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Research on the Impact of Green Finance on Urban Economic Resilience

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Abstract: *Investigating green finance's impact on urban economic resilience is crucial for building a rational green financial system and boosting urban economic resilience. Using panel data of 287 Chinese prefecture-level cities from 2011 to 2021, this study quantifies urban economic resilience and green finance development, and employs a panel fixed-effects model to explore green finance's effect and mechanisms on urban economic resilience. The results show that green finance positively affects urban economic resilience, with regional heterogeneity. We suggest tailored green finance development, advancing urban industrial transformation, and leveraging green finance's positive impacts to foster urban economic resilience.*

Keywords: *Green Finance; Urban Economic Resilience; Industrial Upgrading; Regional Heterogeneity*

1. Introduction

In the international context, the contradictions in world politics and economy have intensified in recent years. As the basic social and economic entities, cities are confronted with mounting shocks and challenges. Alleviating the adverse impacts of such shocks and enhancing urban response capacity have thus become a crucial task. Against this backdrop, the concept of "economic resilience" has emerged, and the indicator of urban economic resilience has been adopted to measure the ability of urban economic entities to recover and adjust in the face of major external shocks. Enhancing urban economic resilience enables effective responses to internal and external risks and challenges, laying a solid foundation for long-term development.

To sum up, this paper takes 287 prefecture-level cities in China from 2011 to 2021 as the research objects, uses the entropy weight method to quantify the development level of urban green finance and economic resilience, explores the influence mechanism between them, and finally provides suggestions for enhancing urban economic resilience.

2. Literature Review

2.1. Urban Economic Resilience

Research on economic resilience mainly focuses on two aspects: one is the construction of specific indicators for quantifying economic resilience, and the other is the analysis of various factors influencing economic resilience.

For the first aspect, the measurement of economic resilience mostly focuses on regional economic resilience or is limited to urban areas in partial regions. There are two main methods for measuring economic resilience. (1) The core indicator method: the measurement process involves selecting a core indicator, and the changes of this indicator under shock and disturbance are used to represent economic resilience. Macroeconomic variables such as GDP and employment population are commonly adopted as core indicators. (2) The indicator system method: although foreign scholars have proposed incorporating short-term indicators related to business activities (Rose & Krausmann, 2013) and people-related indicators (Bristow & Healy, 2014) into the indicator system of economic resilience, there is no consensus on the selection of relevant indicators in this method [1,2]. The authors of this paper hold that weighting through multiple indicators is more comprehensive and stable than using a single core indicator, and thus the indicator system method is adopted for measurement in this study.

For the second aspect, the influencing factors of economic resilience cover multiple dimensions,

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mainly including regional development foundation, industrial structure layout, labor force conditions, financial support capacity and government management capacity. Brown and Greenbaum (2017) probed deeply into the internal relationship between industrial diversity and economic resilience in their research [3].

2.2. A Review of Domestic and Foreign Research

A review of the above literature reveals that the research system of economic resilience has taken initial shape. The measurement scope of economic resilience is basically based on urban agglomerations or regions, and the measurement methods adopt either the core indicator method or the indicator system method.

Research on green finance is relatively comprehensive, focusing on concepts, tools, institutional business strategies and other aspects. The influencing factors of green finance include the product design of financial institutions and government policy guidance, while the impact outcomes of green finance cover the credit risk of commercial banks, corporate investment and financing decisions, the level of industrial structure, carbon emissions and so on. Zhou et al. (2020) further verified the important role of green finance in reconciling the contradictions between economic development and environmental governance, providing strong support for achieving a win-win situation for the economy and the environment [4]. From the perspective of financial products and services, Lee Jung Wan (2020) argued that green finance can activate the traditional capital market and bring about environment-friendly investment returns [5]. This view emphasizes the positive role of green finance in the capital market and its promotion effect on environment-friendly investment. In addition, another perspective regards green finance as a financial system centered on sustainable development from a broader view. This perspective lays more emphasis on the "greening" of the economic system and holds that green finance is an important tool for achieving sustainable development. Desalegn and Tangl (2022) pointed out that against the backdrop of pursuing green growth, green finance plays a pivotal role in achieving the Sustainable Development Goals [6]. Simmie and Martin (2010) held that the concept of economic resilience is highly dependent on the imbalance of regional development, and Martin and Sunley (2015) subsequently pointed out that economic resilience is the "adaptive elasticity" demonstrated by the regional economy in terms of structure and function when facing huge shocks [7,8].

In summary, financial factors are an important part of the factors influencing economic resilience.

3. Data and Method

3.1. Sample and Data Source

This paper finally selects the data of 287 prefecture-level and above cities in China over the 11-year period from 2011 to 2021 as the research sample, excluding Turpan City, Sansha City, Danzhou City, autonomous prefectures and other regions with missing data.

3.2. Variable Description and Model Construction

Both the core explanatory variable (the development level of green finance) and the explained variable (the level of urban economic resilience) used in this paper are measured by the objective weighting method[9]. Drawing on the research of Lee Chi-Chuan and Lee Chien-Chiang (2022), this paper measures the level of green finance from seven dimensions: green credit, green bonds, green funds, green insurance, green investment, green support and carbon finance, and uses the entropy weight method to calculate the weights and the comprehensive values[10]. The same method is adopted to measure the level of urban economic resilience, which includes 3 secondary indicators and 9 tertiary indicators[11].

The entropy weight method is an objective weighting method. Assume that there are n samples and m indicators, X_j represents a certain indicator, x_{ij} is the original value of the j-th indicator of the i-th sample, y_{ij} is the standardized value of the j-th indicator of the i-th sample, p_{ij} is the proportion of the i-th sample in the j-th indicator, e_j is the entropy value of the j-th indicator X_j, w_j is the weight of the j-th indicator X_j, and $score_i$ is the comprehensive score of the i-th sample. The calculation steps are as follows:

(1) Standardize each indicator. If X_j is a positive indicator, then $y_{ij} = \frac{x_{ij} - \min(X_j)}{\max(X_j) - \min(X_j)}$; if X_j is a

ISSN 2616-5902 Vol. 8, Issue 7: 7-12, DOI: 10.25236/AJBM.2026.080702

negative indicator, then $y_{ij} = \frac{\max(X_j) - x_{ij}}{\max(X_j) - \min(X_j)}$.

(2) Calculate the indicator contribution degree p: $p_{ij} = \frac{y_{ij}}{\sum_{j=1}^{m} y_{ij}}$.

(3) Calculate the information entropy e: $e_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} p_{ij} \ln(p_{ij})$.

(4) Calculate the weight w: $w_j = \frac{1 - e_j}{m - \sum_{j=1}^{m} e_j}$.

(5) Calculate the comprehensive score: $score_i = \sum_{j=1}^{m} w_j \, y_{ij}$.

3.2.1. Control Variables

• Financial development level (Fin): measured by the ratio of the year-end balance of various loans of financial institutions to the regional gross domestic product (GDP).

• Environmental governance (Env): environmental governance can reduce pollutant emissions, promote the development of the environmental protection industry, and improve the stability of economic operation.

• Infrastructure (Inv): more complete infrastructure can accelerate economic exchanges between cities and surrounding areas and enhance the recovery capacity of cities.

• Economic density (Eco): measured by GDP per square kilometer.

• Population density (Pop): population density reflects the market scale to a certain extent, measured by the logarithm of population density.

3.2.2. Model Construction

To test the direct impact of green finance on urban economic resilience, the benchmark econometric model in this paper adopts the panel fixed effect model:

$$Resi_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_2 X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

In the formula, $Resi_{it}$ is the explained variable (urban economic resilience), GF_{it} is the core explanatory variable (green finance), X_{it} is the control variable, μ_i is the individual fixed effect, and ε_{it} is the random disturbance term. The subscripts i and t represent the city and the year respectively. When α_1 is positive and significant, Hypothesis H1 can be verified, that is, the development of green finance helps to improve the level of urban economic resilience.

4. Empirical Results

4.1. Descriptive Statistics and Correlation Analysis

The descriptive statistics of each variable are shown in Table 1. There are significant differences in the level of economic resilience and green finance development in China. Specifically, the highest score of economic resilience can reach 0.741, while the lowest is only 0.0106; at the same time, the maximum and minimum values of the green finance score are 0.883 and 0.00391 respectively. The results of the correlation analysis are shown in Table 2.

Table 1: Results of Descriptive Statistics

Variable	Sample Size	Mean	Standard Error	Minimum	Maximum
Resi	3,157	0.0762	0.0784	0.0106	0.741
GF	3,157	0.125	0.0699	0.00391	0.883
Fin	3,157	1.102	0.686	0.118	9.623
Env	3,157	40.12	5.402	2.790	61.58
Inv	3,157	5.887	7.042	0.211	73.04
Eco	3,157	0.337	0.814	0.00248	15.44
Pop	3,157	5.732	0.944	1.513	9.086
IS	3,157	43.06	10.53	10.10	83.80
IA	3,157	7.646	1.573	2.996	12.39
IRIEC1	2,870	80.02	14.21	23.96	100
IRIEC2	2,870	80.26	13.79	15.28	100

ISSN 2616-5902 Vol. 8, Issue 7: 7-12, DOI: 10.25236/AJBM.2026.080702

Table 2 Results of Correlation Analysis

	Resi	GF	Fin	Env	Inv	Eco	Pop
Resi	1						
GF	0.534***	1					
Fin	0.409***	0.165***	1				
Env	0.210***	0.055***	0.088***	1			
Inv	0.347***	0.045**	0.283***	0.242***	1		
Eco	0.653***	0.356***	0.204***	0.157***	0.412***	1	
Pop	0.417***	0.264***	0.032*	0.234***	0.081***	0.422***	1

4.2. Benchmark Regression

The results of the fixed effect regression of green finance on urban economic resilience are reported in Table 3.

Table 3: Results of Fixed Effect Regression

	(1)	(2)	(3)	(4)
GF	0.289***	0.0581***	0.111***	0.0388***
	(17.70)	(3.87)	(10.34)	(3.76)
Fin			0.00600***	-0.00244**
			(8.71)	(-3.28)
Env			0.000496***	-0.0000428
			(6.08)	(-0.54)
Inv			0.00231***	0.00106***
			(17.18)	(7.93)
Eco			0.0701***	0.0618***
			(56.49)	(51.92)
Pop			0.0104***	0.00765**
			(3.52)	(2.81)
Constant term	0.440***	0.530***	0.275***	0.388***
	(41.49)	(57.61)	(13.16)	(19.56)
City fixed effects	YES	YES	YES	YES
Time fixed effects	NO	YES	NO	YES
Sample size	3157	3157	3157	3157

*Note: **, ** and * indicate the significance levels of 1%, 5% and 10% respectively, with t-values in parentheses. The same applies below.*

4.3. Robustness Test

(1) Replacement of explanatory variables: the coupling coordination degree of urban financial development and green development is adopted to measure the level of green finance, and the measurement model is as follows:

$$GF_{it}=2\times\left[\frac{FI_{it}\times GR_{it}}{(FI_{it}+GR_{it})^2}\right]^{\frac{1}{2}}\times(0.5FI_{it}+0.5GR_{it}) \quad (2)$$

In the formula, FI_{it} represents the financial development level of city i in year t, measured by the ratio of the year-end balance of loans of urban financial institutions to the gross national product; GR_{it} represents the green development level of city i in year t, measured by the industrial sulfur dioxide emissions per unit of GDP of the city. The regression results are shown in Column (2) of Table 4. The regression coefficients of green finance on urban economic resilience are significantly positive in both columns.

Table 4: Robustness Test - Results of Replacing Explanatory Variables

	(1)	(2)
GF1	0.00358***	
	(8.65)	
GF2		0.0286***
		(4.96)
Fin	0.00615***	0.00323**
	(8.87)	(3.03)
Env	0.000501***	0.000541***

ISSN 2616-5902 Vol. 8, Issue 7: 7-12, DOI: 10.25236/AJBM.2026.080702

	(6.11)	(6.55)
Inv	0.00233***	0.00242***
	(17.25)	(17.84)
Eco	0.0706***	0.0714***
	(56.65)	(57.16)
Pop	0.0103***	0.0116***
	(3.48)	(3.87)
Constant term	0.305***	0.298***
	(14.78)	(14.07)
Sample size	3157	3157

4.4. Heterogeneity Analysis

In this paper, 287 prefecture-level cities are divided according to the classification criteria established by the National Bureau of Statistics in 2011. Cities are classified by different regions and regressed respectively, and the regression results are shown in Table 5.

The regression coefficients of the eastern and western regions are significantly positive at the 1% level, and the regression coefficient of the central region is significantly positive at the 5% level. Notably, the coefficient of the eastern region is the highest among the four regions and higher than the benchmark regression results, indicating that the promoting effect of green finance on urban economic resilience in the eastern region is stronger than that in other regions. In contrast, the promoting effect of green finance on urban economic resilience is not significant in the northeastern region.

Table 5 Results of Heterogeneity Regression

	(1)	(2)	(3)	(4)
	Eastern Region	Central Region	Western Region	Northeastern Region
GF	0.116***	0.0434**	0.0993***	0.0107
	(5.14)	(3.22)	(6.85)	(1.18)
Fin	0.0150***	0.00465***	0.00305***	0.00354***
	(6.60)	(5.86)	(3.89)	(7.38)
Env	0.000289	0.000264**	0.000252**	-0.00000181
	(1.19)	(2.95)	(2.87)	(-0.03)
Inv	0.00263***	0.00252***	0.000490***	0.000118
	(8.95)	(7.77)	(3.54)	(0.75)
Eco	0.0608***	0.167***	0.274***	0.173***
	(32.83)	(41.09)	(35.14)	(14.51)
Pop	0.0183**	-0.00223	0.000843	-0.0136***
	(2.83)	(-0.44)	(0.21)	(-6.78)
Constant term	-0.117**	0.0117	-0.00446	0.0965***
	(-2.85)	(0.38)	(-0.21)	(9.23)
Sample size	946	880	957	374

5. Conclusions

Based on the panel data of 287 cities in China from 2011 to 2021, this paper constructs an indicator system to evaluate the level of urban economic resilience and green finance development, and uses the panel fixed effect model to empirically test the effect and influence mechanism of green finance on improving urban economic resilience, drawing the following conclusions.

First, through a series of rigorous robustness tests, this paper still finds that green finance has a significant positive driving effect on urban economic resilience. This means that when urban economic entities face external shocks, cities with a higher development level of green finance can exhibit stronger abilities of resistance, adaptation and transformation.

Second, the impact of green finance on urban economic resilience is heterogeneous across different regions, with the strongest promoting effect in the eastern region. It is speculated that the possible reason is that the development process of green finance in the eastern region is faster, and the green finance system is more complete and mature than that in other regions, thus the effect of improving economic resilience is more prominent.

Third, green finance can promote urban economic resilience through upgrading the industrial

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structure, enhancing urban innovation capacity and improving regional innovation and entrepreneurship capacity.

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