ISSN: 2710-0723

Innovation of Land Allocation System and Improvement of Green Utilization Efficiency

Jiamin Rao[1], Jing Cao[2], Chengyun Xie[3]

[1] School of Finance and Public Administration, Anhui University of Finance & Economics, Bengbu, Anhui 233030, China

[2] School of Languages and Media, Anhui University of Finance & Economics, Bengbu, Anhui 233030, China

[3] School of International Trade and Economics, Anhui University of Finance & Economics, Bengbu, Anhui 233030, China

Abstract

Land allocation system is an important part of China's land management system, which is of great significance for achieving the national sustainable development goals. In 2013, the Zhejiang Provincial Government adopted the core development concept of "discussing heroes in terms of yield per mu and promoting transformation through intensification" and implemented the land allocation reform of "discussing heroes in terms of average yield per mu" throughout the province. Based on reviewing existing theories, this article first constructs a theoretical framework for the impact of land allocation system innovation on urban land green utilization efficiency. Secondly, the global super efficiency SBM model considering unexpected outputs is used to measure and analyze the green utilization efficiency of urban land. Finally, based on the quasi-natural experiment of the implementation of the land allocation reform of "Heroes in the Theory of Average Mu", using the panel data of cities at prefecture level and above from 2009 to 2020, the impact of land allocation system innovation on urban land green use efficiency is identified with the help of the double difference model. Research findings: the SBM model measurement results show that the average land green use efficiency of prefecture level cities in China showed an overall trend of first decreasing and then increasing from 2009 to 2020. Than the innovation of land allocation system has significantly improved the green use efficiency of urban land. This conclusion is valid after a series of robustness tests. Based on the above conclusions, this article proposes targeted suggestions for improving the land allocation system and improving the efficiency of green land use in the future.

Keywords

Land Allocation System; On Heroes in Every Mu; SBM Model; Difference-in-Differences Model.

1. Introduction

1.1. Research Background and Significance

1.1.1. Research Background

Resource allocation is a core proposition in economics. When market failures and inappropriate government interventions occur, input factors cannot flow from inefficient enterprises to efficient ones, negatively impacting economic growth[1]. Therefore, the report of the 20th CPC National Congress explicitly calls for promoting the efficient and intensive use of all types of resources. The immobility of land and its high reallocation costs make efficiency losses caused

ISSN: 2710-0723

by land resource misallocation harder to remedy, exerting a more profound impact on high-quality economic development. The 2017 National Land Planning Outline (2016–2030) emphasized the need to “reduce the proportion of industrial land and enhance the input-output efficiency of industrial land use.” The 14th Five-Year Plan (2021–2025) further proposed focusing on developing the real economy, promoting the prosperity and efficiency of industrial land, and encouraging the new utilization of industrial land. Within China's traditional land system, the government remains the dominant force in land resource allocation. Local officials, operating under a political competition model centered on GDP and related economic indicators, exhibit a behavioral bias toward maximizing land transfer revenues. As China's urban spatial footprint continues to expand, local officials rely on land expropriation, development, and transfer to secure substantial land transfer fees, which are then channeled into fueling urban expansion and economic growth. However, in pursuit of “attracting investment” to maximize land transfer revenues, local officials engage in “race-to-the-bottom competition” using land as a bargaining chip. They grant large-scale industrial land at low or even zero prices, which not only wastes land resources but also severely hinders improvements in land utilization efficiency.

In recent years, as global attention to ecological and environmental issues has intensified, green land use efficiency represents not only a fundamental transformation of China's land utilization methods and a breakthrough in land use quality, but also an intrinsic requirement and inevitable choice for achieving high-quality socioeconomic development and comprehensively advancing ecological civilization construction[2]. However, the existing extensive land resource utilization model has led to increasing problems in urban land use, including high resource consumption, high pollution emissions, and high carbon emissions[3]. Given China's large population and the disparate realities across economic zones, general administrative guidance at the national level often struggles to achieve tangible results. Therefore, under the constraint of limited total urban land area, innovating land allocation systems to enhance green land utilization efficiency is a critical task for promoting sustainable regional development in China.

1.1.2. Research Significance

Land is the most fundamental production factor for economic development and the essential material carrier for developing the real economy. From the perspective of developing nations worldwide, industrialization represents the inevitable path for most countries to achieve modernization and accelerate economic growth. Consequently, enhancing the quality of industrial land use and ensuring stable urban industrial development constitute critical challenges for the majority of cities globally. Research on land allocation system innovation and green utilization efficiency not only expands theoretical frameworks related to urban land green efficiency but also provides theoretical references for studies on high-quality urban development. Furthermore, it broadens disciplinary boundaries and significantly enriches research content in urban land use.

1.2. Research Content and Methods

1.2.1. Research Content

The core focus of this study is enhancing green land utilization efficiency and innovating land allocation systems. The overall research content is structured as follows: Chapter 1 serves as the introduction, outlining the research background, significance, methodology, and innovative contributions. Chapter 2 presents a literature review, synthesizing domestic and international studies on land allocation systems and green land utilization efficiency. Chapter 3 addresses policy context, theoretical foundations, and operational mechanisms. First, it systematically introduces the “Heroes Are Measured by Mu” system and its developmental stages relevant to the core research. Next, it reviews the underlying economic theories, and finally elucidates the impact mechanism of land allocation system innovation on enhancing green utilization efficiency. Chapter 4 then measures and analyzes the green utilization efficiency of urban land. Chapter 5 presents empirical analysis. It begins with the specification of the difference-in-differences model, selection of key variables, and data description. It then reports the benchmark regression results and conducts a series of robustness tests on these findings. Chapter 6 concludes with research findings and policy recommendations.

1.2.2. Research Methodology

This study employs a combined approach of empirical and theoretical analysis to examine the relationship between land allocation system innovation and green utilization efficiency enhancement.

This study systematically reviews relevant literature and policies on land allocation systems and green utilization efficiency through multiple channels including CNKI, VIP, Wanfang, and Google Scholar. It first examines closely related domestic and international literature, then introduces the “Heroism by Mu” system, and finally analyzes the mechanisms through which land allocation systems influence green utilization efficiency improvement based on relevant economic theories and methodologies.

1.3. Innovative Aspects of the Study

The primary innovation of this paper lies in its research content. Existing studies on land factor allocation have primarily focused on two areas: first, measuring the rational allocation of land resources and exploring influencing factors such as the privatization of land property rights, natural geographical conditions, and the marketization of land transfers. Second, they have concentrated on the impacts of land allocation, primarily examining its effects on agricultural productivity. Few scholars have directed their research toward the relationship between land allocation systems and green land use efficiency. Second, methodological innovation. This study employs Zhejiang Province's “output per mu” policy as an exogenous shock and utilizes the difference-in-differences approach for empirical analysis, demonstrating scientific rigor and cutting-edge methodology.

2. Literature Review

2.1. Current State of International Research

Optimal allocation of land resources is a crucial prerequisite for sustainable land use and high-quality economic development. Concerns regarding resource allocation emerged as early as the early 19th century, attracting widespread attention from Western economists who conducted extensive research on land allocation issues. Qu (1995) [4] examined the strengths and weaknesses of China's land management system reforms. The reforms created a more efficient land use system and land transfer market, particularly for non-agricultural land. However, the reforms also accelerated issues such as the rapid diversion of arable land to non-agricultural sectors, reduced land use scale, and declining land quality. Some scholars have identified factors influencing land resource allocation. Nizalov et al. (2015) [6] argued that privatizing land property rights alone cannot sufficiently improve market allocation; instead, institutional reforms aimed at reducing uncertainty and enhancing rights protection are essential. Yang et al. (2020) [7] evaluated rural land resource allocation efficiency and influencing factors in Fang County, Hubei Province, from 2011 to 2017 using the SBM model. Results indicate that rural land resource allocation efficiency in Fang County exhibits a steady upward trend. Key factors influencing efficiency include the proportion of primary industry and rural population, as well as natural geographical conditions. Xi and Mei (2022) [8] noted that development zone construction serves as a key government-guided mechanism for land resource allocation. The expansion of land expropriation and transfer scales within development zones can lead to underutilization or inefficient land use, resulting in suboptimal allocation of land factors. Jiang

ISSN: 2710-0723

et al. (2021) [9] first employed the DEA method to measure urban land use efficiency, then utilized a spatial Durbin model to examine the spatial effects of market-based land transfers on urban land. The study found that while market-based land transfers significantly enhance urban land use efficiency in localized areas, they exert a relatively strong inhibitory effect on efficiency in spatially contiguous regions. Liu et al. (2021) [10] argue that optimizing industrial structures plays a crucial role in reshaping urban land use patterns and redistributing land resources across industrial sectors, thereby influencing urban land use efficiency and ensuring sustainable local industrial development.

Other scholars have examined the impact of land resource allocation on economic activities. Janvry et al. (2015) [11] utilized Mexican data from 1993 to 2006 to investigate the relationship between migration and land tenure certification. The study found that decoupling land tenure rights from land ownership and certifying them independently to migrants could protect their fundamental rights to some extent and facilitate increased migration. Aragón (2015) [12] examined the relationship between land resource allocation and household housing costs alongside real wages. Findings indicate that strengthening land resource rights certainty and improving land resource allocation can effectively increase household real income. Most studies primarily focus on the impact of agricultural land resource allocation on agricultural productivity. For example, Chen et al. (2022) [13] utilized Ethiopia's land certification reform methodology to examine the specific effects of the land rental market on agricultural productivity. Findings indicate that land rents significantly boost agricultural productivity by reducing misallocation, and the empirical effects of land certification reform represent only a small fraction of the overall impact of the land market. Restuccia and Santaeulalia-Llopis (2017) [14] analyzed household-level data on agricultural output and inputs in Malawi, revealing that inefficient allocation of land resources increases agricultural income inequality and poverty incidence. Conversely, research examining the effects of industrial land allocation on industrial productivity remains scarce.

2.2. Current State of Domestic Research

Hua Wei et al. (1998) [15] examined the development patterns of both industrial enterprises and township enterprises during China's industrialization process from the perspective of optimizing land resource allocation. Chen Meiqiu and Ai Lianghui (2002) [16] identified numerous problems stemming from the existing land allocation mechanism for small towns, including extensive land use, low land utilization efficiency, large-scale occupation of arable land, widespread hidden land markets, irrational land use structures, and disorderly building layouts. Qu Futian et al. (2005) [17] analyzed key issues in China's land management, identifying fundamental institutional flaws-characterized by absent land property rights holders and abuse of land expropriation authority-and governance deficiencies marked by non-cooperative games between central and local governments in land resource allocation as primary causes of inefficiency. Zhang Xiong et al. (2019) [18] first measured the specific efficiency of land resource allocation among enterprises of different land use types. The study found that land resource allocation was inefficient and ineffective for most enterprises. Deng Huihui et al. (2020, 2021) [19][20] used Zhejiang Province's “per-mu efficiency” land allocation reform as a quasi-natural experiment to assess the impact of optimized land resource allocation on regional economic efficiency and industrial total factor productivity. The study found that the “Heroes by Mu” reform enhanced the economic effects of optimized resource allocation through pathways such as standardizing land marketization, reducing government intervention, and encouraging enterprise technological innovation. Simultaneously, this reform significantly boosted industrial total factor productivity by improving land use efficiency, correcting land resource misallocation, and compelling enterprise innovation.

ISSN: 2710-0723

In recent years, with the rise in global environmental awareness, some scholars have conducted related research on land use from an environmental perspective. Gu Ronghua and Zhu Yulin (2021) [21], addressing the strategic need to establish land use patterns conducive to ecological optimization in the Yangtze River basin for its ecological conservation, empirically examined the effects of land resource allocation and utilization methods on ecological optimization of national territorial space. The study found that increasing the proportion of farmland and forest land, along with the economical and intensive use of construction land, helps reduce ecological pressure and enhance ecological efficiency. Wang Shuai et al. (2022) [22] utilized panel data from 272 prefecture-level and above cities in China spanning 2012–2020. Employing the super-efficient SBM model, systematic GMM estimation, and panel cluster analysis, they examined the impact of governmental environmental concern on urban land resource allocation efficiency. Their findings demonstrated that heightened governmental environmental concern significantly promotes the efficiency of urban land resource allocation.

3. Theoretical Foundations, and Theoretical Mechanisms

3.1. Theoretical Foundations

3.1.1. The Theory of Diminishing Returns to Land

The theory of diminishing returns to land demonstrates that land's productivity is finite. In the mid-17th century, economist Petty first observed the phenomenon of “diminishing returns to land,” where continuously increasing land inputs result in output that initially rises but eventually declines. In 1815, West formally introduced the “law of diminishing returns to land” in his work Capital and Land [23]. Under identical production technology and fixed land area, continuously adding equal quantities of labor or capital to the land yields returns that do not increase proportionally with the additional inputs. Beyond a certain threshold, the rate of return diminishes as labor or capital increases. Specifically, when a plot's carrying capacity exceeds its capacity to absorb factor inputs, each additional unit of labor or capital increases land's total returns by an amount greater than the previous unit's contribution. Upon reaching an optimal value, total returns peak. If output exceeds the optimal input level, the land's carrying capacity becomes insufficient to absorb further factor inputs, and the total marginal product per unit of land diminishes as land input increases. The law of land rent unfolds in three distinct phases: Phase One: Average land rent increases, leading to a greater overall increase in total rent from additional labor input. The second stage occurs when average returns equal marginal returns, lasting until marginal returns reach zero. The third stage begins after marginal returns become zero and total returns peak. Here, average returns continue to decrease, and total returns also decline

The law of diminishing returns in land use serves as a crucial foundation for this paper's exploration of green land utilization efficiency. By refining utilization structures, enhancing land allocation standards, and advancing land use technologies, we can extend the curve of increasing returns and delay the onset of diminishing returns.

3.1.2. Theory of Sustainable Land Resource Utilization

Sustainable land resource utilization constitutes a vital component of sustainable development. In the 1990s, the first International Symposium on Sustainable Land Use Systems was organized by the U.S. Department of Agriculture, the Indian Agricultural Research Council, and the Rodale Institute, where the theory of sustainable land use was formally proposed. In 1993, the Food and Agriculture Organization of the United Nations published the “Outline for the Evaluation of Sustainable Land Management,” introducing the theory of sustainable land resource utilization in the temporal continuity of land suitability. Rydén (2008) [24] defines sustainable land use as the utilization of land resources for goods production that meets

ISSN: 2710-0723

evolving human needs while preserving the long-term productive potential of these resources and maintaining their environmental functions.

3.1.3. Theory of Sustainable Development

The earliest articulation of sustainable development traces back to the 1980 World Conservation Strategy, jointly published by the World Wildlife Fund (WWF), the United Nations Environment Programme (UNEP), and the International Union for Conservation of Nature (IUCN). In 1987, the World Commission on Environment and Development (WCED) released its landmark report Our Common Future. This report formally introduced the concept of sustainable development for the first time and provided a systematic exposition of it. While over 100 definitions exist, the most widely accepted and influential remains the one presented in Our Common Future. The report defines sustainable development as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It encompasses two key concepts: needs and constraints. Needs, particularly the basic needs of people everywhere, should be regarded as a special priority; constraints, the limitations imposed by the state of social organization and technology on the environment's capacity to meet present and future demands."

3.2. Theoretical Mechanism

First, the reform of the “per-mu performance evaluation” system facilitates the optimal allocation of factor resources, thereby enhancing the green utilization efficiency of land. Under its per-mu productivity evaluation mechanism, comprehensive assessments of industrial enterprises above designated size primarily consider six indicators: per-mu tax revenue, per-mu value-added output, total labor productivity, value-added per unit of emissions, value-added per unit of energy consumption, and R&D expenditure as a percentage of main business revenue. Evaluation results are categorized into four tiers, with higher-rated enterprises receiving greater policy incentives. This regulation generates strong market competition effects, not only intensifying incentives for top-tier enterprises but also compelling bottom-tier enterprises to improve resource utilization efficiency. Weak industries (enterprises) characterized by high pollution and low profitability will gradually be phased out. Production factors such as capital, land, and labor will flow toward environmentally friendly and high-yield industries (enterprises), contributing to enhanced green land utilization efficiency.

Second,the “output per mu” reform promotes regional technological innovation, thereby enhancing green land utilization efficiency. On one hand, the reform itself reinforces innovation as the fundamental driver for development and boosting output per mu. For instance, implementing industry-specific “output per mu” leader initiatives establishes exemplary models, guiding enterprises to strengthen innovation in technology, management, business models, and manufacturing methods. It also involves vigorously establishing and improving innovation service systems, engineering research centers, and other innovation platforms or carriers. It integrates planning resources to accelerate the rational flow and efficient allocation of innovation factors-such as talent, achievements, and projects-across regions. On the other hand, the reform's output-per-mu evaluation mechanism and differentiated factor allocation system compel enterprises to pursue technological innovation to maintain competitive advantages or secure monopoly profits. Technological innovation is precisely a crucial factor in enhancing economic efficiency (Schumpeter, 1939) [25].

ISSN: 2710-0723

4. Measurement and Analysis of Green Land Use Efficiency in Cities

4.1. The SBM Model for Global Super-Efficiency Considering Non-Desirable Outputs

Data Envelopment Analysis (DEA) is a nonparametric efficiency evaluation method that calculates the distance between each decision-making unit (DMU) and the production frontier composed of the best DMUs in reality, and further computes the efficiency score for each DMU. However, traditional DEA models cannot address efficiency issues involving undesirable outputs. Tone (2001) [26] proposed a non-radial DEA model-the SBM model. Compared to conventional CCR or BCC models, the SBM model relaxes the assumption of proportional changes in inputs and outputs. As one of the non-radial DEA models, the SBM model not only avoids radial directional bias but also captures the essence of efficiency evaluation. The super-efficient SBM model further ranks efficient units with efficiency equal to 1 within the SBM framework, allowing efficiency values greater than or equal to 1. To enable inter-period comparisons, the global reference technique is integrated with the super-efficient SBM model to construct the global super-efficient SBM model, formulated as follows:

$$min\rho^* = \frac{1+\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{ik}^t}}{1-\frac{1}{s+p}(\sum_{r=1}^{s}\frac{s_r^+}{y_{rk}^t}-\sum_{q=1}^{p}\frac{s_q^{b-}}{b_{qk}^t})} \tag{1}$$

$$\begin{cases} \sum_{t=1}^{T}\sum_{j=1,j\neq 0}^{n} x_{ij}^t\gamma_j^t - s_i^- \le x_{ik}^t, i=1,\dots,m \\ \sum_{t=1}^{T}\sum_{j=1,j\neq 0}^{n} y_{rj}^t\gamma_j^t + s_r^+ \ge y_{rk}^t, r=1,\dots,s \\ \sum_{t=1}^{T}\sum_{j=1,j\neq 0}^{n} b_{qj}^t\gamma_j^t - s_q^{b-} \le b_{qk}^t, q=1,\dots,p \\ \sum_{t=1}^{T}\sum_{j=1,j\neq 0}^{n} \gamma_j^t = 1 \\ \gamma_j^t \ge 0, s_i^- \ge 0, s_r^+ \ge 0, s_q^{b-} \ge 0 \end{cases} \tag{2}$$

ρ^* denotes the green land use efficiency value of decision unit j in period t under global production technology and variable scale conditions. s_i^-,s_i^-,and s_q^{b-} represent non-zero slack constraints for input factors, output factors, and undesirable outputs, respectively.

4.2. Variable Selection and Data Sources

4.2.1. Variable Selection

Urban land green utilization efficiency generally refers to the ratio of green productivity to the human resources and capital consumed in urban areas. It directly reflects the degree to which established objectives-such as maximizing resource utilization efficiency, achieving coordinated ecological-economic development, and minimizing environmental pressure-are fulfilled (Chen Danling et al., 2022). Based on the conceptual framework and essence of measuring urban land green utilization efficiency, and drawing upon the research of Lu Xinhai et al. (2020) and Chen Danling et al. (2022) [26], a “desired output + inputs + undesired output” framework is constructed to calculate urban land green utilization efficiency. Input factors primarily encompass land, capital, labor, and energy inputs, including capital (fixed asset investment), land (built-up area), and labor (total employment in secondary and tertiary

ISSN: 2710-0723

industries). Expected outputs comprise economic benefits (value added in secondary and tertiary industries), ecological benefits (green coverage rate in built-up areas), and certain non-expected outputs (total industrial sulfur dioxide emissions, total industrial wastewater discharge, and industrial smoke/dust emissions).

4.2.2. Data Sources

Data is sourced from the Guotai An database and the China Urban Statistical Yearbook (2010–2021). The empirical research subjects were selected from prefecture-level and above cities in China. Due to difficulties in obtaining data from certain regions and significant variations in the scope of statistical data, cities in Hong Kong, Macao, and Taiwan were excluded from the study. Provincial statistical yearbooks and annual statistical reports from major cities were used to supplement the article's data, with missing values filled using linear interpolation. All time-valued variables were converted using 2009 as the base year.

5. Empirical Analysis

5.1. Model Specification, Variable Selection

This paper employs a double difference model to evaluate the policy effects of the “heroes measured by output per mu” initiative. In 2013, the Zhejiang Provincial Government implemented a development philosophy centered on “measuring heroes by output per mu and promoting transformation through intensive use.” It launched the “Output Per Mu Doubling” initiative province-wide to enhance land intensive and efficient utilization, optimize land resource allocation, and establish a transformation incentive mechanism guided by “measuring heroes by output per unit of land occupied.” This shifted away from the “GDP-only” evaluation standard and introduced a comprehensive policy evaluation system based on land economic performance rankings, categorized by land type and industry. Whether a province (autonomous region, municipality) implemented the “output per mu” land allocation reform provided the empirical basis for distinguishing between treatment and control groups in this study. To effectively identify the impact of land allocation system innovation on urban green land use efficiency, cities implementing the “output per mu” reform were designated as the treatment group, while others served as the control group. Using the indicator (Eff) measured in Chapter 4 to represent green land use efficiency, the following DID models were constructed:

$$Eff_{it} = \alpha_0 + \alpha_1 did_{it} + \sum_{j=2}^{J} \alpha_j Control_{it} + \gamma_t + \mu_i + \varepsilon_{it} \tag{3}$$

In the above equation, i and t represent prefecture-level city and year, respectively. Eff_{it} denotes the green land utilization efficiency level of prefecture-level city i in year t; did_{it} is a dummy variable, valued as 1 for cities implementing the “per-mu performance evaluation” policy in the current and subsequent years, and 0 otherwise; α_1 is the primary focus of this study. Additionally, $Control_{it}$ represents a set of control variables affecting a city's green land utilization efficiency, μ_i denotes the fixed effect, γ_t represents the time fixed effect, and ε_{it} is the random error term.

5.2. Benchmark Regression Results

Table 1 presents the estimated results of land allocation system innovation on urban land green utilization efficiency. Columns (1) to (7) display the estimation results with progressively added control variables, all controlling for time and individual fixed effects. Comparing the estimation results in columns (1) to (7), after controlling for time and individual fixed effects, the estimated coefficient for the did variable remains positive and statistically significant at the

ISSN: 2710-0723

1% confidence level regardless of whether city-level control variables are included in the model. The benchmark regression results demonstrate that innovative land allocation systems can significantly enhance the green land use efficiency of cities.

Table 1. Baseline Regression Results

variable	Eff						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
did	0.064*** (0.022)	0.064*** (0.022)	0.064*** (0.022)	0.066*** (0.022)	0.067*** (0.022)	0.069*** (0.022)	0.070*** (0.022)
Dev		0.006 (0.012)	-0.014 (0.013)	-0.012 (0.013)	-0.021 (0.013)	-0.016 (0.014)	-0.032** (0.014)
Gov			-0.221*** (0.055)	-0.218*** (0.055)	-0.168*** (0.058)	-0.194*** (0.060)	-0.181*** (0.135)
Tec				-2.243* (1.234)	-2.530** (1.238)	-2.497** (1.238)	-2.628** (1.239)
Edu					-1.273** (0.512)	-1.347*** (0.514)	-1.244*** (0.515)
Fin						0.007 (0.004)	0.007* (0.004)
Ind							0.311** (0.137)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,360	3,360	3,360	3,360	3,360	3,360	3,360

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The values in parentheses

5.3. Robustness Tests

5.3.1. Parallel Trends Test and Dynamic Effects Analysis

A key assumption for the effective application of the difference-in-differences method is ensuring that the trends in green land use efficiency changes between the treatment and control groups were parallel prior to policy implementation. Drawing on the principles of event study methodology, we test whether significant differences existed in the levels of green land use efficiency between the treatment and control groups before the policy commenced. The model specification is as follows:

$$Eff_{it} = \alpha_c + \sum_{k=-3}^{7} \alpha_k Policy_{it}^{k} + \sum_{j=8}^{J} \alpha_j Control_{jt} + \gamma_t + \mu_i + \varepsilon_{it} \quad (4)$$

k represents the difference between each year and 2013. $Policy_{it}^{k}$ denotes the implementation status of policies in each year, $Control_{it}$ comprises a series of control variables affecting urban land green utilization efficiency, μ_i is the individual fixed effect, γ_t is the time fixed effect, and ε_{it} is the random error term. The base year is 2009. Test results are shown in Figure 1. Parallel trend results indicate that before the implementation year of the land allocation system innovation policy, the estimated coefficients failed to pass the significance test. This proves that prior to the innovation of the land allocation system, there was no significant difference in the trend of changes in green land use efficiency between the control group and the treatment group cities, satisfying the parallel trend assumption.

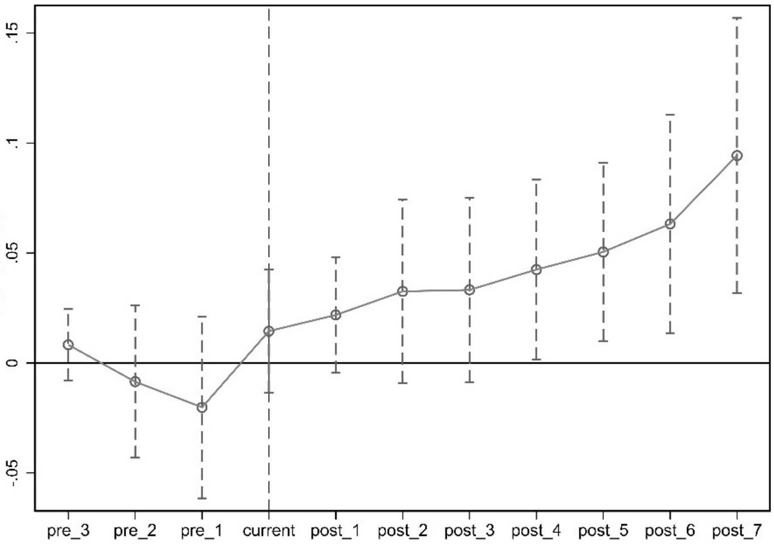

Figure 1. Time Dynamic Effects

5.3.2. Placebo Test

This study conducted a placebo test by randomly selecting cities equivalent in number to the actual treatment group as the control group. By performing benchmark regression on the results obtained through random selection of the treatment group and repeating this process 1,000 times, the kernel density distribution of the estimated coefficients is shown in Figure 2, while the coefficient p-value scatter plot is presented in Figure 3. The vertical solid line represents the true interaction coefficient of the policy interaction term in the benchmark regression, and the vertical dashed line indicates the mean coefficient estimated after 500 repetitions. As shown in Figure 2, the mean of estimated coefficients clusters near zero and approximates a normal distribution. Moreover, the vast majority of estimated P-values exceed 0.1, indicating that under random sampling, the "per-mu performance-based" land allocation reform did not significantly impact urban land green utilization efficiency. The placebo test passes.

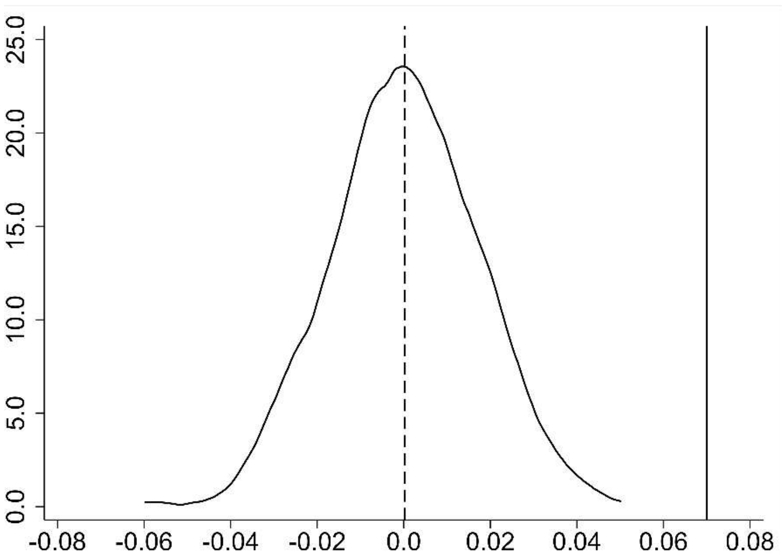

Figure 2. Coefficient Kernel Density

ISSN: 2710-0723

6. Research Findings and Policy Recommendations

6.1. Conclusion

Finally, the paper synthesizes and organizes the findings. Building upon existing theoretical foundations, the first step is to construct a theoretical framework demonstrating how innovations in land allocation systems influence urban green land utilization efficiency. The second step employs a global super-efficiency SBM model that accounts for undesirable outputs to analyze and measure urban green land utilization efficiency. The third step involves conducting a quasi-natural experiment based on the implementation of the "Heroes by Mu" land allocation reform. Using panel data from prefecture-level and above cities from 2009 to 2020, the impact of land allocation system innovation on urban green land use efficiency is identified through a double difference model.

6.2. Policy Recommendations

Based on this study, the following recommendations are proposed: First, consistently adhere to the market-oriented reform direction and continuously enhance the efficiency of land utilization and allocation to fully leverage the competitive and pricing mechanisms of the land market. Second, innovative top-level design and tiered alignment with local governance are required.

Acknowledgments

This work is supported by Innovation and Entrepreneurship Training Project for College Students of Anhui University of Finance and Economics in 2025, Project number: 202510378196.

References

[1] Hsieh C T, Klenow P J. Misallocation and manufacturing TFP in China and India[J]. The Quarterly journal of economics, 2009, 124(4): 1403-1448.

[2] Wang, D., Pang, X. (2019). Research on green land use efficiency in the Jing-Jin-Ji urban agglomeration. China Population, Resources and Environment, 29(4), 68-76.

[3] Zhang, Y. (2010). The impact of changes in economic development patterns on China's carbon emission intensity. Economic Research Journal, 45(4), 120-133..

[4] Qu F, Heerink N, Wang W. Land administration reform in China: Its impact on land allocation and economic development[J]. Land Use Policy, 1995, 12(3): 193-203.

[5] Nizalov D, Thornsbury S, Loveridge S, et al. Dynamics of agricultural production and land use in post-soviet Ukraine[M]//Transition to agricultural market economies: the future of Kazakhstan, Russia and Ukraine. Wallingford UK: CABI, 2015: 215-227.

[6] Yang B, Wang Z, Zhang B, et al. Allocation efficiency, influencing factors and optimization path of rural land resources: a case study in fang county of hubei province, China[J]. International Journal of Environmental Research and Public Health, 2020, 17(16): 5898.

[7] Xi Q, Mei L. How did development zones affect China's land transfers? The scale, marketization, and resource allocation effect[J]. Land Use Policy, 2022, 119: 106181.

[8] Jiang X, Lu X, Liu Q, et al. The effects of land transfer marketization on the urban land use efficiency: An empirical study based on 285 cities in China[J]. Ecological Indicators, 2021, 132: 108296.

[9] Liu J, Hou X, Wang Z, et al. Study the effect of industrial structure optimization on urban land-use efficiency in China[J]. Land Use Policy, 2021, 105: 105390.

[10] De Janvry A, Emerick K, Gonzalez-Navarro M, et al. Delinking land rights from land use: Certification and migration in Mexico[J]. American Economic Review, 2015, 105(10): 3125-3149.

ISSN: 2710-0723

[11] Aragón F M. Do better property rights improve local income?: Evidence from First Nations' treaties[J]. Journal of Development Economics, 2015, 116: 43-56.

[12] Chen C, Restuccia D, Santaeulàlia-Llopis R. The effects of land markets on resource allocation and agricultural productivity[J]. Review of Economic Dynamics, 2022, 45: 41-54.

[13] Restuccia D, Santaeulalia-Llopis R. Land misallocation and productivity[J]. NBER working paper, 2017 (w23128).

[14] Hua, W., Lu, Z., Zhao, F. (1998). On the allocation efficiency of land resources in the process of industrialization and urbanization: Also on the countermeasures for township enterprises in realizing the transformation of economic growth mode. Journal of Nanjing Normal University (Social Science Edition), (2), 23-28.

[15] Chen, M., & Ai, L. (2002). On the innovation of land allocation mechanism in small towns in China. Economic Review, (9), 21-23..

[16] Qu, F., Gao, Y., & Jiang, H. (2005). China's land management policy: Theoretical propositions and mechanism transformation. Management World, (4), 40-47.

[17] Zhang, X., Zhang, A., & Deng, C. (2016). Research on land resource allocation efficiency from the perspective of land-using enterprises. China Land Sciences, 30(8), 90-97..

[18] Deng, H., Zhao, X., & Li, H. (2020). How does optimal allocation of land resources affect economic efficiency? Empirical evidence from the "performance evaluation based on per unit output" reform in Zhejiang Province. China Land Sciences, 34(7), 32-42.

[19] Deng, H., Zhao, X., & Li, H. (2021). Land allocation system innovation and industrial total factor productivity: An evaluation based on the synthetic control method. Zhejiang Social Sciences, (1), 34-43, 156.

[20] Gu, H., & Zhu, Y. (2021). Regional land use and its impact mechanism on territorial spatial ecological optimization: An empirical study of Jiangsu Province. Economic Geography, 41(11), 201-208.

[21] Wang, S., Ma, J., & Li, Z. (2022). The impact of government environmental attention on the efficiency of urban land resource allocation. Economic Geography, 42(12), 186-193.

[22] West E. Essay on the Application of Capital to Land: With Observations Shewing the Impolicy of Any Great Restriction of the Importation of Corn, and that the Bounty of 1688 Did Not Lower the Price of it[M]. T. Underwood, 1815.

[23] Rydén P. Sustainable Land Management-An Approach to Growth in Natural Resource Based Economic Sectors Why and How[J]. World Bank, Washington DC, 2008.

[24] Schumpeter J A. Business cycles[M]. New York: Mcgraw-hill, 1939.

[25] Tone, K., 2001. A slacks-based measure of efficiency in data envelopment analysis. European journal of operational research, 130(3), pp.498-509.

[26] Chen, D., Lu, X., Zhang, C., et al. (2022). Path selection for improving urban green land use efficiency driven by collaborative innovation from a configuration perspective. China Population, Resources and Environment, 32(10), 103-111.