value of 2.638, indicating that, on average, the cities' financial expenditures were 264 % of their budget. These findings align with the results of Wang and Chou [5] and Shao and Chou [7], who noted an increase in financial pressures across Chinese cities in recent years.

Table 1
Descriptive Statistics.

Variable	Mean	Observations	Definition
Emission	59,927	4185	Emission of CO_2. (Unit: tons)
Water	660,425	4713	Water usage (Unit: tons)
Capita	189,863	4770	Output per capita. (Unit: RMB)
Finance Pressure	2.637	4515	Fiscal expenditure divided by fiscal revenue. (Unit: ten thousand RMB)
Plan	0.176	4675	Dummy variable, if the year had Economic plan = 1, others = 0

4. Results

According to Liu et al. [6], the economic performance of Chinese cities have a cycle in each 5 years. We basically follow the process of empirical estimation by Wang and Chou [5], Liu et al. [6]. Table 2 presents a detailed examination of the empirical results, offering insights into the complex interplay between fiscal pressures, economic planning, and environmental impact. The data consistently indicates that fiscal pressures exert a restraining influence on both carbon emissions and water consumption. In cities where fiscal constraints are more pronounced, the ability to drive local economic development through fiscal policy becomes increasingly challenging. Consequently, these cities often resort to scaling back local economic activities and reducing economic supply, which inadvertently leads to a decrease in carbon emissions and water demand associated with these activities. Thus, fiscal pressure emerges as a significant negative determinant of the variables under consideration. Further, the results demonstrate a notable pattern in the context of economic planning cycles. As an economic plan nears the end of its cycle, there is a marked increase in emissions and water consumption. This trend could be attributed to the urgency felt by local governments as they approach the deadline for achieving set targets. Faced with unmet goals, these administrations may accelerate activities in the final year of the planning cycle, leading to increased urban economic activities and enhanced economic production capabilities. This uptick in activity can inadvertently exacerbate urban carbon emissions and intensify the demand for water resources.

This phenomenon underscores a critical aspect of economic planning: the rush to meet targets can lead to short-term increases in environmental impact, highlighting the need for more sustainable planning approaches. It suggests that while fiscal pressures can help in curbing resource consumption and emissions, the cyclical nature of economic plans might inadvertently create periods of increased environmental strain. This pattern also reflects the inherent challenge in balancing the immediate demands of economic growth with the long-term imperative of environmental sustainability. Therefore, these empirical findings suggest a complex relationship between fiscal management, economic planning, and environmental outcomes. They call for a nuanced approach to urban planning and policy-making, one that harmonizes the objectives of economic development, fiscal responsibility, and environmental stewardship. Policymakers must consider these dynamics to devise strategies that not only foster economic growth but also mitigate the adverse environmental impacts of such development. This balance is crucial for achieving sustainable urban growth, where economic prosperity and environmental health are not mutually exclusive but are pursued in tandem.

Table 2 performs regression analysis. we have known the impact of the cycle of economic planning on urban carbon emissions and water consumption. In other words, the estimations of Table 2 indicate the

Table 2
Empirical Results.

dependent	Log(Emission)		Log(Water)	
variable	(1)	(2)	(3)	(4)
Finance Pressure	−0.377 * **	−0.399 * **	−0.385 * **	−0.401 * **
	(0.017)	(0.014)	(0.009)	(0.010)
log(Capita)	−0.120 * **	0.035 * **	−0.080 * **	0.024 * **
	(0.009)	(0.010)	(0.006)	(0.007)
Plan −1	0.223 * *	0.016 * *	0.133 * *	−0.037
(One year prior to the planning)	(0.088)	(0.080)	(0.061)	(0.054)
Plan + 1	0.003	0.029	−0.044	−0.125 * **
(One year after the planning)	(0.075)	(0.069)	(0.050)	(0.046)
Year dummy	No	Yes	No	Yes
Constants	Yes	Yes	Yes	Yes
N	3881	3881	4156	4156
R^2	0.169	0.295	0.277	0.377

average impacts of independent variables on dependent variable [8,9]. We further compare the differences in quantiles. The estimation method is as follows: Considering the empirical outcomes may differ in different quantiles, we further apply the quantile approach to examine the effect of the independent variable on the dependent variable. The quantile estimator is obtained by solving an optimization problem:

$$\min_{\beta \epsilon R^k}\left[\sum_{i\epsilon\{i:y_i \geq x_i'\beta\}} \theta|y_i - x_i'\beta| + \sum_{i\epsilon\{i:y_i < x_i'\beta\}} (1-\theta)|y_i - x_i'\beta|\right] \tag{8}$$

For the θ-th quantile ($0 < \theta < 1$), where y_i is the dependent variable and x_i' is a k by 1 vector of the explanatory variables. In Fig. 2, the horizontal axis is the quantile of urban carbon emission and water consumption, and the vertical axis is the impact of economic planning on its coefficient value. The dotted line and the solid line indicate the coefficient of OLS estimation and the quantile regression estimation. The interaction between dotted line and the solid line mean that the influence of quantile in independent variable is higher or lower than the average effect (the estimation result of OLS).

The graphical analysis in Figs. 2 and 3 provides a nuanced understanding of the relationship between economic planning and environmental impacts. In Fig. 2, the horizontal dotted line representing the OLS estimation intersects with a light-colored line that denotes the varying influences of the explanatory variable across different quantiles of urban carbon emissions. This intersection points to a key insight: the impact of economic planning on urban carbon emissions is not uniform across different emission levels. Particularly, at the lower end of the emission scale (below the 20th quantile), economic planning has a relatively minimal impact. Conversely, when emissions exceed this quantile, the influence of economic planning intensifies, surpassing the average effect predicted by OLS. However, at the highest emission levels (around the 80th quantile), this impact once again diminishes.

These findings align with the Environmental Kuznets Curve Hypothesis (EKC), which posits that economic growth initially leads to increased environmental degradation, but after reaching a certain development threshold, further economic growth results in environmental improvement [8–12]. The data from Fig. 2 indicates that at both low and high extremes of urban carbon emissions, economic activities have a reduced impact on emissions. This pattern suggests a decoupling

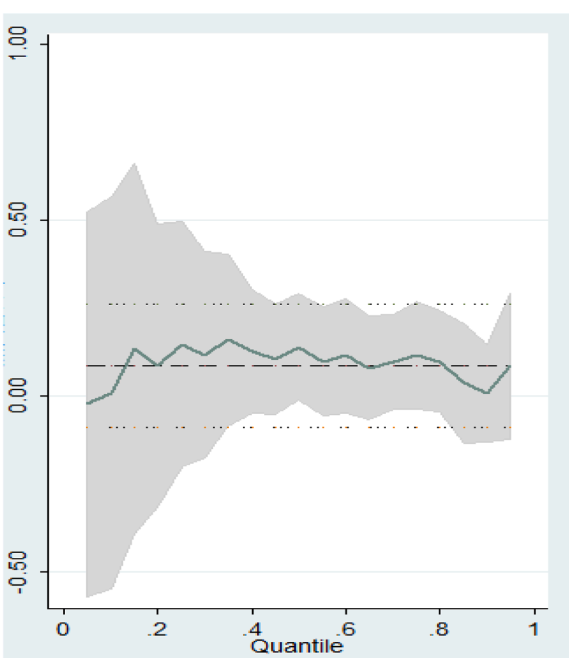

Fig. 2. The Impact of Economic Planning on Carbon Emissions.

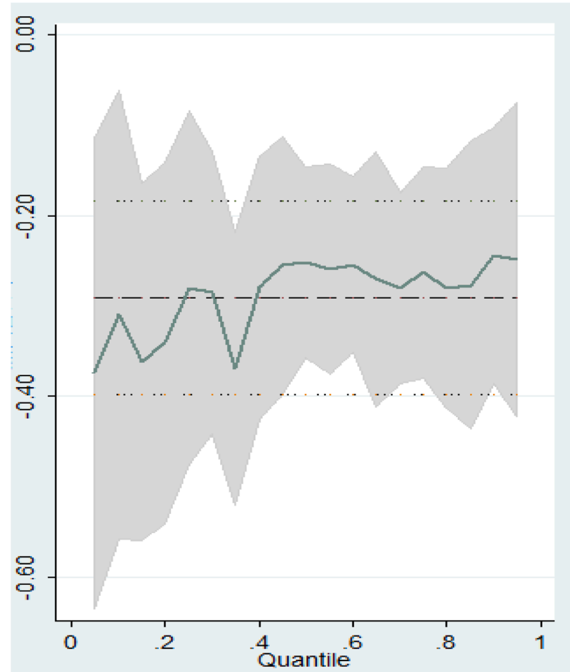

Fig. 3. The Impact of Economic Planning on Water Consumption.

of economic growth from environmental degradation, wherein cities with either very low or high emissions levels manage to moderate the environmental impact of their economic activities more effectively. In Fig. 3, the analysis shifts to the impact of economic planning on urban power supply. The figure shows that above the 40th quantile, the influence of economic planning on power supply strengthens with each increase in quantile. This trend indicates that economic policies drive up the demand for water and electric energy, consequently affecting the pollution associated with these economic activities. Given this dynamic, finding ways to mitigate the environmental impact of increased water supply becomes imperative.

To address this challenge, cities can adopt a multi-faceted approach. Implementing energy efficiency assessments in line with government regulations and undertaking energy conservation reforms are crucial steps [28,29,7]. Optimizing the urban power structure, enhancing the construction of gas pipelines, and promoting centralized urban water systems can improve overall energy efficiency. In agriculture, the development of low-carbon ecological agriculture demonstration parks and the intensive processing of agricultural products can reduce the sector's carbon footprint. Furthermore, advancing urban public transportation systems, restricting or phasing out high-energy-consuming vehicles, and enforcing stricter emissions standards are essential for reducing the environmental impact of urban mobility.

Moreover, these strategies must be integrated into the broader framework of economic planning and policy promotion. By doing so, cities can not only facilitate economic growth but also ensure that such growth is environmentally sustainable. The ultimate goal is to achieve a harmonious balance where economic development and environmental preservation coexist, reducing the negative impact of water consumption and carbon emissions in the process of urban development.

5. Perspective and discussion

The findings of this study provide critical insights into the interplay between urban carbon emissions, water consumption, and economic planning cycles in China. However, they also raise broader concerns about the long-term sustainability of a planning-driven economic model, particularly in the face of global environmental challenges. While

China's five-year economic planning system has played a pivotal role in shaping urban environmental governance, its cyclical nature introduces systematic fluctuations in resource use that may not align with global sustainability goals. The trade-offs between economic growth and environmental conservation require careful examination to develop policies that promote stability while mitigating environmental harm [6,7,30].

5.1. The challenge of cyclical economic planning and international comparisons

A major challenge identified in this study is the tendency for resource consumption and emissions to surge toward the end of each planning cycle. This pattern is driven by local governments accelerating economic activities to meet policy targets, often prioritizing short-term performance over long-term sustainability [31–33]. This phenomenon is not unique to China—similar patterns of economic acceleration due to policy cycles have been observed in other centrally planned or state-interventionist economies. For instance, studies on the former Soviet Union and contemporary Russia indicate that periodic government spending surges often lead to temporary economic booms followed by environmental degradation [34]. Similarly, Japan's long history of government-guided industrial planning has demonstrated that while central intervention can drive rapid growth, it also risks creating policy-induced economic distortions [35]. Unlike China, however, Japan has progressively shifted toward more flexible, market-oriented planning, incorporating adaptive mid-cycle evaluations to mitigate such risks.

Given these international examples, addressing the negative externalities of rigid planning cycles in China may require a more dynamic and responsive framework. Introducing real-time monitoring mechanisms and adaptive policy adjustments throughout the five-year period could help distribute economic activities more evenly and prevent resource-intensive surges toward the end of the cycle. Countries like Germany and Sweden have successfully implemented rolling sustainability plans that reassess environmental and economic priorities periodically, ensuring that economic expansion does not come at the cost of ecological stability [36]. Such models could serve as valuable references for refining China's approach.

5.2. Fiscal pressures and sustainable investment: global experiences

Another critical issue explored in this study is the role of fiscal pressures in shaping resource consumption. While fiscal constraints can limit excessive carbon emissions and water use, they may also hinder the necessary investments in green infrastructure and sustainable technologies. This paradox has been documented in several emerging economies. For example, Brazil and South Africa, both of which face high fiscal constraints, struggle with balancing environmental goals and economic expansion [37]. In contrast, South Korea's Green New Deal—a strategic government-led initiative—has shown that fiscal discipline and sustainability investment can be reconciled by prioritizing public-private partnerships and innovative financing mechanisms, such as green bonds and carbon pricing.

China could benefit from adopting similar fiscal instruments that channel investments into long-term sustainability without imposing excessive short-term economic burdens. Additionally, restructuring local government incentives to reward environmental performance rather than short-term economic output could be a pivotal step in aligning fiscal policies with sustainability goals. Lessons can also be drawn from the European Union's Emissions Trading System (EU ETS), which has successfully integrated carbon pricing into fiscal governance, providing economic incentives for industries to reduce emissions while maintaining fiscal balance [38].

5.3. Regional disparities and policy differentiation

This study also highlights significant regional disparities in the effectiveness of economic planning on environmental outcomes. Wealthier cities with advanced industrial bases, such as Beijing and Shanghai, are better positioned to implement resource-efficient policies, while less-developed regions, particularly in central and western China, face greater challenges in meeting sustainability targets. These disparities are not unique to China—similar challenges exist in large federal economies such as the United States and India, where environmental regulations are unevenly enforced due to regional economic differences [38].

In the case of India, the introduction of state-specific sustainability plans has allowed regions with different economic structures to tailor environmental policies to local conditions while maintaining alignment with national objectives. In China, a similar approach could involve differentiated economic planning strategies based on regional development levels. Coastal megacities could serve as innovation hubs for green technologies, while inland cities could focus on optimizing resource efficiency in traditional industries. Such a strategy would not only address regional inequalities but also enhance the overall effectiveness of national planning efforts.

5.4. Multi-stakeholder governance and global policy integration

Another key implication of this study is the importance of multi-stakeholder governance in addressing urban sustainability challenges. While China's centralized planning approach ensures strong coordination at the macro level, effective environmental governance requires active participation from local governments, businesses, and communities. Many European countries have successfully integrated participatory governance models into their sustainability frameworks, involving private enterprises and civil society in policymaking processes [39,40]. For example, the Netherlands' polder model, which brings together government agencies, businesses, and NGOs to jointly design and implement sustainability policies, has been instrumental in managing the country's water resources efficiently.

A similar governance structure in China could improve the implementation of green policies at the micro level. Encouraging corporate involvement in sustainability initiatives, strengthening local regulatory autonomy, and increasing transparency in policy enforcement could bridge the gap between national ambitions and on-the-ground realities. Furthermore, aligning China's economic planning with international environmental agreements, such as the Paris Agreement, could ensure that domestic policies remain consistent with global sustainability efforts.

5.5. China's role in the global sustainability transition

Finally, China's experience in economic planning and environmental management offers important lessons for other nations, particularly those in the Global South. Many developing economies face similar challenges in balancing industrial growth with ecological sustainability. Comparative studies examining different governance models—centralized versus decentralized—could shed light on best practices for integrating environmental objectives into economic planning. Furthermore, as international organizations push for stronger global climate policies, China's approach can serve as both a model and a cautionary tale, illustrating the potential benefits and risks of top-down planning in sustainability governance.

Future research should explore the role of international environmental agreements in shaping national economic planning strategies and investigate how policy coordination between major economies can enhance global sustainability outcomes. As the world continues to grapple with climate change and resource scarcity, China's ability to refine its economic planning system to prioritize long-term environmental sustainability will have profound global implications.

6. Conclusion

China's rapid economic transformation over recent decades has been accompanied by profound challenges in resource management and environmental sustainability. Urban areas, as the primary drivers of economic activity and hubs of population growth, have borne the brunt of these challenges. This study, by examining the interplay between China's five-year economic planning cycles, carbon emissions, and water consumption, sheds light on the complex trade-offs inherent in balancing economic development with environmental conservation.

The empirical findings highlight the moderating role of fiscal pressures in curbing resource consumption and emissions. However, this restraint is not without its drawbacks. While fiscal constraints effectively reduce immediate environmental impacts, they often limit investments in the infrastructure and technologies needed for a sustainable future. This tension underscores the importance of designing fiscal policies that encourage long-term investments in low-carbon development while maintaining short-term resource efficiency.

The cyclical nature of planning further complicates the picture. The observed uptick in emissions and water use towards the end of planning cycles reflects the systemic pressures faced by local governments to meet economic targets. This phenomenon raises important questions about the temporal alignment of economic and environmental objectives. Without structural reforms to mitigate these end-cycle surges, the sustainability of China's urban development remains in question. Policymakers should consider introducing mechanisms such as rolling plans or mid-cycle evaluations to ensure a more balanced approach to resource management.

In addition to these systemic issues, regional disparities in planning effectiveness present another layer of complexity. Cities with stronger fiscal capacities and more diversified economies are better equipped to implement resource-efficient policies, while less-developed regions often face significant barriers. This calls for a differentiated approach to economic planning that accounts for regional variations in resources, capacities, and development priorities. By tailoring strategies to local conditions, China can address these disparities and improve the overall effectiveness of its planning framework.

Looking beyond China, the findings of this study have broader implications for global urban development. The integration of environmental objectives into economic planning is not unique to China; it is a challenge faced by cities and nations worldwide. As the global community seeks to align economic growth with sustainability goals, China's experience offers valuable lessons. For instance, the emphasis on centralized coordination in China highlights the potential for top-down approaches to achieve large-scale environmental impacts. However, it also underscores the risks of prioritizing short-term economic gains over long-term sustainability.

To address these challenges, a multi-faceted approach is needed. First, cities must transition to more sustainable industrial models, emphasizing high-efficiency, low-carbon technologies. Second, resource allocation must be optimized through circular economic practices, renewable energy adoption, and enhanced emissions control technologies. Third, governance structures must evolve to include diverse stakeholders, fostering greater transparency, accountability, and innovation in policy implementation.

Achieving sustainable urban development necessitates a careful balance between competing economic, social, and environmental priorities. By implementing adaptive planning mechanisms, fostering regional and global collaborations, and integrating environmental considerations at every stage of the policy-making process, China has the potential to set a precedent for building cities that are both economically dynamic and environmentally resilient. The findings of this study contribute to the expanding body of knowledge on sustainable urban development, offering a framework that can guide other nations in reconciling economic growth with environmental stewardship in an increasingly resource-constrained world.

Looking ahead, the Chinese government is expected to place greater emphasis on policy objectives beyond economic expansion. Reforming incentive structures for government officials may serve as a crucial strategy for addressing distortions in the land market and aligning economic activities with broader sustainability goals. While this study highlights the influence of political cycles on China's economic operations, further research is needed to examine the extent to which these cycles affect key sectors such as energy, finance, employment, and industry-specific developments.

Future studies could explore how the timing and implementation of economic planning cycles shape investment patterns in renewable energy, green finance, and industrial decarbonization efforts. Additionally, further investigation is required to understand the role of fiscal pressures and policy incentives in shaping local governments' environmental decision-making processes. Comparative analyses across different governance models—including decentralized and market-driven economies—could yield valuable insights into alternative planning approaches that effectively balance economic development with long-term sustainability. Addressing these areas in future research will provide a more comprehensive understanding of how China and other nations can refine their economic planning models to better align with global sustainability objectives.

CRediT authorship contribution statement

Dai Jie: Visualization, Validation, Resources, Conceptualization. **Ding Rongqing:** Writing – original draft, Formal analysis, Data curation, Conceptualization. **Chou Li-Chen:** Writing – original draft, Supervision, Software, Project administration, Data curation. **Tan Tingting:** Writing – review & editing, Validation, Methodology. **Zhang Ying:** Writing – review & editing, Visualization, Software, Resources, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

References

[1] Nordhaus WD. The political business cycle. Rev Econ Stud 1975;42(2):169.
[2] Alesina A, Rosenthal H. Partisan politics, divided government, and the economy. Cambridge: Cambridge University Press; 1995.
[3] Xia M, Phillips F, Zhang W, Cai HH, Dai J, Zhang L, Wu Y. From Carbon Capture to Cash: Strategic Environmental Leadership, AI, and the Performance of US Firms. Journal of Organizational and End User Computing (JOEUC) 2024;36(1):1–24.
[4] Zhou C, Richardson-Barlow C, Fan L, Cai H, Zhang W, Zhang Z. Towards organic collaborative governance for a more sustainable environment: Evolutionary game analysis within the policy implementation of China's net-zero emissions goals. Journal of Environmental Management 2025;373:123765.
[5] Wang M-Y, Chou L-C. Political cycle and the financial lending scale. Appl Econ Lett 2022;29(6):534.
[6] Liu H, Guo X, Chou L-C, Cai H, Ye X. Public land sales and the political cycle in China. Econ Res-Ekon istraživanja 2023;36:3.
[7] Shao W, Chou L-C. Political influence and air pollution: evidence from Chinese cities. Heliyon 2023;9:7.
[8] Chou L-C, Zhang W-H. The effect of democracy on energy efficiency in European countries. Econ Res-Ekon Istraživanja 2020;33(1):3476.

[9] Chou L-C, Zhang W-H, Wang M-Y, Yang F-M. The influence of democracy on emissions and energy efficiency in America: new evidence from quantile regression analysis. Energy Environ 2020;31(8):1318.
[10] Dogan E, Chishti MZ, Alavijeh NK, Tzeremes P. The roles of technology and Kyoto Protocol in energy transition towards COP26 targets: evidence from the novel GMM-PVAR approach for G-7 countries. Technol Forecast Soc Change 2022;181:121756.
[11] Ertugrul HM, Cetin M, Seker F, Dogan E. The impact of trade openness on global carbon dioxide emissions: evidence from the top ten emitters among developing countries. Ecol Indic 2016;67:543.
[12] Xia M, Chuai X, Xu H, Cai HH, Xiang A, Lu J, Zhang F, Li M. Carbon deficit checks in high resolution and compensation under regional inequity. J Environ Manag 2023;328:116986.
[13] Caldara D, Iacoviello M, Molligo P, Prestipino A, Raffo A. The economic effects of trade policy uncertainty. J Monet Econ 2020;109:38.
[14] Wieland A. Dancing the supply chain: toward transformative supply chain management. J Supply Chain Manag 2021;57(1):58.
[15] Andreoni A, Chang H-J. The political economy of industrial policy: Structural interdependencies, policy alignment and conflict management. Struct Change Econ Dyn 2019;48:136.
[16] Nußholz JLK, Rasmussen FN, Milios L. Circular building materials: carbon saving potential and the role of business model innovation and public policy. Resour Conserv Recycl 2019;141:308.
[17] Yang Y, Zhang S, Zhang N, Wen Z, Zhang Q, Xu M, Zhang Y, Niu M. The dynamic relationship between China's economic cycle, government debt, and economic policy. Sustainability 2022;14(2):1029.
[18] Chen W, Miao W. Government transition, economic policy and political economy cycle. Econ J 2010;(4):14.
[19] Liu Z, Abu Hatab A. Assessing stakeholder engagement in public spending, green finance and sustainable economic recovery in the highest emitting economies. Econ Change Restruct 2023;56(5):3015.
[20] Wang Q, Nayak BS. Two Decades of Fiscal Decentralization and Regional Economic Growth in China. Singapore: Springer Nature; 2023.
[21] Wang Q, Dong Z, Li R, Wang L. Renewable energy and economic growth: new insight from country risks. Energy 2022;238:122018.
[22] L. M W. Political and financial cycles and the effect of monetary policies in large countries. Contemp Financ Econ 2018;(3):46.
[23] Mei Z, Sun Y. Is there a political cycle in the supply of public services? J Yunnan Univ Financ Econ 2020;36(09):88.
[24] Frigerio M, Vandone D. European development banks and the political cycle. Eur J Political Econ 2020;62:101852.
[25] Koetter M, Popov A. Political cycles in bank lending to the government. Rev Financ Stud 2021;34(6):3138.
[26] Faraji O, Kashanipour M, Mohammadrezaei F, Ahmed K, Vatanparast N. Political connections, political cycles and stock returns: evidence from Iran. Emerg Mark Rev 2020;45:100766.
[27] Dogan E, Majeed MT, Luni T. Analyzing the impacts of geopolitical risk and economic uncertainty on natural resources rents. Resour Policy 2021;72:102056.
[28] Chuai X, Xia M, Zhang M, Cai HH, Ye X. Reveal the inequality hidden in industry land use by integrating domestic trade and the industry efficiency. J Environ Manag 2023;344:118716.
[29] Xia M, Zhu B, Cai HH. Does duration of team governance decrease corporate carbon emission intensity. Corp Soc Responsib Environ Manag 2023;30(3):1363.
[30] Zhang W-H, Yuan Q, Cai H. Unravelling regional development through the production-living-ecological perspective: assessing heterogeneity and expert insights. Urban Clim 2024;55:101937.
[31] Rakcho Y, Mouiya M, Bouazizi A, Abouliatim Y, Sehaqui H, Benhammou A, Abourriche A. Enhanced mechanical strength of micro-porous ceramics through the removal of alkaline earth carbonates from Moroccan red clay for membrane support application. Arab J Chem 2024;17(1):105484.
[32] El-Kordy A, Dehmani Y, Douma M, Bouazizi A, El Moustansiri H, El Abbadi S, Tijani N. Experimental study of phenol removal from aqueous solution by adsorption onto synthesized faujasite-type Y zeolite. Desalin Water Treat 2022;277:144–54.
[33] Bouazizi A, Ouammou M, Aaddane A, Tijani N, Younssi SA. Novel low-cost bentonite-based membranes for microfiltration, ultrafiltration, and nanofiltration applications. In *Novel Materials for Environmental Remediation Applications*. Elsevier; 2023. p. 247–75.
[34] Brain S. The environmental history of the Soviet Union. A Companion Glob Environ Hist 2025:187–204.
[35] Yu J, Yan T, Kong H. Exploring the management mode for breeding new species suitable for deep sea mariculture in China: best practices, challenges, and prospects. Ocean Coast Manag 2025;261:107508.
[36] Sverdrup HU, van Allen O, Haraldsson HV. Modeling indium extraction, supply, price, use and recycling 1930–2200 using the WORLD7 model: implication for the imaginaries of sustainable Europe 2050. Nat Resour Res 2024;33(2):539–70.
[37] Khater M, Ibrahim O, Sayed MNE, Faik M. Legal frameworks for sustainable tourism: balancing environmental conservation and economic development. Curr Issues Tour 2024:1–22.
[38] Basaglia P, Grunau J, Drupp MA. The European union emissions trading system might yield large co-benefits from pollution reduction. Proc Natl Acad Sci 2024;121(28):e2319908121.
[39] Levin R, Villanueva CM, Beene D, Cradock AL, Donat-Vargas C, Lewis J, Deziel NC. US drinking water quality: exposure risk profiles for seven legacy and emerging contaminants. J Expo Sci Environ Epidemiol 2024;34(1):3–22.
[40] Ullman AN, Kittner N. Are global efforts coordinated for a just transition? A review of civil society, financial, government, and academic Just Transition frameworks. Energy Res Soc Sci 2024;108:103371.