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Economic Growth Targets, Innovation Transformation, and Urban Carbon Emissions: An Empirical Study of the Yangtze River Delta

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Abstract: In the face of carbon emissions reduction efforts, which are a common but differentiated global responsibility, it is crucial to explore the potential synergistic path between economic growth and carbon emissions reduction. This study integrates economic growth management and carbon emissions into a theoretical framework, based on city-level panel data from 2005 to 2019 in the Yangtze River Delta and the fixed effects model. We explore the impact of economic growth targets on urban carbon emissions. Then, we explore the mechanism by which economic growth target affects carbon emissions with the mediation effect model and moderation effect model. The results reveal that economic growth targets are beneficial for carbon reduction, and innovation development from innovation transformation is an important mechanism driving carbon emissions reduction, but the effects of different innovation outputs exhibit notable variations. In addition, marketization and industrial structure affect the relationship between economic growth targets and carbon emissions. The heterogeneity analysis reveals substantial spatial and temporal differences. Based on the realities of developing countries' ongoing economic targets, this study provides a new explanation for the relationship between government policies and carbon emissions, establishing a scientific basis for policymakers to formulate strategic green development policies.

Keywords: economic growth target; carbon emissions; innovation; heterogeneity; the Yangtze River Delta

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1. Introduction

Economic growth management is a common global phenomenon, particularly in developing countries [1]. However, when governments excessively focus on economic growth in macro-management, insufficient attention is paid to the challenges of environmental pollution, resource shortages, and industrial incoherence, and the crude growth model of high input and high emissions has generated negative outcomes, such as the rapid increase in carbon dioxide (CO_2) emissions [2,3]. Under the new global order and peaceful environment since World War II, international negotiations to address climate change have continued to advance in the face of the unprecedented impact of greenhouse gas emissions on sustainable development, pushing carbon reduction efforts from scientific considerations into global practice [4,5]. Under the influence of global carbon emissions reduction constraints and sovereign economies' right to development, solving the contradiction between economic growth and CO_2 emissions is an urgent concern for developing countries to address global climate change while advancing economic development [3,4]. In this regard, it is of great significance for developing countries to explore the effect of economic growth management on carbon emissions and its mechanisms to advance a synergistic relationship between economic growth and environmental protection.

Previous studies have conducted in-depth research on economic growth management, carbon emissions, and related topics. (1) In the face of developing countries' urgent economic growth needs, research on economic growth management and its effects has received considerable academic attention [6,7]. Government economic growth management has been found to effectively promote economic growth, with an impact on total factor productivity, technological innovation, ecological environment, urban–rural coordination, and related effects [6,8]. Empirical research has yielded differentiated results, such as some scholars have found that economic growth targets inhibit innovation [9,10], while others have found that economic growth targets can promote innovation [7]. (2) Carbon emissions have become a popular research topic in recent years. Based on multivariate carbon emissions estimation methods, some studies have determined that the evolution of carbon emissions has significant spatial and temporal differences, such as the high spatial agglomeration and steady-state characteristics of carbon emissions in China [11–13]. In addition, economic growth, energy consumption, industrial structure, innovation development, level of openness, and macro policies have been found to affect the evolution of carbon emissions, and the Chinese government's macro-policies have significantly affected carbon emissions [13,14]. (3) Employing theoretical models such as Kaya's equation (it links economic, policy, and population factors with the carbon dioxide emissions generated by human activities through a simple mathematical expression, thereby discovering the impact of different factors on carbon emissions) [15] and the environmental Kuznets curve (EKC) hypothesis (it indicates an inverted U-shaped relationship between environmental quality and income level) [16], academics have conducted in-depth research on the relationship between economic growth and carbon emissions [17–19]. The findings have revealed that economic growth is a significant factor of carbon emissions, but its impact varies significantly in different countries [18]. For example, economic growth reduces the negative effect of energy usage on carbon emissions in African countries [17], and a bidirectional causal link exists among carbon emissions and economic growth in China [19]. In addition, economic growth management can promote economic growth, but the two are not completely the same [13,20]. Theoretically, economic growth management has emphasized economic progress over green development, inevitably resulting in increased carbon emissions [1,12]. However, previous empirical studies have reached contradictory conclusions such as economic growth targets reducing carbon emissions [13]. China has achieved a significant reduction in carbon intensity while maintaining strong economic growth, suggesting that growth management does not always incur negative effects [3]. Overall, a rich body of research has provided many references for practical development. However, we find that, compared to research on the relationship between economic growth and carbon emissions, research regarding the relationship between economic growth management and carbon emissions remains in its infancy.

Carbon reduction is a common but differentiated global responsibility, and it is equally undesirable to cause economic stagnation or recession through excessive carbon reduction, particularly for developing countries such as China and India [4,21]. The classical growth model contends that resource input and energy consumption are the source of economic growth, indicating that economic management cannot achieve economic growth and reduce carbon emissions simultaneously [17,22]. Therefore, reducing carbon emissions without greatly affecting economic growth is an important challenge for developing countries [3,5]. In contrast, the EKC hypothesis indicates that a simple static relationship does not exist between economic growth and carbon emissions [16]. Moreover, empirical studies have found that economic management that includes environmental regulations can reduce carbon emissions, and the enhancement in technological innovations spurs economic growth [10,14,23]. In addition, endogenous growth theory contends that innovation is the core driving force for economic growth and advancing quality and efficiency improvement, providing theoretical support for protecting the environment while sustaining economic growth [5,24]. In particular, the characteristics of long-term investment and strong externalities associated with innovation require the government to play a key role in promoting innovation [25,26]. As such, transitioning from factor- to innovation-driven economic growth management may be a feasible approach for activating the synergy between economic growth and carbon emissions reduction [4,25]. This raises a practical question: Does economic growth management promote urban innovation?

In addition, Geels et al. [27] argued that only breakthrough green innovation can lead to rapid and deep green growth. However, whether economic growth target constraints can promote innovation transitions and innovation output can significantly bring about carbon reductions remains somewhat controversial [5,7,28]. Therefore, although most scholars have emphasized the importance of innovation in coordinating economic growth and carbon reduction [17,26], it is essential to deepen the research on the government's practices concerning innovation and its effects in economic growth management.

Carbon reduction is a climate change issue as well as a practical concern that is closely related to economic growth. As the world's largest developing country, the economic and carbon emission growth rates of China have shown an inverted U-shaped pattern since the 21st century (Figure 1), and the economic growth and carbon emissions have not yet fully decoupled, resulting in its total carbon emissions still account for about one-third of the world's total emissions. Although China's carbon emissions' intensity declined by about 48.1% from 2005 to 2019, but the per capita income is only one-third that of member countries of the Organisation for Economic Co-operation and Development. All of these indicate that China is confronting more urgent dual pressures of stable economic growth and rapid carbon reduction [3]. In the context of urban agglomerations becoming the main spatial carriers of economic growth and carbon emissions reduction [2], this study organically combines economic growth target management with carbon emissions. Based on the typical urban agglomeration of the Yangtze River Delta, we explore the correlation between economic growth targets and carbon emissions and examine the mechanism of innovative transmission. Overall, the possible marginal contributions are threefold. (1) We correlate the local government's economic growth management with carbon emissions, providing a novel theoretical analysis framework for investigating government carbon reduction practices that enriches the theoretical study of carbon emissions. (2) This study quantitatively identifies the correlation and impact mechanism between economic growth targets and urban carbon emissions, analyzing the transmission mechanism of innovation and providing a theoretical basis for achieving synergy between local economic growth and carbon reduction. (3) China's economic growth management is typical under the institutional constraints of political centralization and economic decentralization [29], and our findings can also provide theoretical and empirical guidance for other emerging countries to promote carbon emissions reduction while advancing economic growth. The remainder of this study is organized as follows. Section 2 analyses the mechanisms and research hypotheses. Section 3 introduces the study area, methods, and data. Section 4 presents the results. Section 5 presents the discussion. And conclusions are detailed in Section 6.

Figure 1. The trendline between the economic growth and carbon emissions of China, 2000–2019.

2. Theoretical Analysis and Research Hypotheses

Advancing the synergy between economic growth and carbon reduction is a realistic approach for developing countries [5]. Therefore, it is essential to place carbon reduction analysis in the context of local government economic growth management, which is particularly important for China as the world's largest developing country [29]. In China, economic growth plays a significant role in the political promotion assessment of local leaders, meaning that the faster the economic growth, the higher the probability of promotion for local leaders. Therefore, as a rational body, local governments have the motivation to set higher growth targets and achieve or exceed economic growth targets through resource allocation. This is an important political factor contributing to China's economic growth miracle [30]. Guided by relevant theories of political economy such as public choice theory (that is, local leaders will choose the most advantageous action for themselves by comparing costs and benefits in the political market), we incorporate economic growth targets and carbon emissions into an analytical framework to explore the carbon emissions effects and internal transmission mechanisms of economic growth target management, especially the complex mechanisms of innovation. Based on a theoretical analysis, we next propose the research hypotheses of this study. Figure 2 illustrates the theoretical relationships examined in this study.

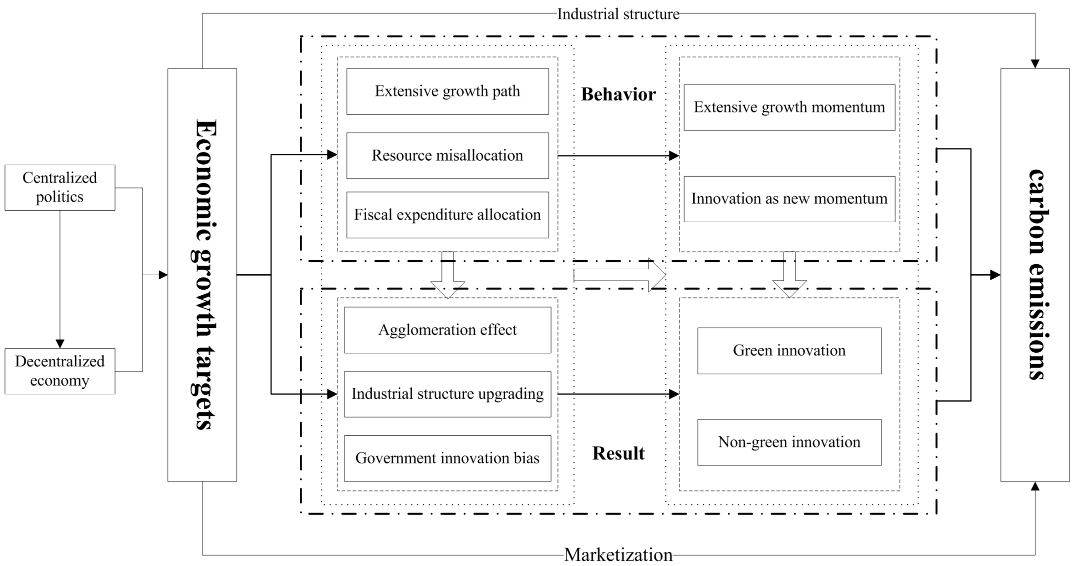

Figure 2. Theoretical mechanism underlying the effect of the economic growth targets on carbon emissions.

2.1. Urban Carbon Emissions Under Economic Growth Target Constraints

Local government competition centered on gross domestic product (GDP) is an important institutional factor in China's economic growth miracle [8]. Under the mandatory institutional constraints of economic management [29], economic growth targets have stimulated local governments' enthusiasm for economic development; however, indiscriminate measures may also inhibit development quality such as increasing carbon emissions [1,12]. First, the single target of GDP and short-term term systems for official assessment in economic growth management have strengthened local governments' preference for high-investment, high energy consumption industries [30]. Furthermore, "race to the bottom" competitions have been undertaken to attract investment by relaxing environmental regulations, which has a negative effect on eliminating local backward production capacity and zombie enterprises and industrial structure upgrading [12,31]. Second, growth target constraints strengthen local governments' impulse to regulate factor allocation, which reduces development efficiency, increasing resource misallocation [32]. For example, when facing scarce land elements, state-owned enterprises (SOEs) with a low production efficiency can obtain more land resources, resulting in inefficient manufacturing industry development [8]. Third, under the constraints of limited local finance, local governments will devote more financial resources to industries and other areas with significant economic benefits, inevitably crowding out financial investment in environmental governance and innovation and increasing carbon emissions [28,33]. In conclusion, the dichotomous relationship between carbon emissions and economic growth [22] can cause local economic management efforts to increase energy consumption and carbon emissions, exacerbate resource misallocation, and inhibit urban innovation, which has been argued by multiple scholars [10,30].

Logically, local government economic growth management does not always incur negative effects [13]. For example, economic growth management can significantly promote economic progress, cultivate efficient markets, and improve resource allocation efficiency through agglomeration economies, consumption effects, and other positive impacts, which can certainly improve high-quality economic development [20,33,34]. In particular, the positive effects of economic growth management are likely to be more prevalent in urban agglomerations with higher development levels and earlier economic transformation [3]. First, economic growth management accelerates economic growth, which contributes to expanding economies of scale effects and improving energy use efficiency [11] and improves production efficiency through technology spillovers, knowledge sharing, and factor matching [34]. Second, economic growth from industrialization that is accompanied by the industrial upgrading and improved urban industrial structures decreases energy consumption and introduces green production transformation into urban economic growth trajectories by promoting advanced industrialization and the integration of manufacturing and service industries [35]. For example, green consumption rises with income growth, establishing a market-based foundation for enterprises' green transformation [23]. Third, the growth momentum of developing countries' economic catch-up is not static. In particular, obvious declines in the marginal effects of investment and the emergence of the negative effects of environmental pollution have compelled local governments to revise development models to strengthen investment in innovation as a development path to achieve sustainable economic growth and shape new kinetic energy [10,36]. Therefore, we propose the following research hypotheses:

Hypothesis 1a: *Economic growth target constraints increase carbon emissions.*

Hypothesis 1b: *Economic growth target constraints decrease carbon emissions.*

2.2. Effects of Growth Target Constraints on Innovation

Theoretical and empirical evidence has demonstrated that technological progress provides endogenous power for economic growth by altering production processes, and is also an essential element for achieving synergy between economic growth and carbon emissions reduction [26]. Although the government is not the primary subject of innovation, the characteristics of high cost, high risk, and a long cycle [37] make it necessary for the government to provide support by implementing associated measures and increasing innovation investments [25,33]. First, the contradiction between short-term economic growth and long-term innovation investment results in local governments allocating limited resources to more favorable short-term economic growth projects [6,31]. This practice has a considerable inhibitory effect on innovation by crowding out innovation investment and inhibiting human capital investment, among other negative effects [9]. As the primary site of innovation, enterprises actively cater to local governments' development preferences, which can result in postponing or shelving technological innovation activities and weakening innovation capabilities and activities when supporting local governments' growth targets [8]. Second, as the marginal utility of investment decreases and innovation returns increase during economic growth, innovation has become the core driving force for local governments to achieve economic growth [23]. In response, local governments have eased financing constraints by increasing support and tax relief for enterprises [31], which has stimulated enterprises' enthusiasm to increase research and development (R&D) investments [25]. These efforts have advanced economic growth and decreased energy consumption while improving urban production efficiency [4]. That is, faced with the economic growth target constraints with limited resources, local governments also manage resource allocation in the context of cost and benefit trade-offs, altering the common practices of innovation investment bias and reducing carbon emissions by improving resource allocation efficiency and decreasing energy consumption [5].

Government innovation investment can increase enterprises' innovation output [24,38]; however, not all innovation output improves development quality. For example, Shahbaz et al. [28] found that innovation has a negative impact on carbon emissions in China. The underlying reason for this is that different innovation entities have different response strategies when navigating imperfect innovation systems, which result in heterogeneous outputs and their associated effects [39]. For example, unlike general innovations that optimize existing technologies and products, disruptive and high-quality innovations can radically reduce carbon emissions by creating new low-carbon products, industries, and production processes [27]. In particular, representing high-quality innovation output with innovation and green attributes, green innovation can significantly reduce carbon emissions by developing more affordable energy-saving and emissions-reducing technologies [26]. However, a higher technological content also requires long-term investment and stronger government support, which is in conflict with short-term growth objectives and quantitative innovation [7,26]. From the perspective of real development, under short-term, goal-oriented, quantitatively biased evaluation criteria, innovation subjects tend to choose low-technology innovation projects with short-term and quick results to obtain more government innovation support funds. This is also one of the root causes of China's explosive growth in patents and weak industrial competitiveness in recent years [28,37]. This approach can crowd out innovation resources, generate inefficient innovation outputs, and may not contribute to development quality. To this end, we propose the following research hypotheses from the perspectives of government practices and innovation output:

Hypothesis 2a: *Economic growth target constraints significantly affect local governments' innovation bias practices.*

Hypothesis 2b: *Differentiated innovation outputs in response to economic growth management have varying carbon reduction effects.*

2.3. Moderating Effects of Urban Development

Economic growth management is a resource allocation process [8,13]. Urban development affects economic growth by influencing enterprise progress, resource allocation efficiency, and government regulatory effects [32,40]. Furthermore, economic growth management and carbon emissions are also affected by resource allocation, and a lower development level can incur a more significant efficiency loss from resource mismatch [39]. First, the market guides the free flow of factors and optimal resource allocation through the mechanism of benefit optimization, which significantly improves factors' return rate and stimulates innovation subjects' vitality, promoting synergy between economic growth and carbon emissions reduction [32]. Market failures such as the pressure on enterprise survival from intensified market competition may also weaken motivation for pollution control and increase pollution emissions [41]. Second, improved economic development can diminish information asymmetry, which can mitigate the negative effects of government economic growth management. For example, enterprises are less sensitive to policies in environments with lower development levels, whereas enterprises respond more quickly to market information in environments with more mature market mechanisms, which compels them to improve innovation quality [33]. This may also cause governments to implement stronger resource allocation initiatives, resulting in more significant resource misallocation and higher carbon emissions [13].

Industry is a core driver of economic growth and a significant source of carbon emissions [13,38]. In particular, for developing countries such as China that are at the stage of rapid growth, industrialization is the core driving force that supports economic growth, which increases carbon emissions [35]. Industrial structure directly affects the government's economic management initiatives, and economic growth management also affects industrial structure [12,31]. First, industrial upgrading from economic growth transforms industrial structure, increasing the proportion of service and technology-intensive industries, which subsequently promotes a matching structure of clean factor inputs and decreases energy consumption and carbon emissions [3]. In addition, this process is generally accompanied by local governments' strengthening of environmental regulations and improves residents' environmental awareness and aspirations, laying the foundation for reducing carbon emissions and optimizing environmental quality while raising the threshold for enterprises' environmental access. Second, service industry development resulting from industrial structure upgrading strengthens the coordinated development between secondary and service industries, and lowers carbon emissions by improving industrial development efficiency and weakening factor mismatch [31]. Therefore, it is reasonable to assert that a mature market and upgraded industrial structure significantly affect the relationship between economic growth targets and carbon emissions, leading to the following proposed hypotheses:

Hypothesis 3a: *The level development significantly affects the relationship between economic growth target constraints and carbon emissions.*

Hypothesis 3b: *Industrial structure significantly influences the relationship between economic growth target constraints and carbon emissions.*

3. Empirical Model and Data Description

3.1. Study Area

By maximizing the advantages of agglomeration in expanding cooperative space, urban agglomerations are the main carriers of population concentration and industrial agglomeration. The Yangtze River Delta urban agglomeration (Figure 3), located in China's eastern coastal region, has always been a core area driving economic growth, which has been supported by an open development model that is guided by the government and led by the manufacturing industry. As the sixth largest urban agglomeration in the world, this region concentrates about one-quarter of the total economic output and one-quarter of the industrial added value, with an area that covers only 2.1% of China's total territory but also contributes about one-fifth of the nation's carbon emissions. For example, the carbon emissions of the Yangtze River Delta were 215.54 billion tons in 2020, which is equivalent to the total scale in Thailand, and the region's carbon emissions increased by 448.75 million tons from 2010 to 2020, which is equivalent to the scale of Turkey [2]. As one of the most densely populated urban agglomerations in the world, the rapid growth of carbon emissions has a significant impact on population health and other considerations.

The Yangtze River Delta has an important role in global economic development. In the face of complex economic and environmental challenges, this urban agglomeration has taken various initiatives to address environmental issues since the turn of the century, including but not limited to industrial transformation, innovation drive, and other approaches. As the region with the highest concentration of innovation resources in China, innovation has accelerated the green transformation of the Yangtze River Delta. In 2023, approximately 247,800 invention patents were granted in the Yangtze River Delta, accounting for 26.91% of China's patent applications. In addition, cities in the Yangtze River Delta have significantly different policy environments, industrial structures, and location conditions, with significant regional disparities and diverse development models. This means that the

Yangtze River Delta also has the most acute economic and social contradictions in China. Therefore, conducting empirical research on the Yangtze River Delta will not only evaluate the applicability of our proposed model and test the diversity of internal relationships, but will also provide a valuable reference for promoting the green transformation of urban agglomerations in other developing countries.

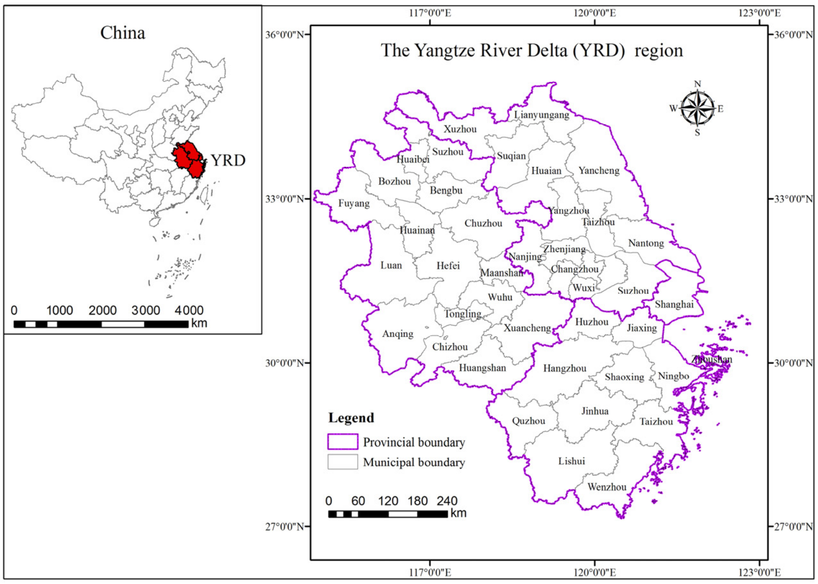

Figure 3. Location map and administrative divisions of the Yangtze River Delta.

3.2. Empirical Model

To empirically test the relationship between economic growth targets and carbon emissions, we constructed model (1) for empirical analysis. In addition, we constructed model (2) to test whether there is a nonlinear relationship between economic growth and carbon emissions. The specific models are as follows:

$$Car_{it} = \alpha_0 + \alpha_1 Tg_{it} + \alpha_2 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (1)$$

$$Car_{it} = \alpha_0 + \alpha_1 Tg_{it} + \alpha_2 Tg^2{}_{it} + \alpha_3 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (2)$$

where *Car* (Carbon emissions) is the explained variable and Tg (economic growth target) is the explanatory variable; i and t, respectively, denote region and year; α is a vector of regression coefficients; ε_{it} is a random disturbance term; X denotes control variables; and η_i and λ_t denote the region and year fixed effects, respectively.

This study explores the impact of economic growth management on carbon emissions and examines the role of innovation development. Referencing previous research [42], we conducted the analysis using the following three-step mediating effects model:

$$Car_{it} = \alpha_0 + \alpha_1 Tg_{it} + \alpha_2 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$Med_{it} = \beta_0 + \beta_1 Tg_{it} + \beta_2 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (4)$$

$$Car_{it} = \gamma_0 + \gamma_1 Tg_{it} + \gamma_2 Med_{it} + \gamma_3 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (5)$$

where *Med* is the mediating variable; α, β, and γ are regression coefficients; and the meaning of the remaining variables follow those of model (1).

The evolution of carbon emissions during economic growth is a dynamic and complex process that is significantly influenced by other externalities. Referencing related research [42], we constructed the following moderated effects model:

$$Car_{it} = \phi_0 + \phi_1 Tg_{it} + \phi_2 Reg_{it} + \phi_3 Tg_{it} \times Reg_{it} + \phi_4 X_{it} + \eta_i + \lambda_t + \varepsilon_{it} \quad (6)$$

where *Reg* is the moderating variable, and remaining variables follow those of model (1).

3.3. Variable Descriptions

(1) Explained variable: *Car*. Advancing carbon reduction while promoting economic growth is essential [13]. In this regard, we used the scale of carbon emissions as the explained variable, and the unit was millions of tons.

(2) Explanatory variable: *Tg*. Setting targets for economic growth management is an important measure that local governments implement to promote economic progress. Such targets are established in governments' annual work reports, five-year planning outlines, and various development plans. However, driven by short-term tenure and cross-location exchange constraints, local officials often prioritize short-term economic growth targets. In this regard, we used the expected economic growth rate in local governments' annual work reports as economic growth targets, and the unit was percent.

(3) Control variables. Based on relevant research [1,2,4], we selected the following control variables.

- The consumption of fossil fuels and other energy sources during economic growth is a direct source of carbon emissions. We used GDP to characterize cities' economic scale, and the unit was CNY billions.
- Local governments influence socioeconomic development and factor allocation through administrative measures, macro-policies, and other approaches, which have a subsequent impact on carbon emissions. Considering that financial support is needed for the formulation and implementation of relevant policies, we used local financial expenditure as a proxy for the strength of government policies, and the unit was CNY billions.
- Infrastructure affects factor allocation efficiency and carbon emissions by driving shared public facilities and lowering trade costs, among other effects. In particular, transportation has an important influence on factor allocation. We used the total amount of passenger traffic to measure transportation status, and the unit was 10,000 people.
- Openness affects carbon emissions through factor agglomeration, industrial change and innovation evolution, and related effects. We measured cities' openness using the total amount of imports and exports, and the unit was USD billions.

(4) Mediating variable: Innovation development. Innovation refers to the sum of a series of activities, such as thinking, R&D, design, manufacturing, and other processes, and is also the result of the combined effect of innovation factor inputs and outputs [36]. First, government innovation investment is key for guiding and supporting innovation development, and we used the intensity of local government R&D investment to measure local governments' innovation bias level in economic management (*Inno*), referencing the proportion of science and technology and education expenditure to GDP to characterize it, and the unit was percent. Second, as an important indicator of innovation output, patents have been commonly used to quantify innovation due to the consistency of the evaluation criteria and data availability [17,26]. However, developing countries are generally characterized by quantity over quality innovation [39] and heterogeneity in the effects of different innovation outputs. In this regard, we used granted patents to measure innovation output and compare the impact of different innovation outputs on the carbon emissions effect in economic growth management in terms of green (*Green*) and non-green (*Non-green*) innovation; the unit was the number of patents owned per 10,000 people.

(5) Moderating variables. Considering China's unique business ownership structure, particularly SOEs assuming more social responsibilities and possessing strong resource acquisition capabilities, we measured marketization referencing the proportion of private employees to on-the-job employees (*Mark*), and the unit was percent. For cities that are in mid to late industrialization, service industry development is an important measure to achieve economic growth and carbon emissions reduction [13]. Therefore, we used the

proportion of the added value of the service industry in GDP to characterize the industrial structure (*Str*), and the unit was percent.

3.4. Data Specification

Considering data availability and the effects of the COVID-19 pandemic, this study used city-level panel data from 2005 to 2019. First, data on cities' economic growth targets are unavailable before 2005. In addition, as the most authoritative and commonly used database on carbon emissions in China, the Carbon Emission Accounts & Datasets (CEADs) only provides relevant data until 2019. Second, the COVID-19 pandemic that has swept the world since the end of 2019 has had a vast impact on socioeconomic development. As the Chinese central government's pandemic prevention policy system from 2020 to 2022 became a prerequisite for government action, socioeconomic development during this period is expected to be significantly heterogeneous compared with pre-pandemic years, and unexpected events weaken the comparability of this period.

The data on economic growth targets were obtained from local governments' annual work reports, the carbon emissions data were from CEADs database (www.ceads.net), and the remaining data were obtained from cities' statistical yearbooks, statistical bulletins, and CEIC database. Considering that the administrative divisions in Anhui Province were considerably adjusted in 2011 and 2015, this study took the 2010 administrative division as the benchmark, and the research unit included 42 cities. In addition, we processed the relevant data as follows. Table 1 details the descriptive statistical results.

Table 1. Descriptive statistical results for the variables.

Variable	N	Mean	Std. Dev.	Min.	Max.
Carbon emissions	630	41.70	44.63	1.10	236.49
Economic growth target	630	10.58	2.41	5.00	17.00
GDP	630	2523.71	3470.78	110.18	28,234.03
Financial expenditure	630	356.72	677.67	15.79	6871.89
Transportation status	630	18,102.06	15,243.91	1434.00	130,000.00
Openness	630	338.92	882.34	0.18	9170.26
Innovation bias level	630	2.97	1.16	0.75	7.17
Green innovation output	630	0.97	1.29	0.00	8.72
Non-green innovation output	630	14.24	15.91	0.04	82.99
The marketization level	630	25.13	17.24	1.61	90.24
Industrial structure	630	41.33	7.83	23.37	72.74

- For the economic growth target set in the form of intervals, we used the average value as the economic growth target.
- For cities involved in the administrative division adjustment, the data were estimated referencing county-level data.
- For some missing or adjusted data, the average growth rate of the previous period was used for estimation.
- Economic data were adjusted by price indices based on the year 2005.

4. Empirical Results Analysis

4.1. Benchmark Model Results

Table 2 presents the benchmark model results. The coefficients of the explanatory variables in Columns (1) and (2) are significantly negative, indicating that economic growth targets contribute to carbon reduction. In contrast to previous studies showing that economic management strengthens the government's anti-market regulation and reduces development efficiency [9,10], this study found that for developed urban agglomerations, economic management advances green development, providing a theoretical basis for supporting economic management. The findings indicate that governments can achieve the balance between economic growth and environmental protection with strategic economic management, verifying Hypothesis 1b. This also has reference significance for other developing countries. That is, the government should consider how to optimize the development model in economic management.

Table 2. Benchmark model.

	(1)	(2)	(3)
Tg	−1.081 *** (−2.70)	−0.693 ** (−2.00)	0.251 (0.14)
Tg^2			−0.0404 (−0.55)
Control variables	NO	YES	YES
Time effect	YES	YES	YES
City effect	YES	YES	YES
Constant	19.518 *** (3.21)	14.046 *** (2.69)	8.684 (0.79)
R-squared	0.425	0.589	0.589
Observations	630	630	630

Note: t-statistics are in parentheses, ** $p < 0.05$, and *** $p < 0.01$.

Model (2) examines whether a nonlinear relationship exists between economic growth targets and carbon emissions. The explanatory variable and its squared regression coefficients in Column (3) do not pass the significance test. Furthermore, the U-test [43] reveals that the extreme point of the explanatory variable was not within the range of the data and the *p*-value was greater than 0.1. These results suggest that a linear relationship exists between the economic growth target and carbon emissions and the benchmark model is highly accurate.

4.2. Robustness Tests

- Re-estimation of the explained variable. As carbon emissions are the basis of our empirical research, referencing previous research methods [12,13], we re-estimated carbon emissions from the perspective of energy consumption, which estimates urban carbon emissions by setting specific carbon emission coefficients for different energy consumption. The explanatory variable coefficient in Column (1) of Table 3 is significantly negative, validating that the regression results of the benchmark model.

Table 3. Robustness tests.

	(1)	(2)	(3)	(4)
Tg	−0.853 *** (−3.38)	−0.693 ** (−2.00)	−0.657 ** (−2.02)	−0.608 *** (3.58)
Pilot		−0.0205 (−0.01)		
Control variables	YES	YES	YES	YES
Time effect	YES	YES	YES	YES
City effect	YES	YES	YES	YES
Constant	37.422 *** (9.79)	14.047 *** (2.68)	13.317 *** (2.77)	13.082 *** (3.27)
R-squared	0.902	0.589	0.600	0.591
Observations	630	630	555	630

Note: t-statistics are in parentheses, ** $p < 0.05$, and *** $p < 0.01$.

- Controlling for external shock. The central government has implemented many types of low-carbon pilot programs, aiming to reconcile economic growth and environmental protection by supporting institutional optimization, industrial transformation, and innovative development, which has become an important factor influencing economic management and carbon emissions reduction [13]. We re-estimated the benchmark model controlling for China's low-carbon pilot, which is a centrally led pilot decarbonization policy (*Pilot*). We used the difference-in-differences model to estimate the results. The results in Column (2) of Table 3 reveal that the coefficients of the explanatory variables are still significantly negative, once again confirming the strong credibility of the benchmark results.

- Adjusting the sample. The Chinese system involves differences in the political status, resource endowment, and economic functions of cities at different levels. First, as national key development areas, provincial capitals and sub-provincial cities tend to set higher growth targets in economic management, which is manifested in a higher level of self-pressure. Second, high-ranking cities also generally have greater resource allocation power, which is reflected in the relatively low pressure to achieve economic growth targets. Considering the special status of cities such as Shanghai, Nanjing, Hangzhou, Hefei, and Ningbo, we conducted further empirical testing after excluding relevant cities. Column (3) of Table 3 shows that the coefficient of the explanatory variables remains significantly negative, again indicating the strong robustness of the benchmark model results.
- Estimation using the dynamic panel model. The static panel model ignores the systematic relationship between economic growth management and carbon emissions, which may produce biased results. Therefore, we adopted a dynamic panel model to examine the relationship between economic growth management and carbon emissions. This introduced lagged terms of the dependent variable in the static panel data model to reflect the dynamic lag effect. And we used the system GMM (Gaussian Mixture Model) method to estimate the results. The result in Column (4) of Table 3 also demonstrates the robustness of our benchmark model.
- Bootstrapping robustness test. Bootstrapping is a non-parametric statistical method in which multiple samples are obtained by resampling the sample data to estimate the distribution of model parameters. This study used the bootstrap method to verify the robustness of the benchmark model. Based on the regression model, 1000 random samples were selected from the valid samples, and the results are shown in Table 4. The findings indicate that the results are not dependent on a specific time period or certain cities and the benchmark model results are strongly robust.

Table 4. Bootstrap test.

	Coefficient	Bootstrap Standard Error	*p*-Value	95% Confidence Interval	
				Lower Limit Value	Upper Limit Value
Tg	−0.693	0.286	0.015	−1.253	−0.133

4.3. Mediating Effect of Innovation Development

Economic growth management can curb urban carbon emissions. Understanding the key mechanisms is of great significance for formulating reasonable economic management measures. Given the development reality of developing countries, we focused on exploring the innovation mechanism. And innovation includes two parts: input and output. Innovation is a complex and dynamic process, and the government can significantly promote innovation development by implementing measures to guide innovation development [25,33], for which increasing innovation support through fiscal resources is a commonly used approach. This also reflects the innovation bias in government economic management. The mediating effect of government innovation bias behavior is presented in Table 5. The coefficient of the explanatory variable in Column (1) is significantly negative, confirming the mediating effect of economic growth targets on carbon emissions. The explanatory variables in Column (2) have a significant positive effect on the mediating variables, indicating that the economic growth target strengthens local governments' innovation bias. In other words, for urban agglomerations with a higher economic development, as labor dividends disappear and investment contribution rates decline, local governments are increasingly emphasizing the importance of innovation and focusing on transformative innovation in economic management to achieve higher-quality economic growth [13]. That is, economic growth targets help accelerate innovation transformation. The coefficient of the mediating variable in Column (3) is significantly negative, indicating that local governments' innovation bias behavior has a mediating effect in the impact of economic growth target on carbon emissions. In particular, an increase in fiscal innovation funding can significantly reduce carbon emissions, which also provides a direction for local governments to advance synergy between economic growth and carbon reduction in economic growth management [5,38], which validates Hypothesis 2a. This result indicates that the government's emphasis on innovation in economic management is an important measure to achieve synergy between economic growth and carbon emissions reduction. But the contribution rate of the mediating effect of innovation investment is relatively low, reflecting the objective reality of low quality innovation development and low conversion rate of innovation achievements in developing countries.

Table 5. Mediating effect models.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tg	−0.693 ** (−2.00)	0.0473 *** (3.08)	−0.610 * (−1.75)				
Inno			−1.756 * (−1.86)	0.246 *** (4.52)		1.510 ** (2.04)	
Green					−1.990 *** (−2.82)		
Non-green							0.00144 (0.03)
Control variables	YES	YES	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES	YES	YES
City effect	YES	YES	YES	YES	YES	YES	YES
Constant	14.046 *** (2.69)	1.287 *** (5.54)	16.306 *** (3.04)	−0.833 *** (−4.69)	4.091 * (1.65)	−6.205 *** (−2.57)	4.816 * (1.94)
R-squared	0.589	0.729	0.591	0.798	0.969	0.784	0.968
Observations	630	630	630	630	630	630	630

Note: t-statistics are in parentheses, * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

Different actors' innovation motivations result in different innovation outputs, which also produces heterogeneous carbon reduction effects [20]. Specifically, green innovation, which is closely related to carbon reduction and directly aimed at the production process, requires greater financial investment, longer R&D cycles, and higher innovation risks [44]. Columns (4) and (6) in Table 5 show that government innovation investment can significantly promote green and non-green innovation, but has a stronger effect on non-green innovation, which confirms the general circumstances of quantity over quality innovation development in developing countries. Furthermore, the results in Columns (5) and (7) in Table 5 compare the carbon emissions effects of green and non-green innovation outputs. Improved green innovation can significantly reduce carbon emissions by optimizing production processes and reducing unit energy consumption [38,39]; however, the insignificant positive effects of non-green innovation may be related to the crowding out effect of high-quality innovation. The findings also confirm the reality of lower conversion rates and non-positive socioeconomic effects of quantitative innovation outputs [28]. The results confirm Hypothesis 2b, indicating that optimizing the innovation development environment and directing limited innovation resources toward innovative entities that can produce higher technological content is an important measure to achieve high-quality green development. The heterogeneity effect of different innovation outputs indicates that developing countries should strive to transition towards high-quality innovation.

4.4. Mechanism Analysis with the Moderating Effect Model

4.4.1. Marketization Effect

The free flow of factors under the guidance of market mechanisms is an inherent mechanism for promoting economic growth and reducing carbon emissions. Column (1) in Table 6 confirms a substitution relationship between marketization level and economic growth targets. We argue that the possible mechanisms are as follows. (1) From a macro-perspective, marketization may also lead to uneven factor agglomeration, resulting in uneven factor allocation and decreasing development efficiency. At the same time, in development driven by high energy consumption factors, marketization has caused factor agglomeration and increased carbon emissions during economic growth [41]. Marketization can also weaken the problem of information asymmetry [33], but it may also compel the government to adopt stronger resource allocation measures, which can lead to more significant resource misallocation and increased carbon emissions [13]. (2) From a micro-perspective, large enterprises with monopoly advantages are the main body of economic growth and carbon emissions [44]. When fierce competition weakens the market position and bargaining power of large enterprises, firms are more inclined to adopt conservative and gradual emissions reduction measures rather than engaging in long-term investment in high-quality innovation [41]. Although deepening market-oriented reforms are of great significance for improving development efficiency, market mechanisms may also be inadequate for reducing carbon emissions [28]. Therefore, it is imperative to jointly promote market-oriented reform and optimize government economic management practices.

Table 6. Moderating effect models.

	(1)	**(2)**
Tg	−1.417 *** (−3.47)	−4.296 *** (−3.95)
Mark	−0.358 *** (−3.08)	
Tg × *Mark*	0.0412 *** (3.27)	
Str		−1.035 *** (−2.98)
Tg × *Str*		0.0987 *** (3.55)
Control variables	YES	YES
Time effect	YES	YES
City effect	YES	YES
Constant	21.924 *** (3.83)	51.270 *** (3.59)
R-squared	0.597	0.598
Observations	630	630

Note: t-statistics are in parentheses, *** $p < 0.01$.

4.4.2. Industrial Structure Effect

The evolution of industrial structure in economic growth is an objective law that affects urban carbon emissions through complex mechanisms [13,38]. Column (2) in Table 6 reveals a substitution relationship between the industrial structure and economic growth targets. We argue that the possible mechanisms are as follows. (1) The secondary industry, which has high investment intensity, a significant GDP driving effect, and high tax contribution, is the core force for stabilizing economic growth and absorbing social employment [35]. With service-oriented industrial structure development, the decline in the proportion of manufacturing industry weakens local governments' ability to regulate economic growth. For example, with the decay of the economic contribution rate of fixed assets, local governments must strengthen the development of short-term projects to maintain economic growth, which increases carbon emissions through innovation crowding out and resource misallocation effects [3,31]. (2) The carbon reduction effect of industrial structure is constrained by the synergy between manufacturing and service industries. For most cities, the low degree of synergy between these industries is a significant factor that promotes the substitution effect [31]. In general, as an inevitable result of economic growth, the service-oriented industrial structure can increase carbon reduction, but strategic management measures must be implemented for different industrial structures to achieve high-quality economic growth.

4.5. Heterogeneity Analysis

Urban development is influenced by location, policies, resources, and other factors, and this heterogeneity has been confirmed in previous studies [13,14]. In this regard, we examined the heterogeneity of the impact of economic growth targets on carbon emissions from perspectives of time and space.

4.5.1. Temporal Heterogeneity

For many decades, the labor- and capital-intensive industrial structure of China's export-oriented development model has been an important factor of the nation's high carbon emissions [35]. The impact of the global financial crisis in 2008 compelled the government to reflect on the robustness of this model and actively explore new development paths. Has this affected the relationship between economic management and carbon emissions? This section took 2008 as the key time node to compare the carbon emissions effects of the economic growth targets in 2005–2008 and 2009–2019.

The results in Columns (1) and (2) of Table 7 reveal a transition from insignificant negative effects to significant negative effects. The period from 2005 to 2008 was the stage of economic take-off and urbanization acceleration, exhibiting characteristics of industry-led and extensive development. Although local governments' economic growth targets were generally high, the environment of optimized development did not offset the increase in energy consumption amid the extensive growth of labor- and capital-intensive investments. After 2008, local governments' economic growth targets were significantly lower, and accelerating innovation to achieve the transformation of growth momentum became a general trend. At the same time, with the emergence of environmental degradation in the context of extensive economic growth, the central government began to prioritize the importance of environmental quality when evaluating local officials, proposing a transition from quantitative growth to qualitative development [13]. In this context, local governments also started to pay attention to developing a synergy between economic growth and environmental protection, which also strengthened the carbon reduction effect of economic management. Temporal heterogeneity not only verifies the significant impact of macro-policies and the external environment, but also indicates that policy formulation and implementation should keep pace with the times.

Table 7. Heterogeneity tests.

	(1)	**(2)**	**(3)**	**(4)**	**(5)**
Tg	−0.0251 (−0.06)	−0.891 ** (−2.41)	−0.771 (−0.76)	0.438 (0.43)	−0.597 * (−1.74)
Control variables	YES	YES	YES	YES	YES
Time effect	YES	YES	YES	YES	YES
City effect	YES	YES	YES	YES	YES
Constant	7.079 (1.13)	24.069 *** (4.76)	16.282 (1.13)	8.532 (0.66)	19.528 *** (4.65)
R-squared	0.676	0.451	0.783	0.437	0.613
Observations	168	462	195	165	255

Note: t-statistics are in parentheses, * $p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$.

4.5.2. Spatial Heterogeneity

Unbalanced development is a common phenomenon that results from numerous factors. The development models of Yangtze River Delta provinces have obvious differences such as the relatively low development level of Anhui Province, the strong government of Jiangsu, and the strong market of Zhejiang, establishing a significant gap in cities' development. In this regard, this section compared the carbon emissions effects of economic growth targets in Jiangsu, Zhejiang, and Anhui to examine spatial heterogeneity.

The results of Columns (3)–(5) in Table 7 show that Jiangsu presents no significant negative effects, Zhejiang presents insignificant positive effects, and Anhui presents significant negative effects. This indicates that a higher economic development results in weaker carbon reduction effects, and Fisher's combination test confirms the robustness of this result. (1) Anhui's city economic growth is still predominantly driven by investment, and the optimization of the development environment brought about by economic management provides the possibility for innovative development and industrial transformation. Compared to developed cities, the innovation output effect per unit of R&D investment is stronger, which is the core factor of the significant negative effect. (2) For cities in Jiangsu and Zhejiang, which are in the critical period of economic development adjustment, many uncertainties in economic growth remain, along with a greater pressure to maintain growth. In particular, the marginal economic growth of investment is gradually declining, leading local governments to implement more short-term projects to achieve predetermined economic growth targets, which will inevitably crowd out the space for high-quality industrial development. In addition, as a region with a high concentration of foreign capital, the low willingness of foreign-funded enterprises to innovate also inhibits the innovation development of economic management [44]. Spatial heterogeneity indicates that local policies should be strategically adapted to local conditions.

5. Discussion

Exploring an inclusive development path that balances growth and protection is a major practical issue faced by emerging economies [13]. This study took the Yangtze River Delta as the research subject to answer the practical question of whether economic growth and environmental protection can be balanced and how it can be coordinated. Facing the high-quality development needs of developing countries, several scientific problems remain that must urgently be solved, and it is also essential to accelerate the exploration of a multi-party collaborative development path in practice.

(1) Promote the synergy between economic growth and carbon reduction. Promoting carbon reduction is not only a practical need to advance the transformation of economic growth model, but also a shared responsibility for addressing global climate change [4,5]. As a global issue, countries around the world have proposed timetables for reaching carbon peak and neutrality. Economic growth management can promote the synergy between economic growth and carbon emissions reduction, but excessively high growth targets can also lead to resource misallocation by strengthening imbalanced measures [13,35]. In addition, Nordhaus's [45] Integrated Climate Change Assessment Model and other empirical analyses [14] have shown that excessive carbon emissions constraints can significantly lower GDP growth. These raise two practical issues that must be urgently investigated. First, exploring the development path of synergy between economic growth and carbon reduction. Numerous studies have shown that the key lies in accelerating green technology innovation and strengthening environmental regulation, factor marketization, industrial upgrading, and energy structure optimization [13,35]. That is, green economic transition can be expected to become a new driving force for reshaping developing countries' economic growth. This certainly requires the government to abandon the extensive growth model. Second, designing a suitable carbon reduction roadmap. Of course, not all cities have decoupled economic growth from carbon emissions [3]. At the national level, the relationship between economic growth and carbon emissions should be fully considered, scientifically dividing the carbon peak echelon and promoting the carbon peak process in stages. As a response, local governments should develop refined carbon reduction plans in different regions and time periods, choosing optimal development paths based on resource endowments. In this regard, the strategic spatial allocation of national carbon reduction targets is a practical problem worthy of in-depth study.

(2) Guide the implementation of higher-quality green innovation. Previous studies have confirmed the carbon reduction effect of innovation [5,36]. Local governments' efforts to improve the innovation service system, stimulate the vitality of innovation entities, and strengthen intellectual property protections are also crucial for encouraging innovative development [5,25]. In addition, innovation does not always lead to an improved development quality [7,27,28], indicating that innovation support is not only about increasing innovation investment, but more importantly, about improving innovation quality [8,27]. Considering the objective reality of the low the innovation conversion rate in developing countries, advancing the transformation of technological output into practical application

is also of great practical significance [13]. This requires the collaborative efforts of the government, enterprises, and society to build a green innovation system that is supported by the government, dominated by enterprises, and guided by the market, which will advance green development. Furthermore, the most dynamic enterprises in economic activities should become the main body of green innovation [33]. Enterprises should adapt innovation development practices to actual internal development capabilities. For enterprises with technological accumulation, technological progress should be achieved through independent research and innovation, and low-tech manufacturing enterprises should consider purchasing external technology and improving technological transformation efficiency. In particular, the government should prioritize the central role of large enterprises in promoting carbon reduction, implement more targeted measures to guide large enterprises to conduct higher-quality green innovation, and establish an atmosphere of collaborative innovation between large and small enterprises, encouraging large enterprises to contribute more to energy conservation and emissions reduction.

(3) Accelerate the improvement of market-oriented mechanisms. Goal-oriented economic growth target management is a common characteristic of global economic growth [44]. However, resource misallocation in economic growth management is the fundamental factor of increased carbon emissions [10]. This raises a key question, who should take the lead in resource allocation? Some studies have proposed promoting marketization to achieve synergy between economic growth and environmental protection [8]; however, the substitution effect of marketization in the impact of economic growth targets on carbon emissions demonstrates that the market is not omnipotent. In fact, the widening income gap and increased environmental pollution indicate that marketization alone is not a viable solution [41]. Therefore, institutionalizing coordinated economic growth and carbon reduction requires market-oriented reforms as well as scientifically positioning the roles of the market and the government. The focus of market-oriented reform is to break down various interest and market barriers that restrict the free flow of factors and strengthen the decisive influence of the market on resource allocation efficiency. The government should focus on cultivating dynamic, creative, and competitive market entities by improving the fundamental systems of the market economy such as property rights, negative market access, and fair competition review systems. For example, accelerating the improvement in the carbon trading market and providing incentives for enterprises that actively engage in green innovation will advance local economic green growth. Of course, in a centrally led political system, the assessment of economic growth should be diluted and local governments should be encouraged to set more reasonable growth targets. This is also the key to weakening the anti-market regulation of local governments.

6. Conclusions

To examine the reality of socioeconomic development in developing countries, this study takes the Yangtze River Delta as an example to systematically investigate the carbon emissions effect and mechanism of economic growth target management. The results reveal that economic growth target setting can help reduce carbon emissions, providing a theoretical basis for developing countries to conduct targeted economic growth management. Governments' innovation bias in economic growth management is the core mechanism of economic growth targets' inhibition of carbon emissions, but the carbon emissions effects of different innovation outputs are heterogeneous. In addition, the marketization level and industrial structure exhibit substitution effects in the impact of economic growth targets on carbon emissions. The heterogeneity analysis reveals that the carbon emissions effects of economic growth targets have obvious spatial and temporal heterogeneity, indicating that a transition from an insignificant effect to a significant negative effect in temporal heterogeneity, with a significant negative effect in Anhui Province and insignificant effects of Jiangsu and Zhejiang in spatial heterogeneity. These findings all indicate that government approaches to optimize economic management should keep pace with the times and adapt to evolving local conditions.

Promoting carbon reduction to address global climate change is a common but differentiated responsibility of all countries. Carbon reduction under economic growth constraints is a realistic path for developing countries. The conclusions of this study provide theoretical support for other emerging economies, particularly those in rapidly growing countries such as those in East Asia and Africa, to collaboratively address economic growth and climate change. This systematic study supports the practical necessity of economic growth management in developing countries and reminds governments to strengthen high-quality innovation transformation, deepen market-oriented reforms, and conduct targeted economic management according to local conditions in this process to establish a stable institutional environment for continuous green economic growth.

Given the complexity of economic management and carbon emissions, several considerations still need to be further explored. First, innovation is the key foundation to support the synergy between economic growth and carbon reduction; however, although patent data are easily accessible and consistent, it cannot truly capture the innate characteristics of innovation quality and efficiency, and research results may also overestimate the innovation level. Second, government economic management is a complex process, and this study focuses on the impact of local governments' economic growth target setting on carbon emissions and may neglect the impact of subtle behaviors under the economic growth target constraints. Third, economic growth management in developing countries is affected by the central–local government relationship, and the influence of this dynamic on economic growth management also requires further investigation. Therefore, it is essential to construct a more micro-analytical framework, obtain more detailed data, and explore the effects of economic management in more regions and from a more comprehensive perspective.

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