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The impact of land finance dependence on green economic efficiency: evidence from China

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China's reliance on land finance poses challenges to green economic efficiency. This study examines how local governments' land finance dependence affects green economic efficiency, using panel data from prefecture-level cities and a super-efficiency SBM model. Findings show that land finance dependence significantly reduces green economic efficiency, particularly in non-resource-based, environmentally protected, and urban agglomeration cities, by diverting fiscal resources to short-term development and increasing debt risks. Policy reforms are recommended to reduce land finance dependence and promote sustainable fiscal incentives.

KEYWORDS

land finance dependence, green economic efficiency, SBM model, environmental governance, local government debt risk, fiscal reform

1 Introduction

Over the past few decades, China has strategically shifted its development focus to green sectors. The purpose of this transition is not merely to improve ecology, but to build a new development pattern where economic progress and ecological sustainability complement each other, while ensuring the momentum of economic growth. However, a series of reforms that centralized fiscal revenues while decentralizing expenditure responsibilities has placed fiscal pressure on local governments responsible for infrastructure, public services, and environmental governance. To bridge these gaps, local governments have increasingly relied on land finance, leveraging monopolized land supply to generate revenues, often at the expense of environmental priorities. This institutional tension raises a critical question: How does local governments' dependence on land finance shape urban green economic efficiency, and through which mechanisms do these effects manifest across diverse city types? This study investigates these dynamics, offering a novel perspective by linking fiscal incentives to resource misallocation and environmental externalities in China's decentralized system.

Behind this overarching green strategy lies a profound institutional paradox rooted in the fiscal relationship between central and local authorities. Stemming from the 1994 tax-sharing reform, which shifted revenue authority upward while devolving spending responsibilities, this paradox reshaped intergovernmental resource allocation. Local governments, charged with infrastructure provision, public services, and environmental governance, continue to face persistent fiscal shortfalls. To bridge these gaps—and to meet growth-oriented performance assessments—local officials have increasingly relied on land finance, a model that monopolizes the supply of land to generate revenues. While this reliance has reshaped local economic structures, it frequently clashes with environmental objectives. Consequently, the central government's green-development vision is constrained by local behavioral logic, generating tension between economic expansion

and ecological protection. This study seeks to analyze the environmental externalities of such fiscal dependence and to unveil the intricate landscape shaped by institutional design and local rational choice.

A pivotal question for the success of China's development transition remains unanswered: How, in quantitative terms and through which mechanisms, does local governments' dependence on land finance shape urban green economic efficiency? Existing scholarships are sharply divided. One strand highlights the positive side of land-finance revenues, arguing that they have supplied critical capital for rapid urbanization and large-scale infrastructure, some of which has improved green public facilities and thus fostered economic growth and public-goods provision. Gyourko et al. (2022) provide a comprehensive analysis of China's land finance system, emphasizing its core role in funding urban development and infrastructure projects that have been crucial for China's economic growth. Similarly, Mo (2018) finds that land finance has positively contributed to county-level economic growth by providing necessary funds for local development projects. Furthermore, Pan et al. (2015) note that land finance helps local governments manage fiscal deficits and invest in real estate markets, thereby stimulating economic activity.

The opposing strand of literature is markedly critical, asserting that overreliance on land finance distorts local officials' incentives, ensnaring them in a "growth-for-competition" prisoner's dilemma. In pursuing short-term fiscal gains and investment attraction, governments loosen environmental regulations and partake in a "race to the bottom," resulting in resource misallocation, industrial lock-in, and profound environmental damage. Van der Kamp et al. (2017) contend that decentralization and land finance prioritize economic expansion over ecological safeguards, yielding lax regulatory enforcement. Zheng et al. (2014) caution that this model jeopardizes China's sustainability by fostering "ghost cities" and social unrest. Wang et al. (2020) show empirically that land finance has escalated carbon emissions since 2003, linked to economic progress. Recent works add nuance: Chen et al. (2024) examine land finance's role in inter-city integration, noting spatiotemporal effects on sustainability; Wang D et al. (2021) assess its influence on industrial shifts, highlighting environmental and social drawbacks. This scholarly divide highlights the multifaceted effects of land finance on green economic efficiency, making resolution of the positive-negative paradox vital for evidence-based policies that harmonize growth and environmental goals in China's transition.

This study employs panel data from Chinese prefecture-level cities over the period from 2015 to 2023, utilizing a super-efficiency SBM model to assess green economic efficiency and a two-way fixed effects model for baseline regressions, which demonstrate that land finance dependence substantially hinders green economic efficiency after accounting for various controls such as *per capita* GDP and financial development; endogeneity concerns are mitigated through two-stage least squares estimation with a retail sales-to-GDP ratio as an instrumental variable, reinforcing the adverse relationship; robustness is confirmed via alternative efficiency measurement approaches like directional distance functions and global Malmquist-Luenberger indices, substitute indicators for land finance dependence, and exclusion of potentially anomalous data years;

mechanism examinations reveal that land finance dependence indirectly impairs green economic efficiency by diminishing environmental regulation—evident in reduced policy emphasis and protection expenditures—and by escalating local debt risks through higher debt balances and investment bonds; heterogeneity analyses indicate more pronounced negative effects in non-resource-based cities, key environmental protection cities, and urban agglomeration cities, highlighting the institutional tensions between fiscal incentives and ecological priorities, with policy recommendations advocating for reduced reliance on land finance via sustainable reforms to harmonize economic growth and environmental sustainability in China's green development pathway.

This study makes three significant contributions to the literature. First, it extends research on resource misallocation by introducing land finance dependence as a critical institutional determinant of environmental inefficiencies. While foundational work quantified productivity losses from factor market distortions (Brandt et al., 2013), this analysis demonstrates how a specific fiscal arrangement induces misallocation in the environmental domain, resulting in measurable losses in green economic performance. Second, this study provides a critical institutional perspective—specifically focusing on local governments' land finance dependence (Porter and Claas van der, 1995; Dechezleprêtre and Sato, 2017), it reveals that fiscal pressures inherent in decentralization systematically weaken regulatory stringency, thereby explaining why the purported innovation-driving benefits of environmental policy may fail to materialize in fiscally constrained local governments. Third, the study advances the understanding of how local economic structures mediate the effects of national policies, a line of inquiry influenced by institutional analyses of innovation and reallocation (Acemoglu et al., 2018).

The paper is structured as follows: Section 2 reviews the relevant literature and presents the research hypotheses; Section 3 outlines the data sources, variable definitions, and methodology; Section 4 presents and discusses the regression results, along with robustness checks; Section 5 explores the mechanisms through which land finance dependence influences green economic efficiency; and Section 6 concludes with policy recommendations.

2 Research hypotheses

2.1 Impact of land finance dependence on urban green economic efficiency

Urban green economic efficiency represents a city's capacity to achieve economic outputs while minimizing resource inputs and environmental externalities, serving as a core metric for sustainable development under resource constraints. From a fiscal decentralization perspective, local governments in China operate within a system where revenue-sharing reforms have centralized fiscal authority while decentralizing expenditure responsibilities, creating incentives for officials to pursue short-term growth targets to secure promotions and revenues. Land finance dependence emerges as a rational adaptation to these pressures, as governments monopolize land supply to generate off-budget

revenues for infrastructure and urbanization. However, this dependence is expected to undermine green economic efficiency because it fosters a “growth-at-all-costs” logic: by prioritizing land sales and real estate-driven investments, local officials divert resources toward expansive, pollution-intensive projects that maximize immediate fiscal gains but impose long-term ecological costs, such as habitat loss and increased emissions. This relationship is theoretically rooted in the principal-agent problem, where misaligned incentives between central environmental mandates and local fiscal imperatives lead to suboptimal resource allocation, perpetuating inefficiencies in green transitions. Supporting this, Wang P et al. (2021) demonstrate that land finance reduces urban land use efficiency, leading to sprawling development that increases energy consumption and environmental degradation, while Wang et al. (2020) find that land finance significantly contributes to carbon emissions. Similarly, Gyourko et al. (2022) argue that land finance drives up land and housing prices, encouraging investment in high-pollution sectors, and (Cheng et al., 2022) highlight resource misallocation under fiscal pressures, though Zhao et al. (2024) note that green finance could mitigate volatility but is often overshadowed by land dependence.

H1: Land finance dependence negatively affects urban green economic efficiency.

2.2 Land finance dependence and environmental regulation

Environmental regulation comprises a suite of institutional tools—laws, policies, and enforcement mechanisms—designed to internalize environmental externalities and align economic activities with sustainability goals, as posited by the Porter Hypothesis, which suggests that well-crafted regulations can stimulate innovation and efficiency. In the context of China’s decentralized governance, land finance dependence is theorized to weaken these regulations because it heightens fiscal vulnerabilities, compelling local governments to relax enforcement to attract investment and sustain land revenue streams. This dynamic arises from a “race to the bottom” incentive structure: under performance-based evaluations focused on GDP growth, officials face a prisoner’s dilemma where competing jurisdictions undercut environmental standards to secure economic advantages, resulting in diluted regulatory stringency. Consequently, weakened regulations fail to curb pollution or promote green innovations, amplifying the negative spillover from land finance to green economic efficiency by allowing unchecked resource exploitation and environmental degradation. Empirical insights align with this, as Wang et al. (2019) find that land finance encourages relaxed regulations leading to a “race to the bottom,” and Zhuge et al. (2020) highlight paradoxes where economic targets undermine efforts. Regional variations are noted by Zhao et al. (2024), while Dechezleprêtre and Sato (2017) confirm regulations’ innovation potential but fiscal constraints from land dependence divert resources.

H2: Land finance dependence weakens environmental regulation, which in turn negatively affects urban green economic efficiency.

2.3 Land finance dependence and local government debt

Local government debt in China often accumulates through land-collateralized borrowing and financing platforms, reflecting a broader fiscal mismatch where decentralized spending exceeds centralized revenues. Theoretically, land finance dependence exacerbates this debt expansion by creating a leverage cycle: governments use anticipated land revenues as collateral to fund infrastructure, but volatile real estate markets and over-reliance on non-recurring income sources trap them in a debt trap, as per the soft budget constraint theory. High debt levels are expected to constrain green investments because they crowd out funding for long-term, low-return environmental projects in favor of short-term, high-yield urban developments, perpetuating a vicious cycle of fiscal risk and ecological neglect. This mediation pathway underscores how debt acts as an amplifier of land finance’s negative externalities, limiting fiscal flexibility and prioritizing debt servicing over sustainable initiatives. Consistent with this framework, Cai et al. (2021) and Geng and Qian (2024) describe land as collateral driving debt risks, while Qu et al. (2023) and Tao et al. (2010) highlight regional competition and infrastructure financing limitations. Mechanisms are further explored by Zhou et al. (2023), who link debt to increased pollution, Xu (2019) tracing origins to fiscal pressures, and Wang et al. (2020) connecting to carbon emissions, with Jin et al. (2021) noting green finance’s constrained mitigation potential.

H3: Land finance dependence leads to local government debt expansion, which negatively affects urban green economic efficiency.

3 Methodology

3.1 Data

To ensure data availability and completeness, this study utilizes panel data of Chinese prefecture-level cities from 2015 to 2023 for empirical analysis. The input-output indicators for green economic efficiency are primarily sourced from the China Environmental Statistical Yearbook and the China Statistical Yearbook. Data on land finance dependence are compiled from official statistics published by provincial and municipal departments of finance. Other control variables are obtained from the China City Statistical Yearbook and local statistical bulletins. Missing values are supplemented through manual searches; samples with irreparable missing data are excluded. All monetary variables are adjusted to constant 2011 prices using the GDP deflator of each city’s respective province to eliminate the effects of inflation. All continuous variables have been trimmed at 1%. Ultimately, a total of 2199 valid observations are obtained.

3.2 Variable definition

3.2.1 Independent variable

The measurement of green economic efficiency (GEE) requires an analytical framework capable of simultaneously handling desirable outputs and undesirable outputs.

TABLE 1 Input-output indicators and descriptions for measuring urban green economic efficiency.

Input Indicators	Capital Input	Estimated capital stock based on the perpetual inventory method (100 million CNY)
	Labor Input	Number of employed persons at year-end (10,000 persons)
	Land Input	Built-up area (square kilometers)
	Energy Input	Total electricity consumption (100 million kWh)
	Water Resource Input	Total water consumption (100 million cubic meters)
Expected Output	Economic Output	Actual GDP (100 million CNY)
Undesirable Output	Industrial SO ₂ Emissions	Industrial sulfur dioxide emissions (10,000 tons)
	Industrial Dust Emissions	Industrial smoke (dust) emissions (10,000 tons)
	Industrial Wastewater Discharge	Industrial wastewater discharge (10,000 tons)

Traditional Data Envelopment Analysis (DEA) models, such as CCR and BCC, are not suited for this task as they are typically radial, assuming proportional changes in inputs and outputs, and fail to account for non-radial slacks, which can lead to an incomplete assessment of inefficiency. To address this, we adopt the non-radial Slacks-Based Measure (SBM) model, which directly incorporates input excesses and output shortfalls into the efficiency calculation, providing a more accurate and comprehensive evaluation (Tone, 2001). The variable selection of input-output indicators is shown in Table 1. Furthermore, to overcome the limitation of standard DEA models that often assign multiple Decision-Making Units (DMUs) an identical efficiency score of '1' and thus cannot be ranked, we employ the super-efficiency SBM model. This advanced method allows efficiency scores to exceed unity, enabling the ranking of all DMUs, including those on the efficiency frontier, which offers superior discriminatory power for detailed comparative analysis.

For the dynamic analysis and robustness testing of GEE, this study selects the Directional Distance Function (DDF)-based Global Malmquist-Luenberger (GML) index model. The evolution of productivity analysis began with the Malmquist index, which, while foundational for measuring total factor productivity change, could not incorporate environmental externalities (Färe et al., 1994). A significant advancement was the development of the Malmquist-Luenberger (ML) index, which utilizes a DDF to handle undesirable outputs by simultaneously seeking to increase desirable outputs while decreasing undesirable ones (Chambers et al., 1996). However, the conventional ML index suffers from key methodological issues, including the potential for infeasibility in its linear programming and a lack of circularity, which compromises the reliability of inter-temporal comparisons. The GML index, proposed by Oh (2010), overcomes these limitations by constructing a single, global production frontier that envelops all periods. This approach ensures both the feasibility and transitivity of the results, making it a more robust and theoretically sound method for tracking the dynamics of environmental efficiency.

In essence, the dual-methodological approach employing both the super-efficiency SBM and the DDF-GML models is uniquely suited for this research because it provides a comprehensive, robust, and nuanced assessment of green economic efficiency. It has been successfully applied in similar contexts to evaluate

environmental performance (Zhang and Choi, 2013). The super-efficiency SBM model offers a precise and high-resolution static analysis, capable of accurately measuring inefficiency by directly accounting for input and output slacks and providing a complete ranking of all entities, which is a critical feature that overcomes the limitations of traditional DEA models. Complementing this, the DDF-GML index provides a methodologically superior dynamic analysis. By constructing a single global frontier, it avoids the problems of infeasibility and non-transitivity that plague earlier Malmquist-Luenberger models, thus ensuring that the tracking of efficiency changes over time is both reliable and consistent. This combination allows the study to capture the robust, long-term dynamic trends, offering a far more complete and analytically rigorous evaluation than a single model could provide.

3.2.2 Dependent variable

The dependent variable in this study is local governments' land finance dependence (LFD), defined as the extent to which local governments rely on land-related fiscal revenues to support their public budgets. Conceptually, land finance broadly encompasses all fiscal revenues derived from land and real estate activities, including land transfer revenues (fees collected from leasing or selling state-owned land use rights) and associated taxes, such as urban land use tax, land value increment tax, and real estate-related taxes. However, due to the practical challenges of accurately and consistently capturing the full range of direct and indirect land-related taxes across jurisdictions—stemming from variations in tax reporting and data availability—this study adopts a narrower and more precise definition of LFD. Specifically, LFD is operationalized as the proportion of land transfer revenue in a local government's public budget revenue. This measure is widely used in the literature due to its reliability and availability in official fiscal data, enabling a clear and consistent assessment of local governments' reliance on land-based financing.

3.2.3 Control variables

This study selects control variables from the perspectives of urban macroeconomic characteristics and land resources, including economic development level (PGDP), financial development level

TABLE 2 Variable definition.

Variable type	Variable name	Variable measurement
Independent variable	<i>GEE</i>	Green economic efficiency, measured using the super-efficiency SBM model
Dependent variable	<i>LFD</i>	Land finance dependence, measured by land transfer revenue/public budget expenditure
Control variables	<i>PGDP</i>	Per capita GDP (log-transformed)
	<i>FIR</i>	Balance of financial institutions' deposits and loans at year-end/regional GDP
	<i>IU</i>	Value added of the tertiary industry/value added of the secondary industry
	<i>FDI</i>	Actual utilization of foreign direct investment/regional GDP
	<i>URBAN</i>	Non-agricultural population/registered population
	<i>FISDEC</i>	General government revenue/general government expenditure

TABLE 3 Descriptive statistics.

Variables	Obs	Mean	Std.Dev	Min	Median	Max
<i>GEE</i>	2199	0.378	0.176	0.100	0.335	1.220
<i>LFD</i>	2199	0.257	0.239	0.000	0.192	1.538
<i>PGDP</i>	2199	10.895	0.663	9.224	10.812	13.185
<i>FIR</i>	2199	2.808	1.252	0.910	2.492	21.301
<i>IU</i>	2199	1.227	0.638	0.321	1.075	5.650
<i>FDI</i>	2199	0.002	0.003	0.000	0.001	0.029
<i>URBAN</i>	2199	0.411	0.219	0.075	0.349	1.000
<i>FISDEC</i>	2199	0.429	0.211	0.056	0.393	1.086

(*FIR*), industrial upgrading (*IU*), openness to foreign investment (*FDI*), urbanization level (*URBAN*), and fiscal decentralization (*FISDEC*). The definitions of all variables are presented in Table 2, and their descriptive statistics are shown in Table 3.

Prior to the regression, multicollinearity in the baseline OLS model is diagnosed using the Variance Inflation Factor (VIF) method. The results show that the VIF values of all variables are below 10, suggesting that serious multicollinearity is not a concern. Since the number of cross-sectional units (*N*) exceeds the time span (*T*), Levin–Lin–Chu (LLC) and Fisher-ADF unit root tests are conducted to ensure the stationarity of the panel data and the robustness of the regression results. Both tests reject the null hypothesis of a unit root, indicating that the sample data are stationary. In addition, as shown in Table 3, there are considerable differences between the mean, maximum, and minimum values of several variables, implying potential heterogeneity across samples.

Table 3 presents the descriptive statistics of the key variables in this study. The dependent variable, *GEE*, has a mean of 0.378 and a standard deviation of 0.176, with values ranging from 0.100 to 1.220. This indicates substantial variation in green economic performance across cities. The concentration of *GEE* values in the lower range suggests that most Chinese cities still face significant challenges in achieving environmentally sustainable development, and that the overall level of green transformation remains relatively low. The independent variable, *LFD*, shows a mean of 0.257 and a relatively

high standard deviation of 0.239. Its values range from 0 to a maximum of 1.538, indicating pronounced differences in the extent to which local governments rely on land-based revenues. In some cities, such reliance is remarkably high, which may incentivize local authorities to overlook environmental constraints in pursuit of fiscal expansion, thereby potentially impairing green economic efficiency. Figure 1 plots the change in green economic efficiency on lagged land fiscal dependence. The fitted line slopes downward, indicating a negative association. It should be noted that the inference relies on the panel regressions with controls and robustness checks. In addition, the distributions of other control variables appear generally normal, with no evident statistical outliers, providing a sound foundation for empirical investigation.

3.3 Model construction

This study employs a panel data model for empirical analysis. The results of the Hausman test indicate that a two-way fixed effects (FE) model with robust standard errors is more appropriate, given the significant differences across provinces. Therefore, the FE model is adopted for regression. The model is shown in Formula 1:

$$GEE_{it} = \beta_0 + \beta_1 LFD_{it} + \beta_2 \sum Control_{it} + Year_t + Province_k + \varepsilon_{it}, \quad (1)$$

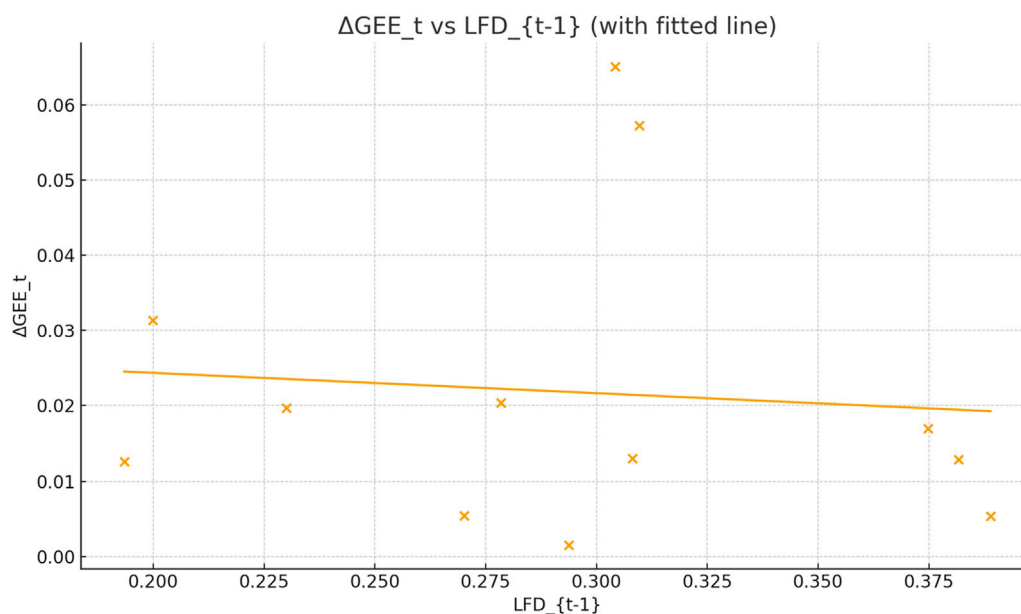


FIGURE 1
Relationship between lagged land fiscal dependence and green economic efficiency growth.

where i denotes the city, t indicates the year, and each city i belongs to a province k , which is accounted for through province fixed effects to control for inter-provincial differences in institutional settings, policy environments, and resource endowments. The term $Year_t$ captures time-fixed effects to eliminate year-specific shocks or macroeconomic trends. $Control_{it}$ is a vector of control variables. ε_{it} is the error term. The primary coefficient of interest is β_1 , which reflects the impact of land finance dependence on green economic efficiency—both in terms of direction and statistical significance.

4 Basic results

4.1 Basic regression analysis

The results of the baseline regressions are presented in Table 4. All three models control for both year and province fixed effects. Column (1) shows that when land finance dependence is included as the sole explanatory variable, the estimated coefficient is statistically insignificant. This suggests that, in the absence of other key controls, the impact of land finance dependence on green economic efficiency is not clearly identifiable. A likely reason is the omission of important structural economic variables, which may weaken the explanatory power of the model.

In Columns (2) and (3), the model progressively incorporates additional control variables. After these inclusions, the coefficient on land finance dependence becomes significantly negative at the 5% level, indicating that land finance dependence has a statistically significant suppressing effect on green economic efficiency. This finding supports the negative externalities of land finance, which posits that heavy reliance on land-based revenues by local governments may erode their intrinsic motivation to pursue green transformation, thereby contributing to resource

inefficiency and environmental degradation. So, Hypothesis 1 has been proven.

The theory of Fiscal Federalism explores the division of expenditure responsibilities and fiscal powers between central and local governments. While the theory emphasizes that decentralization can better meet the demand for local public goods, it also warns of the potential negative consequences of inter-jurisdictional competition. Research by scholars such as Wilson and Wildasin (2004) has provided a solid theoretical foundation for the “Race to the Bottom.” To attract mobile capital and investment, local governments not only compete on taxes but may also engage in a “downward competition” on environmental, labor, and other standards. Driven by land finance, local governments have a strong incentive to maximize land transfer revenue by attracting industrial and real estate projects that can be quickly implemented. To this end, they might relax regulations in areas such as planning approval and environmental assessment, tolerating or even encouraging the entry of high-pollution, high-energy-consumption firms, thereby sacrificing environmental quality for short-term economic growth and fiscal revenue. This prevalent “race to the bottom” behavior is a significant reason for the widespread suppression of green economic efficiency at the regional level.

4.2 Endogeneity tests

In the study of green economic efficiency, land finance dependence as a core explanatory variable may suffer from endogeneity issues. On the one hand, local governments’ reliance on land-based revenues can directly influence the formulation and implementation of urban green development strategies. On the other hand, changes in green economic efficiency may in turn

TABLE 4 Benchmark regression results.

Variables	(1)	(2)	(3)
	GEE	GEE	GEE
LFD	−0.0074	−0.0415**	−0.0352**
	(0.016)	(0.017)	(0.017)
PGDP		0.0725***	0.0893***
		(0.006)	(0.011)
FIR		−0.0274***	−0.0239***
		(0.004)	(0.004)
IU		0.0214***	0.0218***
		(0.008)	(0.008)
FDI			−6.6248***
			(1.669)
URBAN			−0.0538**
			(0.021)
FISDEC			−0.0013
			(0.038)
Constant	0.3798***	−0.3509***	−0.5084***
	(0.005)	(0.068)	(0.112)
Observations	2,199	2,199	2,199
Adjusted R-squared	0.372	0.415	0.420
Year FE	YES	YES	YES
Province FE	YES	YES	YES

Parentheses contain heteroscedasticity robust standard errors. *, **, and *** represent significance levels at 10%, 5%, and 1% respectively.

affect the extent to which local governments depend on land transfer income, resulting in potential bidirectional causality. Additionally, omitted variable bias and institutional differences at the city level may introduce further endogeneity concerns. To address these issues, this study adopts the two-stage least squares (2SLS) estimation method and employs an external instrumental variable to identify the causal impact of land finance dependence on green economic efficiency.

This study selects the ratio of total retail sales of consumer goods to GDP (*RETAIL*) as the instrumental variable for the endogeneity test in the baseline regression. First, in terms of relevance, retail sales of consumer goods reflect the vitality of domestic demand and the consumption structure within a city, which indirectly influences the fiscal revenue capacity of local governments. When a city exhibits strong consumption capacity and high household spending levels, the reliance of local governments on land transfer revenues tends to be lower, suggesting a strong statistical correlation between *RETAIL* and *LFD*. Second, from the perspective of exogeneity, *RETAIL* serves as an indicator of economic dynamism, and its fluctuations are primarily driven by factors such as household income, consumption preferences, and demographic structure. It does not directly intervene in the mechanisms that determine green

economic efficiency, nor is it likely to affect *GEE* through channels such as green technology innovation or environmental regulation. Therefore, it satisfies the condition of exogeneity. Overall, *RETAIL* is a theoretically sound and operationally feasible instrumental variable, making it appropriate for identifying the net effect of land finance dependence on green economic efficiency.

The 2SLS regression results of Table 5 confirm the robustness of the baseline finding that “land finance dependence suppresses green economic efficiency,” even after addressing endogeneity concerns. The F-value of the first-stage regression is 22.555, indicating that there is no issue of weak instruments. Specifically, a high level of reliance on land-based revenues by local governments not only affects the structure of municipal finance but may also incentivize them to overlook ecological and environmental costs in the process of urban expansion. This, in turn, undermines the effectiveness of green transition policies and significantly hampers improvements in green economic efficiency. After addressing potential reverse causality and omitted variable bias using an instrumental variable, the negative impact of land finance dependence on green economic efficiency remains statistically significant. This provides further empirical support for the theory of negative externalities of land finance. Therefore, advancing green development requires not only technological and industrial

TABLE 5 2SLS regression results.

Variables	(1)	(2)
	<i>LFD</i>	<i>GEE</i>
<i>LFD</i>		−0.3403**
		(0.169)
<i>RETAIL</i>	0.2070***	
	(0.040)	
<i>PGDP</i>	0.0136	0.0899***
	(0.014)	(0.012)
<i>FIR</i>	0.0353***	−0.0112
	(0.005)	(0.008)
<i>IU</i>	0.0121	0.0263***
	(0.010)	(0.009)
<i>FDI</i>	1.6342	−6.1205***
	(2.053)	(1.799)
<i>URBAN</i>	0.0861***	−0.0259
	(0.026)	(0.027)
<i>FISDEC</i>	0.3988***	0.1192
	(0.046)	(0.079)
Observations	2,199	2,199
Year FE	YES	YES
Province FE	YES	YES

Parentheses contain heteroscedasticity robust standard errors. *, **, and *** represent significance levels at 10%, 5%, and 1% respectively. Since the intercept and R-squared in the 2SLS, regression have limited statistical interpretability, they are not reported in this table.

efforts but also institutional reforms in fiscal policy and land management. Reducing dependence on land transfer revenues and restructuring a green-oriented fiscal incentive mechanism are essential steps in this process.

4.3 Robustness tests

To ensure the reliability of the baseline findings, this study conducts a series of robustness checks. First, to verify the robustness of the green economic efficiency measurement, this study recalculates green economic efficiency (*GEE1*) using the Directional Distance Function (DDF) and the Global Malmquist–Luenberger Index (GML) under the assumption of variable returns to scale (VRS). The inputs include the total number of employed persons, capital stock estimated using the perpetual inventory method with 2003 as the base year, and electricity consumption. Desired output is represented by real GDP at constant prices, while undesirable outputs are measured by the three types of industrial pollution. Second, to test the sensitivity of the results to the construction of the core independent variable, this study introduces an alternative indicator, defined as the ratio of land transfer revenue to local government comprehensive fiscal capacity (*LFD1*).

Comprehensive fiscal capacity includes local revenue, tax rebates, transfer payments, government fund budget revenue, and part of the extra-budgetary income, thus providing a more comprehensive reflection of the local fiscal situation. Third, this study addresses the potential influence of anomalous events. In 2015, the National Audit Office launched a nationwide “land audit storm,” conducting extensive investigations into land transfer violations. This event may have led to structural anomalies in land transfer revenue and usage behavior. To ensure the robustness of the results, this study excludes the 2015 data and re-estimates the model. Finally, to account for potential omitted variable bias, the model is re-estimated after controlling for three additional variables: green patent applications (*GPATENT*), infrastructure quality (*INFRA*), and urban river density (*RIVER*), to account for the influence of innovation capacity, physical infrastructure, and natural geographic factors.

The regression results from these tests confirm the stability of the baseline conclusions. As shown in Column (1) of Table 6, when using the alternative *GEE1* measure, the coefficient of *LFD* is −0.024, which is statistically significant at the 10% level. This indicates that the research conclusions do not depend on a specific efficiency measurement method; although the SBM and DDF-GML models differ in structure, the empirical findings consistently show that land finance dependence

TABLE 6 Robustness regression tests.

Variables	(1)	(2)	(3)	(4)
	GEE1	GEE	GEE	GEE
LFD	−0.0235*		−0.0427**	−0.0452***
	(0.014)		(0.019)	(0.017)
LFD1		−0.0054***		
		(0.002)		
PGDP	0.1110***	0.0882***	0.0912***	0.0794***
	(0.009)	(0.011)	(0.013)	(0.012)
FIR	−0.0022	−0.0239***	−0.0267***	−0.0298***
	(0.004)	(0.004)	(0.005)	(0.004)
IU	0.0298***	0.0211***	0.0251***	0.0197**
	(0.006)	(0.008)	(0.008)	(0.008)
FDI	−4.5964***	−6.5435***	−6.7790***	−6.6522***
	(1.363)	(1.667)	(1.842)	(1.697)
URBAN	−0.0113	−0.0551***	−0.0533**	−0.0553***
	(0.017)	(0.021)	(0.022)	(0.021)
FISDEC	−0.0810***	−0.0149	0.0152	−0.0291
	(0.031)	(0.038)	(0.044)	(0.039)
GPATENT				0.0000***
				(0.000)
INFRA				−0.0406***
				(0.009)
RIVER				0.1496***
				(0.033)
Constant	−0.8551***	−0.4839***	−0.5209***	−0.3730***
	(0.091)	(0.112)	(0.127)	(0.115)
Observations	2,199	2,199	1,925	2,121
Adjusted R-squared	0.466	0.422	0.414	0.442
Year FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES

Parentheses contain heteroscedasticity robust standard errors. *, **, and *** represent significance levels at 10%, 5%, and 1% respectively.

significantly suppresses green economic efficiency under both methods. The results for the alternative land finance dependence indicator are presented in Column (2) of Table 6. The coefficient of *LFD1* is −0.005, statistically significant at the 5% level and consistent with the baseline regression. This suggests that even with a broader definition of land finance dependence, the conclusion that a higher reliance on land revenue corresponds to lower green economic efficiency remains valid. When the 2015 data is excluded, the results, presented in Column (3) of Table 6, show that the coefficient of *LFD* is −0.043, statistically significant at the 5% level. This indicates that the negative impact

of land finance dependence on green economic efficiency is a persistent phenomenon and not driven by an anomalous event in a specific year. In Column (4) of Table 6, after including additional controls for innovation, infrastructure, and geography, the coefficient of land finance dependence remains significantly negative. This demonstrates that the negative relationship is not a mere artifact of a city’s innovation level, infrastructure quality, or natural geography. The stability of the coefficient under this expanded set of controls confirms the robustness of the findings and provides stronger evidence for a direct link.

TABLE 7 Heterogeneity regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Resource-based	Non-resource-based	Key city	Non-key city	Urban agglomeration	Non-urban agglomeration
<i>LFD</i>	−0.0345	−0.0671***	−0.0701***	−0.0575*	−0.1014***	−0.0048
	(0.038)	(0.023)	(0.023)	(0.030)	(0.025)	(0.028)
<i>PGDP</i>	−0.0300	0.1063***	0.1419***	−0.0241	0.0875***	0.0524***
	(0.024)	(0.016)	(0.019)	(0.019)	(0.021)	(0.018)
<i>FIR</i>	−0.0754***	−0.0208***	−0.0250***	−0.0728***	0.0176*	−0.0445***
	(0.011)	(0.006)	(0.007)	(0.009)	(0.010)	(0.006)
<i>IU</i>	−0.0036	0.0380***	0.0174	0.0195*	0.0021	0.0203**
	(0.013)	(0.011)	(0.013)	(0.011)	(0.022)	(0.009)
<i>FDI</i>	−3.0427	−9.1559***	13.5613***	−5.5239**	−14.6857***	−3.5665
	(3.032)	(2.410)	(2.500)	(2.591)	(2.649)	(2.506)
<i>URBAN</i>	−0.1176***	0.0489	−0.1102***	−0.0765**	0.1677***	−0.1184***
	(0.035)	(0.032)	(0.034)	(0.030)	(0.038)	(0.028)
<i>FISDEC</i>	0.2949***	−0.1248**	0.1955***	0.1890***	−0.0885	0.1342**
	(0.072)	(0.057)	(0.064)	(0.061)	(0.069)	(0.056)
Constant	0.8276***	−0.6719***	−1.1346***	0.7816***	−0.5534***	−0.0911
	(0.248)	(0.161)	(0.184)	(0.200)	(0.206)	(0.174)
Observations	770	1,141	769	1,142	622	1,289
Adjusted R-squared	0.422	0.452	0.568	0.410	0.470	0.433
Year FE	YES	YES	YES	YES	YES	YES
Province FE	YES	YES	YES	YES	YES	YES

Parentheses contain heteroscedasticity robust standard errors. *, **, and *** represent significance levels at 10%, 5%, and 1% respectively.

5 Heterogeneity analysis

Heterogeneity analysis is essential for uncovering how the impacts of land finance dependence on green economic efficiency vary across city types, providing insights into underlying mechanisms and informing targeted policy interventions. Drawing on resource dependence theory and fiscal decentralization frameworks, we theorize that structural differences in fiscal bases, environmental pressures, and competitive dynamics moderate these effects. We conduct subgroup regressions based on three dimensions: resource-based vs non-resource-based cities (per the National Plan for Sustainable Development of Resource-Based Cities, 2013–2020), key vs non-key environmental protection cities (per the National Environmental Protection “11th Five-Year Plan”), and urban agglomeration vs non-agglomeration cities (focusing on five major national clusters: Beijing–Tianjin–Hebei, Yangtze River Delta, Pearl River Delta, Central Yangtze, and Chengdu–Chongqing). Results are reported in Table 7.

Resource-based cities, endowed with natural resources, often benefit from alternative fiscal revenues like resource taxes and

central transfers, theoretically buffering against heavy land finance dependence and allowing more balanced environmental investments despite inherent pollution pressures from extractive industries. In contrast, non-resource-based cities lack such buffers, making them more vulnerable to LFD-driven fiscal shortfalls that crowd out green initiatives and exacerbate resource misallocation under decentralization incentives. This aligns with the “resource curse” literature, which argues that the economic impact of a dominant revenue source is conditional on institutional quality; in contexts with weaker governance or intense rent-seeking pressures, such dependence can distort incentives and crowd out investment in more sustainable, productive sectors (Mehlum et al., 2006). The results in Columns (1) and (2) support this: the *LFD* coefficient is insignificant in resource-based cities but significantly negative in non-resource-based ones. Mechanistically, this links to weakened regulation in non-resource cities, where land finance dependence intensifies a “race to the bottom” to attract non-extractive investments, impairing green economic efficiency.

Key environmental protection cities are designated with stricter mandates and enhanced central support, theoretically fostering stronger regulatory frameworks and green awareness to mitigate

harms to land finance dependence. Counterintuitively, however, fiscal pressures from land finance dependence may amplify negative effects here: heightened environmental standards increase compliance costs, but LFD-induced revenue volatility forces trade-offs, diluting enforcement and crowding out investments, as central mandates clash with local fiscal imperatives. This reflects the inherent tensions in fiscal federalism, where local governments are caught between central mandates and local economic pressures. The intense competition for capital can discipline governments to adopt pro-business policies, sometimes at the expense of regulatory stringency (Cai and Treisman, 2005). Columns (3) and (4) show the coefficients of *LFD* is significantly negative in key cities while milder and less significant in non-key ones. This mechanism ties to debt escalation, where land finance dependence in mandated cities leads to leveraged borrowing for compliance, paradoxically undermining long-term green economic efficiency.

Urban agglomerations feature intense intercity competition, regional integration, and infrastructure demands, theorized to exacerbate the effects of land finance dependence via amplified “growth-for-competition” dilemmas. The high density and close proximity within urban agglomerations intensify inter-jurisdictional competition (Duranton and Diego, 2020), pressuring local governments to use land finance as a tool for rapid, large-scale development to attract mobile capital and talent. Clustered governments face heightened pressures to leverage land for coordinated development, often at ecological costs, while non-agglomeration cities operate with less rivalry and more localized strategies. Columns (5) and (6) confirm this: *LFD*’s coefficient is significantly negative in agglomeration cities while it is insignificant in non-agglomeration ones. Mechanistically, this reflects regulatory weakening and debt risks in agglomerations, where competition drives relaxed standards and collective borrowing, intensifying environmental inefficiencies.

6 Influence mechanisms

6.1 The intensity of environmental regulation

Theoretically, the fiscal structure of local governments not only determines the direction of fiscal resource allocation but also shapes their policy implementation preferences. When local governments heavily rely on land transfer revenues, they tend to prioritize land supply and infrastructure investment to attract investment and boost GDP growth. This, in turn, reduces their fiscal attention and political commitment to environmental protection and ecological governance. Therefore, the intensity of environmental regulation may serve as a key mediating variable through which land finance dependence affects green economic efficiency. This paper selects “environmental regulation intensity” as one of the transmission channels in the mechanism analysis. By examining whether land finance dependence significantly influences local governments’ willingness and capacity to engage in environmental governance, the study further explores how it constrains green development.

Columns (1) and (2) of Table 8 present the regression results for the environmental regulation mechanism. Drawing on the text-

based policy indices constructed by Baker et al. (2016), Caldara and Iacoviello (2022), and Li et al. (2024), we calculated the government attention index on environmental issues; this rigorous measurement method has been applied to the analysis of a broader range of government reports. Specifically, in Column (1), the dependent variable is the frequency and proportion of environmental terms appearing in local government work reports (*DEC*), which serves as a proxy for government environmental governance following (Chen et al., 2018). Government work reports are official, programmatic policy documents that outline administrative agendas and implement decisions of legislative bodies. As such, the frequency and relative weight of environmental language in these reports offer a comprehensive reflection of the government’s regulatory emphasis and environmental policy stance. The regression result shows that the coefficient of land finance dependence is -5.8328 , statistically significant at the 5% level, indicating that higher land finance dependence is associated with fewer environmental expressions in formal policy documents—reflecting a reduced emphasis on environmental concerns.

Column (2) uses the share of energy conservation and environmental protection expenditure in total fiscal expenditure (*PEE*) as the dependent variable. The coefficient of *LFD* is -0.0040 , statistically significant at the 10% level, suggesting that as local governments become more dependent on land finance, they allocate a smaller proportion of their fiscal resources to environmental protection.

These findings demonstrate that land finance dependence indirectly affects urban green economic efficiency by weakening the intensity of environmental regulation. Both mechanism variables are significantly and negatively impacted by land finance dependence, providing further empirical support for the theory of negative externalities of land finance. Hypothesis 2 has been verified. This mechanism highlights that to effectively enhance green economic efficiency, it is necessary to reduce reliance on land-based revenues at the source, strengthen the political incentives and fiscal support for environmental policy, and enhance the capacity and willingness of local governments to engage in effective environmental governance.

6.2 Local government debt risk

In addition to the intensity of environmental regulation, local government debt risk may also serve as a crucial mechanism through which land finance dependence affects green economic efficiency. Under the current fiscal system, local governments face an imbalance between revenue and expenditure responsibilities, often resorting to borrowing to fill fiscal gaps. Especially as land transfer revenues become a key source of fiscal income, governments may engage in large-scale borrowing by leveraging land assets or anticipated revenues to sustain intensive infrastructure investment and urban expansion, thereby escalating debt risk. More critically, excessive reliance on land finance and implicit debt instruments reinforces short-term growth preferences, crowding out fiscal support for environmental governance and green industries. Therefore, if land finance dependence significantly increases government debt risk, it provides indirect evidence that its negative effect on green economic efficiency may operate through a “leveraged expansion” pathway.

TABLE 8 Mechanism regression tests.

Variables	(1)	(2)	(3)	(4)
	Environmental regulation		Government debt risk	
	<i>DEC</i>	<i>PEE</i>	<i>LGB</i>	<i>UIB</i>
<i>LFD</i>	−5.8328**	−0.0040*	0.5333***	1.0265***
	(2.306)	(0.002)	(0.069)	(0.119)
<i>PGDP</i>	3.7326**	0.0024*	0.0549	0.4374***
	(1.578)	(0.001)	(0.048)	(0.082)
<i>FIR</i>	−0.6885	0.0006	0.1667***	0.3592***
	(0.585)	(0.001)	(0.017)	(0.031)
<i>IU</i>	3.5736***	−0.0005	0.1245***	0.0181
	(1.042)	(0.001)	(0.031)	(0.056)
<i>FDI</i>	436.5522*	−0.1288	31.2347***	56.1805***
	(225.785)	(0.204)	(6.865)	(11.686)
<i>URBAN</i>	2.3857	0.0085***	−0.2875***	−0.4833***
	(2.756)	(0.002)	(0.082)	(0.144)
<i>FISDEC</i>	−16.4313***	−0.0024	1.2999***	1.3141***
	(5.334)	(0.005)	(0.162)	(0.278)
Constant	14.4557	0.0016	13.4155***	8.4011***
	(15.562)	(0.014)	(0.469)	(0.811)
Observations	1,925	1,925	1,844	1,876
Adjusted R-squared	0.224	0.250	0.703	0.717
Year FE	YES	YES	YES	YES
Province FE	YES	YES	YES	YES

Parentheses contain heteroscedasticity robust standard errors. *, **, and *** represent significance levels at 10%, 5%, and 1% respectively. For the convenience of reporting, we have implemented order of magnitude control.

Columns (3) and (4) of Table 8 present the regression results for the debt risk mechanism. In Column (3), where the dependent variable is the outstanding balance of local government debt (*LGB*), the coefficient of land finance dependence is significantly positive at the 1% level, indicating that greater dependence on land finance is associated with higher government debt levels. Column (4) uses the share of urban investment bonds (*UIB*) issued by local government financing platforms as the dependent variable. The *LFD* coefficient is again significantly positive at the 1% level, suggesting that land finance dependence significantly promotes the expansion of urban investment bonds, further reflecting the accumulation of government debt risk.

These results indicate that land finance dependence suppresses green economic efficiency indirectly by increasing the debt burden of local governments. Hypothesis 3 has been verified. The volatility of land revenue, combined with aggressive fiscal behavior, encourages local governments to maintain urban expansion through a land–debt–investment cycle. This not only exacerbates fiscal unsustainability but also undermines strategic investment in green transformation. Faced with mounting debt pressure, local governments are more likely to prioritize projects with short-term

fiscal returns over those with long-term environmental benefits. This mechanism confirms that the “leveraged expansion logic” inherent in land finance dependence is a critical cause of inefficient and unsustainable green development. Therefore, curbing the expansion of local government debt and regulating land finance behavior are institutional prerequisites for improving green economic efficiency.

7 Conclusions and implications

This paper empirically investigates the impact of land finance dependence on green economic efficiency. The results indicate that a high dependence on land finance significantly suppresses green economic efficiency. Using the super-efficiency SBM model to measure green economic efficiency and conducting heterogeneity tests to examine differences across various city types, the study finds that the negative impact of land finance dependence is more pronounced in non-resource-based cities, key environmental protection cities, and urban agglomerations. This supports the theory of negative externalities of land finance, which suggests that local governments, in pursuit of short-term economic

growth and fiscal revenue, often overlook environmental protection and green development, leading to a decline in green economic efficiency. The study also explores the mediating mechanisms of environmental regulation intensity and local government debt risk, revealing the pathways through which land finance dependence affects green economic efficiency and highlighting the importance of fiscal and land policy reforms.

These findings carry significant implications for the literature on environmental economics and public finance. By demonstrating how a specific fiscal institution, land finance dependence, induces environmental inefficiency, this study contributes a crucial institutional perspective to the resource misallocation literature. The results suggest that the growth-at-all-costs driven by fiscal pressures, systematically undermines the effectiveness of environmental governance. The identified mechanism of weakened environmental regulation challenges the universal applicability of the Porter Hypothesis, which posits that stringent regulation can foster innovation. Our findings indicate that in contexts of high fiscal stress, local governments may lack the political will or financial capacity to enforce such regulations, leading to environmental standards becoming more lenient rather than stricter. Similarly, the link between land finance and escalating local debt reveals a critical trade-off between short-term urban expansion and long-term sustainable development. This pressure on fiscal revenue growth crowds out necessary green investments, suggesting that achieving environmental goals is intrinsically linked to fiscal reform and the management of systemic financial risks. Therefore, the very mechanism designed to fund urbanization through land finance simultaneously erects barriers to a sustainable green transition.

While this study contributes to understanding land finance dependence's impact on green economic efficiency, limitations exist. First, panel data from prefecture-level cities may miss regional variations, especially in counties. Second, other fiscal sources like external inflows were not fully considered. Future research can expand by exploring dynamic relationships across city types, introducing variables like governance capacity and green innovation as moderators, and using natural experiments with longer data for robustness.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The datasets contained in the article are

from the publicly available documents of various departments and have been manually organized. We are willing to provide them when readers need them. Requests to access these datasets should be directed to CG, chen_fu@sjtu.edu.cn.

Author contributions

CG: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing.

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References

- Acemoglu, D., Akcigit, U., Alp, H., Bloom, N., and Kerr, W. (2018). Innovation, reallocation, and growth. *Am. Econ. Rev.* 108 (11), 3450–3491. doi:10.1257/aer.20130470
- Baker, S. R., Bloom, N., and Davis, S. J. (2016). Measuring economic policy uncertainty. *Q. J. Econ.* 131 (4), 1593–1636. doi:10.1093/qje/qjw024
- Brandt, L., Tombe, T., and Zhu, X. (2013). Factor market distortions across time, Space and sectors in China. *Rev. Econ. Dyn.* 16 (1), 39–58. doi:10.1016/j.red.2012.10.002
- Cai, H., and Treisman, D. (2005). Does competition for capital discipline governments? Decentralization, Globalization, and public policy. *Am. Econ. Rev.* 95 (3), 817–830. doi:10.1257/0002828054201314
- Cai, M., Fan, J., Ye, C., and Qi, Z. (2021). Government debt, land financing and distributive Justice in China. *Urban Stud.* 58 (11), 2329–2347. doi:10.1177/0042098020938523
- Caldara, D., and Iacoviello, M. (2022). Measuring Geopolitical risk. *Am. Econ. Rev.* 112 (4), 1–81. doi:10.17016/ifdp.2018.1222r1
- Chambers, R. G., Chung, Y., and Färe, R. (1996). Benefit and distance functions. *J. Econ. Theory* 70 (2), 407–419. doi:10.1006/jeth.1996.0096
- Chen, Z., Kahn, M. E., Liu, Yu, and Wang, Z. (2018). The consequences of Spatially Differentiated Water pollution regulation in China. *J. Environ. Econ. Manag.* 88, 468–485. doi:10.1016/j.jeeem.2018.01.010

- Chen, D., Li, Y., Hu, W., Lang, Y., Zhang, Y., and Chen, C. (2024). Uncovering the influence of land finance dependency on inter-city regional integration: an explanatory framework integrating time-nonlinear and spatial factors. *Land Use Policy* 144, 107207. doi:10.1016/j.landusepol.2024.107207
- Cheng, Y., Jia, S., and Meng, H. (2022). Fiscal policy choices of local governments in China: land finance or local government debt? *Int. Rev. Econ. & Finance* 80, 294–308. doi:10.1016/j.iref.2022.02.070
- Dechezleprêtre, A., and Sato, M. (2017). The impacts of environmental regulations on competitiveness. *Rev. Environ. Econ. Policy*. doi:10.1093/reep/rex013
- Duranton, G., and Diego, P. (2020). The economics of urban density. *J. Econ. Perspect.* 34 (3), 3–26. doi:10.1257/jep.34.3.3
- Färe, R., Grosskopf, S., Norris, M., and Zhang, Z. (1994). Productivity growth, technical progress, and efficiency change in Industrialized Countries. *Am. Econ. Rev.*, 66–83. Available online at: <http://www.jstor.org/stable/2117971>.
- Geng, X., and Qian, M. (2024). Understanding the local government debt in China. *Pacific-Basin Finance J.* 86, 102456. doi:10.1016/j.pacfin.2024.102456
- Gyourko, J., Shen, Y., Wu, J., and Zhang, R. (2022). Land finance in China: analysis and review. *China Econ. Rev.* 76:101868. doi:10.1016/j.chieco.2022.101868
- Jin, Yi, Gao, X., and Wang, M. (2021). The financing efficiency of Listed energy conservation and environmental protection firms: evidence and implications for green finance in China. *Energy Policy* 153, 112254. doi:10.1016/j.enpol.2021.112254
- Li, Q., Shan, H., Tang, Y., and Vincent, Y. (2024). Corporate Climate risk: Measurements and Responses. *Rev. Financial Stud.* 37 (6), 1778–1830. doi:10.1093/rfs/hhad094
- Mehlum, H., Moene, K., and Torvik, R. (2006). Institutions and the resource curse. *Econ. J.* 116 (508), 1–20. doi:10.1111/j.1468-0297.2006.01045.x
- Mo, J. (2018). Land financing and economic growth: evidence from Chinese counties. *China Econ. Rev.* 50, 218–239. doi:10.1016/j.chieco.2018.04.011
- Oh, D.-hyun (2010). A global Malmquist-luenberger productivity index. *J. Prod. Analysis* 34 (3), 183–197. doi:10.1007/s11123-010-0178-y
- Pan, J.-N., Huang, J.-T., and Chiang, T.-F. (2015). Empirical study of the local government deficit, land finance and real estate markets in China. *China Econ. Rev.* 32, 57–67. doi:10.1016/j.chieco.2014.11.003
- Porter, M. E., and Claas van der, L. (1995). Toward a new conception of the Environment-Competitiveness relationship. *J. Econ. Perspect.* 9 (4), 97–118. doi:10.1257/jep.9.4.97
- Qu, Xi, Xu, Z., Yu, J., and Zhu, J. (2023). Understanding local government debt in China: a regional competition perspective. *Regional Sci. Urban Econ.* 98, 103859. doi:10.1016/j.regsciurbeco.2022.103859
- Tao, R., Su, F., Liu, M., and Cao, G. (2010). Land leasing and local public finance in China's regional development: evidence from prefecture-level cities. *Urban Stud.* 47 (10), 2217–2236. doi:10.1177/0042098009357961
- Tone, K. (2001). A slacks-based measure of efficiency in data Envelopment analysis. *Eur. J. Operational Res.* 130 (3), 498–509. doi:10.1016/s0377-2217(99)00407-5
- Van der Kamp, D., Lorentzen, P., and Mattingly, D. (2017). Racing to the bottom or to the Top? Decentralization, revenue pressures, and governance reform in China. *World Dev.* 95, 164–176. doi:10.1016/j.worlddev.2017.02.021
- Wang D, Di, Ren, C., and Zhou, T. (2021). Understanding the impact of land finance on industrial structure change in China: insights from a spatial Econometric analysis. *Land Use Policy* 103, 105323. doi:10.1016/j.landusepol.2021.105323
- Wang, X., Zhang, C., and Zhang, Z. (2019). Pollution haven or Porter? The impact of environmental regulation on Location choices of pollution-intensive firms in China. *J. Environ. Manag.* 248, 109248. doi:10.1016/j.jenvman.2019.07.019
- Wang, L.-Ou, Wu, H., and Yu, H. (2020). How does China's land finance affect its carbon emissions? *Struct. Change Econ. Dyn.* 54, 267–281. doi:10.1016/j.strueco.2020.05.006
- Wang P, P., Shao, Z., Wang, J., and Wu, Q. (2021). The impact of land finance on urban land Use efficiency: a panel Threshold model for Chinese provinces. *Growth Change* 52 (1), 310–331. doi:10.1111/grow.12464
- Wilson, J. D., and Wildasin, D. E. (2004). Capital tax competition: Bane or Boon. *J. Public Econ.* 88 (6), 1065–1091. doi:10.1016/s0047-2727(03)00057-4
- Xu, N. (2019). What Gave Rise to China's land finance? *Land Use Policy* 87, 104015. doi:10.1016/j.landusepol.2019.05.034
- Zhang, N., and Choi, Y. (2013). Total-factor carbon emission performance of Fossil Fuel power Plants in China: a Metafrontier non-radial Malmquist index analysis. *Energy Econ.* 40, 549–559. doi:10.1016/j.eneco.2013.08.012
- Zhao, X., Zeng, B., Zhao, X., Zeng, S., and Jiang, S. (2024). Impact of green finance on green energy efficiency: a pathway to sustainable development in China. *J. Clean. Prod.* 450, 141943. doi:10.1016/j.jclepro.2024.141943
- Zheng, H., Wang, X., and Cao, S. (2014). The land finance model jeopardizes China's sustainable development. *Habitat Int.* 44, 130–136. doi:10.1016/j.habitatint.2014.05.008
- Zhou, M., Jiang, K., and Chen, Z. (2023). The side effects of local government debt: evidence from urban investment bonds and Corporate pollution in China. *J. Environ. Manag.* 344, 118739. doi:10.1016/j.jenvman.2023.118739
- Zhuge, L., Freeman, R. B., and Higgins, M. T. (2020). Regulation and innovation: examining Outcomes in Chinese pollution control policy areas. *Econ. Model.* 89, 19–31. doi:10.1016/j.econmod.2019.09.041