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Impact of Digital Inclusive Finance on Urban Economy Resilience: Evidence from China's Inclusive Finance Development Demonstration Zone

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Abstract: *This paper adopts the panel data of 25 cities in different regions of China, and uses the dual machine learning method to build the random forest regression model analysis index, and compare it in the two dimensions of space and time to verify the impact of digital inclusive finance on the resilience of urban economy. The study found that the implementation of financial inclusion policy has a significant causal relationship with the urban resilience index, which has a positive effect on it. This paper describes the effect of urban digital economy development on the resilience of urban economy. Through the causal analysis method of dual machine learning, the relationship between the development of digital economy and improving economic resilience is analyzed. Provide new ideas for the existing scientific research.*

Keywords: *Digital Inclusive Finance; economic resilience; double machine learning; quasi-natural experiment*

1. Research background

Economic resilience is an important ability for a country or region to effectively resist, adapt to and continuously develop in the face of external shocks and risks. At present, the world is in a turbulent period, and a series of global events have brought great challenges to the economies of all countries. The Central Economic Work Conference pointed out that Chinas economy is facing multiple pressures, such as demand contraction, supply shocks and weakening expectations. Against this backdrop, improving economic resilience has become a top priority. Chinas leader has repeatedly stressed that "Chinas economy is resilient" because China has long adhered to the Marxist concept of development, paid attention to all-round human development, and continuously enhanced individual ability to withstand shocks and entrepreneurs innovation and development, so as to provide lasting impetus for economic growth. From a historical perspective, China has experienced various shocks and challenges since reform and opening up. By constantly summarizing successful experiences and drawing lessons from failures, China has enhanced its political system, social cohesion and technological innovation capacity, and enhanced its economic resilience. Digital inclusive finance, as a hot topic to enhance the resilience of the urban economy, has attracted much attention. Through the application of digital technology, inclusive financial services can better cover all levels of the city, improve the popularity and convenience of financial services, so as to enhance the adaptability and risk resistance of the urban economy. Therefore, Digital Inclusive Finance is considered as one of the important means to enhance the resilience of the urban economy. In the current wave of globalization and digitalization, all countries are faced with common challenges, and enhancing economic resilience has become the common mission of the international community. Only by constantly strengthening economic restructuring, promoting innovative development, and improving the quality and intelligence of the people, can we enhance the resilience of the economy, respond to external shocks, and achieve sustainable economic development.

2. Literature review

At present, the academic study of urban economic toughness mainly focus on different spatial and temporal dimensions and influencing factors, for example, Ye Wenxian [1] research using the deviation-share analysis and geographic detector model, to explore the Yellow River basin 34 regional and above city economic toughness of time and space evolution characteristics and influencing factors. The results show that the overall economic resilience of these cities is weak, showing obvious spatial differentiation, and showing the agglomeration effect of "high-high" and "low-low". The direction of economic

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resilience is gradually weakened, and the centripetal force changes are mainly in the southeast and northwest regions. The economic resilience development of the Yellow River Basin has gone through different stages, from the joint promotion of structural quality of the tertiary industry and industrial competitiveness to the structural quality of the secondary and tertiary industries, to the joint promotion of structural quality of the primary and secondary industries and industrial competitiveness. The dominant influencing factors are per capita fixed asset investment and per capita total import and export volume. In 2022, the interaction between per capita fiscal budget revenue and per capita fixed asset investment in 2022 will have the greatest impact on economic resilience. This study provides an in-depth analysis of the spatial and temporal evolution characteristics of urban economic resilience in the Yellow River basin, providing an important reference for regional economic development, but other potential influencing factors and the evolution mechanisms of economic resilience should be further explored to improve the comprehensiveness and depth of the research;In a study conducted by Liu Yi, Ji Jiehan, Zhang Yifan, and Yang Yu[2] in a large bay area of Guangdong, exports, industrial production, unemployment, total retail sales, and GDP were selected as five economic indicators. They used Martin and others' method to measure regional economic resilience multidimensionally and, combined with economic geography theory perspective, explained the formation of internal regional differences. Studies show that economic resilience is difficult to determine in a single dimension, and multi-dimensional indicators reveal significant differences. Among cities within the Greater Bay Area, differences in economic resilience are closely related to how the industrial economic structure and the global production network are embedded, rather than location and GDP size. The difference in economic resilience of Bay Area cities can be preliminarily explained through strategic coupling. Shenzhen performs the best with independent coupling, followed by Foshan and Guangzhou. Hong Kong,China, and Macao,China, are embedded in global financial and hotel networks, so their economic resilience is relatively poor. Research highlights the multifaceted nature of regional economic resilience, noting that reliance on a single GDP indicator is overly simplistic and tends to overlook the diverse impacts of economic shocks. This finding has important theoretical implications for the accurate description of the regional evolution. The literature details the structure, spatial and temporal evolution and influencing factors of economic resilience of cities or urban agglomerations in different regions of China, but does not mention specific methods to improve urban economic resilience. Despite the vital importance of economic development, the impact of uncertainty on the economy remains unpredictable. In this case, economic resilience is particularly important, which is not only a shield to meet the external shocks, but also a catalyst to promote urban economic construction. So improving economic resilience is the key. This paper intends to use the panel data of cities in different regions of China, use dual machine learning methods to analyze the indicators, compare in the spatial and temporal dimensions, establish a regression model and verify the positive work of digital inclusive finance on the resilience of urban economy

3. Research hypothesis

Digital Inclusive Finance has brought a positive effect on the resilience of urban economies

4. Theoretical analysis

Digital inclusive finance plays an important role in the urban economy, and its influence is multidimensional and far-reaching. By enhancing financial inclusion, digital inclusive finance enables more people to integrate into the financial system and enhance economic participation; meanwhile, improve risk management capacity to provide more financial options for urban residents and enterprises and reduce economic risks. In addition, digital inclusive finance also promotes fintech innovation, improves the competitiveness of the financial market, and stimulates the urban economic vitality and innovation capacity. Finally, the promotion of digital inclusive finance promotes economic growth, injects vitality into the urban economy, enhances the resilience of the urban economy, improves the competitiveness of the city on the global economic stage, and makes positive contributions to the sustainable development of the city. Therefore, the hypothesis is that Digital Inclusive Finance has brought a positive effect on the resilience of urban economies.

5. Index system construction

Learn the index selection of Lu Yuan, Wang Han and Wang Yang[3] to construct the index system of this paper.

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Table 1: Indicator system

Level 1 indicators	Secondary indicators	Level 3 indicators	Indicator attributes	Indicator weight
City toughness	Resistance and resilience	Per capita GDP	+	5.31%
		Registered urban unemployment rate	-	1.62%
		ratio of dependence on foreign trade	-	0.58%
		Dependency of foreign capital	-	0.40%
		Regional GDP growth rate	+	0.88%
		Balance of savings of urban and rural residents	+	6.25%
		Per capita disposable income (RMB)	+	3.69%
		Per capita expenditure on social security	+	13.46%
	Adaptation and regulation	Total retail sales of social consumer goods	+	7.33%
		fixed investments	+	9.56%
		Fiscal self-sufficiency rate	+	2.82%
		financial structure	+	1.95%
		Number of beds in health institutions per capita	+	1.12%
	Innovation and transformation	Financial expenditure on education (ten thousand yuan)	+	5.95%
		Expenditure on science and technology	+	19.65%
		Patent authorization	+	13.03%
		The proportion of the added value of the tertiary industry	+	5.16%
		Urbanization rate (urbanization rate of permanent residents)	+	1.23%

The final indicator system was constructed as shown in Table 1.

In the study of urban economic resilience, scholars adopt a variety of single index measures. For example, Ji Shengbao, Wei Shanshan and Wang Dingxuan[4] used the spatial geographical model to study the impact of foreign direct investment on the resilience of Chinese cities. Liu Xiaoxing[5] and others also constructed a systematic risk absorption intensity index to measure urban resilience based on other literature. Scholars use the index system method to assess the resilience of the urban economy, considering comprehensiveness and precision. This method combines multiple indicators to describe the comprehensive performance of urban economy and improve the measurement accuracy. Data standardization and weight allocation reduce the influence of subjective factors to ensure the accuracy and comparability of data analysis.

The calculation results are shown in Table 2. From the time dimension, the national 25 digital pratt & whitney amount development demonstration area city economic toughness is not obvious, in 2019-2024, the city economic average toughness reached 0.285, and 2019 to 2021 urban toughness significantly lower than 2022 to 2024, the new crown outbreak widely spread to the city economy and digital pratt & whitney amount policy in cities are better implemented. Combined with the forecast values of the government financial reports in 2024, the average resilience of urban economy in 2024 reached 3.2, a significant jump, and the resilience of urban economy is improving. From a spatial perspective, Ningbo City exhibits strong economic resilience with a six-year mean of 0.927 and a minimum of 0.787. Qingdao ranks second in economic resilience, with a mean value of 0.845 and a minimum of 0.750, the lowest value in nearly six years in 2020. All years show values over 0.7, indicating a more resilient urban economy. The remaining 23 cities all scored below 0.5 or near 0.5. The average economic resilience of Jinhua, Wuhu, Zhangzhou, Nanning, and Xiangyang falls between 0.3 and 0.5. Among them, the average economic resilience of Fengtai, Xingtai, and Changzhi over the past six years ranges from 0.1 to 0.3, suggesting a low overall ability to resist risk.

The economic resilience level of cities varies significantly among different provinces and regions. Take Ningbo as an example, the economic resilience of its city is increasing, with the overall level reaching 0.927. In 2023, Ningbo will accelerate the adjustment and transformation and upgrading, and the expenditure on science and technology will reach 18.216 billion yuan, the fiscal expenditure on science and technology will increase by 16.6%, the investment in high-tech industry by 26.3%, and the investment in R & D expenditure above the designated level will increase by 28.1%. These inputs accelerated the transformation of innovation achievements. The value of new industrial products above

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the designated level increased by 26.3%, and the value of new products reached 34.3%. Financial regulatory authorities help the local economic transformation and upgrading through the strategy of "strong supervision" and "promoting development". Qingdao has implemented the innovation-driven development strategy and built the "Qingdao Science and Technology Innovation Corridor", significantly improving the resilience of the citys economy. Other cities have also increased to varying degrees, but the urban economic resilience of Urumqi, Liaocheng and Dehong Prefecture has been reduced, and the stability of economic development in these areas needs to be improved.

Table 2: Economic resilience level of demonstration zones

prefectural and municipal	2019	2020	2021	2022	2023	2024	mean
FengTai District	0.261	0.264	0.297	0.272	0.314	0.314	0.287
Xingtai	0.168	0.185	0.177	0.193	0.185	0.195	0.1834
Changzhi City	0.159	0.164	0.191	0.210	0.210	0.219	0.192
Hohehot Municipality	0.205	0.209	0.227	0.230	0.252	0.258	0.230
Fuxin City	0.094	0.086	0.095	0.098	0.104	0.117	0.099
Mudanjiang City	0.142	0.149	0.160	0.166	0.168	0.174	0.160
Jinhua	0.453	0.464	0.494	0.504	0.546	0.586	0.508
Ningbo City	0.787	0.807	0.896	0.963	1.030	1.079	0.927
Wuhu City	0.340	0.366	0.442	0.450	0.476	0.499	0.429
Zhangzhou City	0.293	0.277	0.295	0.365	0.351	0.362	0.324
Pingxiang City	0.144	0.144	0.203	0.163	0.170	0.179	0.167
Liaocheng	0.216	0.182	0.209	0.214	0.228	0.225	0.212
Qingdao City	0.755	0.750	0.840	0.855	0.911	0.959	0.845
Xinxiang City	0.209	0.218	0.239	0.255	0.257	0.267	0.241
Xiangyang city	0.332	0.296	0.346	0.363	0.377	0.397	0.352
Loudi city	0.135	0.151	0.151	0.165	0.176	0.180	0.160
Jiangmen	0.258	0.268	0.262	0.265	0.280	0.282	0.269
Nanning	0.357	0.356	0.390	0.385	0.389	0.392	0.378
seaport	0.191	0.194	0.228	0.222	0.228	0.230	0.216
Haibei	0.077	0.079	0.080	0.080	0.097	0.101	0.086
Dehong prefecture	0.102	0.097	0.085	0.089	0.091	0.093	0.093
Ürümqi City	0.284	0.253	0.279	0.251	0.278	0.283	0.271
Zunyi City	0.197	0.211	0.226	0.219	0.240	0.248	0.224
Qamdo city	0.068	0.073	0.083	0.091	0.101	0.107	0.087
Yanan City	0.149	0.158	0.200	0.221	0.258	0.272	0.210
mean	0.255	0.256	0.28	0.292	0.309	0.320	0.285

6. Selection of variables

Table 3: Variable Description Statistical Table

Variable	Obs	Mean	Std. Dev.	Min	Max
Urban economic resilience	150	0.285952	0.208766	0.067862	1.079034
population density	150	0.646868	1.261521	0.006917	6.898693
Government intervention	150	0.265955	0.30893	0.080307	2.611583
Industrial structure	150	1.643135	0.959177	0.431077	4.87312
GDP is taken as the natural logarithm	150	26.139254	1.143682	22.939203	28.181354
The per capita volume of road freight is taken as thenatural logarithm	131	3.159240	0.556472	1.47083	4.863547

6.1. Outcome variable

Urban economic resilience index, and the index calculation method refers to the index system method.

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6.2. Strategic variable

The development of digital inclusive finance policies.

6.3. Covariates

In order to eliminate the influence of city size in different periods, this paper selects population density, government intervention, industrial structure, economic development level, product flow and infrastructure construction degree as covariates, and uses machine learning models to fit the outcome variates and strategy variables by machine learning.

From Table 3, it can be seen that: the mean value of the urban economic resilience index of the outcome variable is 0.28, the minimum value is 0.07, and the maximum value is 1.08, indicating the large gap of economic resilience between cities. The mean value of population density in the covariates was 0.64, the minimum value was 0.01, and the maximum value was 6.89, indicating that the population density of different cities is different, some cities are densely populated, some cities have sparse population, and a large economic stability gap between different cities. The mean value of government intervention was 0.26, the variance was only 0.3, the minimum was 0.08 and the maximum was 2.61, indicating the high similarity of government intervention in the sample cities and less influence of government intervention on the results. The mean value of the industrial structure is 26.14, the variance is 0.95, the minimum value is 22.94, and the maximum value is 28.18, indicating that the industrial structure gap between different cities is large, and may have a greater impact on the urban economic resilience index. The average level of economic development is 26.13, the minimum value is 22.94, and the maximum value is 28.18. It can be seen that the development level of different cities is different, and the corresponding economic stability gap is also relatively large. The average natural logarithm of the per capita road freight volume is 3.16, the minimum value is 1.47, and the maximum value is 4.86, indicating that the different highway development between different cities, which also confirms that the above economic stability gap is large.

7. Data source

Through a series of official websites such as various government portals, Sina Weibo, Sohu, and Mark Data Network, we selected 25 cities in China from 2019 to 2024 to retrieve the index data we needed. Build on these data for analysis, eventually forming a panel of data.

Model formula: This paper uses dual machine learning (Double Machine Learning) to process the data and make the following linear model

$$Y = T\theta_0 + g(X) + U, \quad E[U(X,T)] = 0$$

$$T = m(X) + V, \quad E[V|X] = 0$$

Based on the machine learning model (random forest regression model in this paper), use X (covariate) to fit Y (outcome variable) and T (strategy variable), and fit the residuals to obtain the true causal effect value.

8. Data analysis

After selecting relevant variables, we used the method in the sklearn library to use the random forest regression model to predict the implementation of financial inclusion policy and calculate the residuals of the urban resilience index, so as to eliminate the interference of irrelevant variables on causal inference. Finally, a linear regression model was used to analyze the residuals, and then to verify the causal effect of the implementation of financial inclusion policies on the comprehensive values. After the implementation of the model, we obtained two coefficients: $R^2 = 0.993$, which means that the model has a high degree of fit, and the explanatory power of residuals is almost perfect; the regression coefficient = 1.0007, close to 1, indicating a strong positive causal relationship between "implementation of inclusive inclusion policy" and "urban resilience index". Therefore, we can determine that there is a

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significant causal relationship between the implementation of the financial inclusion policy and the urban resilience index.

9. Conclusion and Suggestions

This paper summarizes the existing literature and puts forward hypotheses on what role Digital Inclusive Finance plays and how it plays in the resilience of urban economies. Then we found the panel data of 25 cities in different regions of China, and used the methods of dual machine learning to analyze the indicators in space and time to verify the impact of Digital Inclusive Finance on the resilience of urban economy: Digital Inclusive Finance has brought a positive role in the resilience of urban economy. Based on the conclusions drawn above, here are some of our recommendations to help cities improve their economic resilience: Promote the development of digital inclusive finance. Improve financial inclusion by building a more accessible and convenient digital financial service network. Strengthen the digital financial security and privacy protection mechanism to enhance public trust and encourage more people to participate in digital financial services. Support new high-tech innovation and entrepreneurship by formulating policies that back scientific and technological innovation and startup enterprises, and encourage digital inclusive financial institutions to collaborate with technology companies to drive technological innovation. Narrow the income gap between rural and urban areas by popularizing financial services, developing rural finance, promoting rural entrepreneurship, and providing education and training to help reduce the urban-rural income disparity. Strengthen data monitoring and evaluation by establishing a robust data collection and analysis mechanism, monitoring the impact of digital inclusive finance on urban economic resilience, and adjusting policies and measures in a timely manner. Conduct regular assessments of the resilience of urban economies, identify issues, and take timely measures to address them to ensure sustained and stable economic development.

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