The Impact of Financial Innovation on Regional Economic Resilience: Evidence from 284 Prefecture-level Cities in China

Abstract: When the economic system is shocked by the financial crisis, trade frictions, pandemics, etc., how to resolve the crisis and restore economic growth relies on economic resilience. Financial technology (Fintech) development brought profound changes in financial transactions and industrial efficiency and is expected to promote high-quality economic growth. Therefore, this research explores the impact of financial innovation on regional economic resilience. The rate of GDP change is used to measure economic resilience, a theoretical model of the relationship between financial technology and regional economic resilience is constructed, and the case of 284 prefecture-level cities in China from 2010 to 2020 is used as the empirical test. The results show that Fintech is enhancing the economic resilience of most cities in China. There is a mediating effect of green innovation and financial constraint on the impact between Fintech and urban economic resilience. Moreover, the enhanced effect of Fintech on urban economic resilience is more potent in cities with less innovation capacity, smaller areas, smaller populations, less population density, fewer financial resources, and lower levels of Fintech. The findings of the study indicate that Fintech can serve as a vital tool for building economic resilience in Chinese cities. Policymakers and city planners should consider investing in Fintech to help mitigate the impacts of financial constraints and promote green innovation. Additionally, the study suggests that Fintech can be particularly effective in smaller, less developed cities, where the benefits of the technology can be more pronounced.

Keywords: crisis, economic resilience, Fintech, econometric analysis, China

1. Introduction

Urban economic development refers to the growth and prosperity of cities and metropolitan areas, and the processes and strategies that facilitate this growth. One crucial aspect of urban economic development is urban economic resilience, which refers to a city's ability to withstand and recover from economic shocks and disruptions, such as recessions, natural disasters, or technological changes (Corodescu-Roșca et al., 2023). Urban economic resilience depends on a variety of factors, including the diversity of the local economy, the strength of local institutions and governance, the availability of human capital, and the level of social and environmental sustainability (Feng et al., 2023; Hu et al., 2022; Wang & Wei, 2021). Understanding the sources of urban economic resilience is essential for policymakers, urban planners, and local communities to develop effective strategies and policies for promoting sustainable and inclusive urban economic development.

Financial technology (Fintech) refers to the use of technology to provide financial services to individuals and businesses, disrupting traditional financial systems and offering innovative solutions for financial transactions. It has become a rapidly growing industry in recent years. With its innovative solutions and disruptive technologies, fintech has the potential to improve access to finance, enhance risk management, and promote innovation and competition, among other benefits, and presumably contributing to urban economic resilience.

Fintech development in China is very advanced and rapidly evolving, becoming a key driver of the country's digital economy, and the country is widely considered to be a global leader in fintech innovation and adoption (Zhou et al., 2022). China's large and highly connected population has created a fertile ground for fintech development, with companies such as Alibaba's Ant Group and Tencent's WeChat Pay becoming major players in the industry. The use of mobile payments, peer-to-peer lending, and other fintech services is widespread in China, and fintech companies are increasingly partnering with traditional financial institutions to provide a range of financial services

to consumers and businesses. Therefore, we chose China to further the empirical investigation of this study.

Overall, this study aims to investigate whether Fintech development contributes to urban economic resilience and selects 284 prefectural cities in China as the case study to empirically assess the impact of Fintech on economic resilience. The following sections of this paper are structured as follows: Section 2 presents the overall methodology with research hypotheses, resilience measurement, econometric model, and data source. Section 3 demonstrates the resilience assessment results and correlation with the Fintech level. Section 4 introduces the empirical results and mechanism analysis. Section 5 concludes this study with discussions of critical findings.

2. Methodology

2.1 Research hypotheses

The relationship between Fintech and urban economic resilience follows a U-shaped curve. At lower levels of fintech development, fintech is a new emerging industry with lower integration levels with other industries, leading to a lack of coherence. Furthermore, inadequate regulation exacerbates the problem, ultimately weakening the macroeconomic resilience of cities. Thus, at this stage, fintech can weaken the overall economic resilience of urban areas. However, as Fintech development reaches a certain level, it can strengthen economic resilience by promoting technological progress and alleviating financing constraints. Therefore, we propose the following hypotheses:

H1: Fintech has a non-linear impact on improving the economic resilience of cities.

H2: Fintech has an indirect role in influencing the economic resilience of cities by promoting green innovation.

H3: Fintech has an indirect role in influencing the economic resilience of cities by alleviating financial constraints.

2.2 Measuring economic resilience and its spatial autocorrelation with Fintech level

In this research, urban economic resilience is chosen as the explanatory variable. Economic resilience refers to the ability of an economy to withstand and recover from external shocks or disturbances, such as economic downturns, natural disasters, or pandemics. It encompasses the capacity of an economic system to adapt to changing circumstances, minimize the negative impact of shocks, and quickly recover to pre-crisis levels. Economic resilience is measured by indicators such as GDP growth rates, employment rates, and productivity levels, as well as by factors such as diversification of economic activities, availability of resources, and sound institutional and governance frameworks.

Drawing on Martin et al.(2016), we calculate the national economic performance during the downward and upward periods as the resistance and recovery process in economic resilience. Other things being equal, economic growth in each region will contract (during a recession) and expand (during a recovery) at the same rate as the nation. Thus, the expected change in, for example, employment rate in region *r* during a recession or recovery, for a period of duration *k*, is

$$ER_i = \frac{\left(ER_i^{t+k} - ER_i^t\right) - \left(ER_N^{t+k} - ER_N^t\right)}{\left|\left(ER_N^{t+k} - ER_N^t\right)\right|} \quad (1)$$

where ER_i is the urban economic resilience of region *i* in period *t* to *t*+*k*, and period *t* to *t*+*k* is a period of economic upswing or downswing. ER_i^t is the economic growth rate of region *i* in period *t*, and ER_N^t is the national economic growth rate in period *t*. ER_i takes on the following meanings:

ER_i equals 0, the change in economic growth in city *i* is the same as the change in the national economy.

ER_i greater than 0, high economic resilience: the change in economic growth in city *i* is greater than the change in the national economy in an upward period and less than the change in the national economy in a downward period. The larger the ER_i, the more resilient the economy.

ER_i smaller than 0, low economic resilience, the change in economic growth in city i is smaller than the change in the national economy in an upward period and larger than the change in the national economy in a downward period. The smaller the ER_i, the less resilient the economy.

Regarding the division of economic cycles, this research uses the HP filtering method (Cogley & Nason, 1995). The Stata software is used to filter the analysis of China's GDP growth rate from 2010-2020, and as annual data were used, the calibration parameter λ was set to 100 (Backus et al., 1992). The output denotes the cycling term (**Figure 1**). The cycle component variables decomposed using the HP filter represent the gap between the actual and potential values of the variable, with an increasing gap indicating that it is in an upward cycle and a decreasing gap indicating that it is in a downward cycle. Therefore, the economic cycle division for 2010-2020 is shown in **Figure 1**.

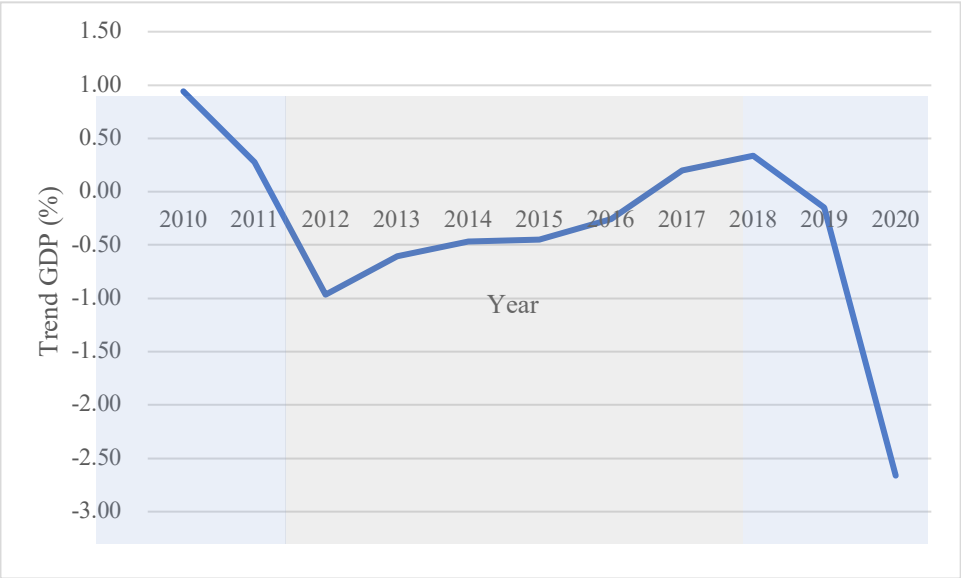

Figure 1 HP filer analysis results on economic cycles

With Equation (1), this study calculates the urban economic resilience of 284 cities in China during the period of declining economic growth (2010-2012, 2018-2020) and the period of ascending economy (2012-2018), respectively, the results are presented in Section 3. Spatial autocorrelation analysis methods (Anselin et al., 2002) are applied to examine the spatial clustering of economic resilience and Fintech development level. The results are also presented in Section 3, with the global Moran's I (Moran, 1948)

applied to evaluate global spatial autocorrelation and cold-hot spot analysis with Local Indicators of Spatial Association (LISA) (Anselin, 2010) used to assess local spatial autocorrelation. While spatial autocorrelation only shows the correlation between economic resilience and Fintech level, we further develop an econometric model analysis to investigate the causation. The empirical strategies are presented in the following subsection.

2.3 Empirical strategy

Explained variable: the economic resilience calculated in Section 2.2 is chosen as the explanatory variable.

Explanatory variables: the Digital Financial Inclusion Index[1] published by Peking University (Guo et al., 2020) is used as the core explanatory variable, and this index is taken as the natural logarithm to reduce heteroscedasticity and enhance the reliability of the results. To test the specific role of different dimensions of Fintech, regressions on urban economic resilience were conducted using Fintech coverage breadth, Fintech usage depth, and Fintech digitization level, respectively.

Mediating variables: green innovation involves developing and implementing new technologies, processes, and business models that are environmentally sustainable and socially responsible. By reducing resource consumption and waste, green innovation can help to mitigate the impact of environmental challenges, such as climate change, and promote the efficient use of resources. Therefore, green innovation can help to reduce the vulnerability of economies to environmental risks and shocks. In the empirical analysis, "the number of green utility model patents"[2] by the city is used as

[1] The Peking University Digital Financial Inclusion Index of China (PKU-DFIIC) involves coverage breadth, usage depth and digitization level; usage depth involves sub-indexes such as payment, credit, insurance, credit, investment, and money funds. The index is measured by coefficient of variation method and Analytic Hierarchy Process (AHP).

[2] In the context of green patent data for listed companies in China, "the number of green utility model patents" typically refers to the number of green utility model patents owned by the company. Green utility model patents are practical new patents that have utility in environmental protection, resource utilization, energy conservation and emission reduction, and clean production. Unlike invention patents, green utility model patents

the proxy variable for green innovation. And household deposits in financial institutions is the proxy variable for financial constraints to indicate the availability of capital.

Control variables include factors that tend to have an impact on urban economic resilience. Openness: compared to closed systems, open economies are more exposed to external shocks. However, the relationship between openness and resilience becomes more complex during the adjustment period after a shock as the system is more accessible to resources for recovery. The openness of a city is measured by the proportion of the actual amount of foreign capital used to GDP.

Human capital: On the one hand, highly skilled human resources typically have higher income levels and consumption capacity, which can help the economy shift towards reliance on domestic demand and stabilize fluctuations in the face of external shocks, thereby acting as a shock absorber (de Graaf-Zijl et al., 2015). On the other hand, abundant human capital is the foundation for regional innovation and industrial restructuring and upgrading. Only adaptive and dynamic structural adjustments can provide a sustainable source of regional economic resilience. The number of university students per thousand people is used as a measure.

Economic development: GDP is widely used as a measure of the size and health of an economy and can provide valuable information on the overall economic conditions of a region or country. By controlling for GDP in the regression analysis, the impact of other variables on economic resilience can be more accurately estimated, as the effects of economic development (changes in GDP) are already accounted for.

Fiscal autonomy: in China's rather centralized fiscal system is represented by fiscal decentralization. It is the primary expression of governments' capacity, and the structure of expenditures is directly related to the region's ability to cope with risks. Fiscal Expenditure/Fiscal Revenue is used to represent the degree of fiscal decentralization i.e., fiscal autonomy.

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focus more on practicality and actual application effects and are usually directed at improvement inventions in the fields of technology and environmental protection. In the field of green patents, having more green utility model patents can often reflect the company's technological strength and innovation capabilities in environmental protection.

Market size: it is generally believed that the scale advantage possessed by an economy is the foundation for its ability to resist external shocks and recover quickly. This is because the larger the market size of an economy, the better it can absorb negative impacts and the more easily it can rely on the domestic market size to achieve adjustments (Christopherson et al., 2010). The "total retail sales of consumption goods" is used as a measure to indicate the overall market size.

Table 1 Variable definition and description

Variable type	Definition	Abbreviation	Variable Measurement
Explained variable	Urban economic resilience	RE	Equation (1)
Explanatory variable	Fintech level	lnfinind	Peking University Digital Financial Inclusion Index of China
		lncovbre	Coverage breadth of Fintech
		lnusadep	Usage depth of Fintech
		lndiglev	Digitization level of Fintech
Control variable	Openness	FDI	Actual amount of foreign capital used (10,000 RMB)/GDP
	Human capital	lnstud	Number of college students per 1,000 population (ln)
	Economic development	lngdp	GDP (10,000 RMB) (ln)
	Fiscal autonomy	fisdec	Fiscal Expenditure/Fiscal Revenue
	Market size	lnconsu	Total retail sales of consumption goods (10,000 RMB) (ln)
Mediating variable	Green innovation	lnUgrmg	Number of Green Utility Models
	Financial constraint	lndeposit	Deposits in financial institutions (10,000 RMB)
Urban heterogeneity variable	Urban innovation index	invent	Index of Regional Innovation and Entrepreneurship in China (IRIEC)
	Urban area	area	City area (square kilometers)
	Urban population	population	Household population by year-end (10,000 persons)
	Population density	popden	Household population by year-end / City area

Model setting: to analyze the relationship between Fintech and urban economic resilience, we first construct a panel model as shown in equation (2).

$$ER_{it} = \alpha_0 + \alpha_1 Fintech_{it}^{\ 2} + \alpha_2 Fintech_{it} + \alpha_\tau X_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

where *i* is the prefecture city and *t* is the year. *ER* is the explained variable, economic resilience. α is the constant term. *Fintech* is the core explanatory variable, i.e., the level of financial technology. *X* is the vector of control variables affecting urban economic resilience. μ_i is the individual effect, γ_t is the time effect, and ε is the random error term, which follows a normal distribution. α_1 is the key coefficient of this research, indicating the effect of financial technology on urban economic resilience. α_τ is the vector of coefficients of the effect of control variables on urban economic resilience. But where are the mediating and heterogeneity variables?

To further explore the mechanism of Fintech affecting urban economic resilience, we further construct two sets of equations (3)-(4) and (5)-(6), where *GINV* is the urban green innovation capacity, *Finance* is the deposits in financial institutions. v_{it}, ω_{it}, σ_{it} and π_{it} is the random error terms.

$$GINV_{it} = \beta_0 + \beta_1 Fintech_{it}^{\ 2} + \beta_2 Fintech_{it} + \beta_\tau X_{it} + \mu_i + \gamma_t + v_{it} \quad (3)$$

$$ER_{it} = \gamma_0 + \gamma_1 Fintech_{it}^{\ 2} + \gamma_2 Fintech_{it} + \gamma_3 GINV_{it} + \gamma_\tau X_{it} + \mu_i + \gamma_t + \omega_{it} \quad (4)$$

$$Finance_{it} = \beta_0 + \beta_1 Fintech_{it}^{\ 2} + \beta_2 Fintech_{it} + \beta_\tau X_{it} + \mu_i + \gamma_t + v_{it} \quad (5)$$

$$ER_{it} = \gamma_0 + \gamma_1 Fintech_{it}^{\ 2} + \gamma_2 Fintech_{it} + \gamma_3 Finance_{it} + \gamma_\tau X_{it} + \mu_i + \gamma_t + \omega_{it} \quad (6)$$

2.4 Data

This study selects 284 prefecture-level cities[3] in China as a case study to empirically assess the impact of Fintech on economic resilience and uses the panel data of the 284 prefecture-level cities in China from 2011 to 2020 as the research sample. Urban economic resilience is calculated based on the GDP growth rate, Fintech data are from "the Peking University Digital Financial Inclusion Index of China" and the rest city panel data are obtained from the China City Statistical Yearbook and the Statistical Yearbook of each province. After excluding the missing samples of variables, the final data of 284 prefecture-level cities were obtained, with a total of 2840

[3] We exclude cities with missing data and come up with a sample of 284 prefecture-level cities.

observations and a study period of 2011-2020. All data are logarithmized and the summary statistics are shown in **Table 1**. There is a significant deviation in economic resilience between cities. The data distribution is scientifically sound.

Table 1 Summary statistics of variables

Variable	Obs	Mean	Std.dev.	Min	Max
RE	2,840	-1.161	3.926	-21.66	25.98
lnfinindex	2,840	5.054	0.512	2.834	5.788
lnfi	2,840	3.247	1.329	0	7.128
lngdp	2,840	7.305	0.972	3.554	10.56
lnstud 1	2,829	10.42	1.507	4.094	14.40
lnIngrvg 1	2,684	2.881	1.748	0	8.844
indstr2 1	2,840	0.460	0.110	0.107	0.893
DIV	2,836	0.624	1.376	-43.43	1.098
lnpopden 1	2,839	5.739	0.944	1.628	9.086
lninvent 1	2,814	-0.700	0.338	-4.455	-0.0567
lndeposit 1	2,830	16.80	1.083	14.19	21.32
lnloans 1	2,840	16.49	1.161	13.72	20.51
fisdec	2,839	0.456	0.223	0.0506	1.541
lndomenter 1	2,826	6.485	1.057	2.773	9.107
lnemployee 1	2,830	4.418	0.883	2.141	7.455
lnpemploye~1	2,814	3.722	1.021	-0.0452	7.174
procap	2,840	0.109	0.312	0	1
area	2,840	16492	21651	1113	261570
population 1	2,840	450.9	327.7	19.50	3416
popden 1	2,840	445.4	402.0	0	8828
invent 1	2,830	0.518	0.150	0	0.945

3. Economic resilience assessment results

3.1 Spatial and temporal disparities of economic resilience in Chinese cities

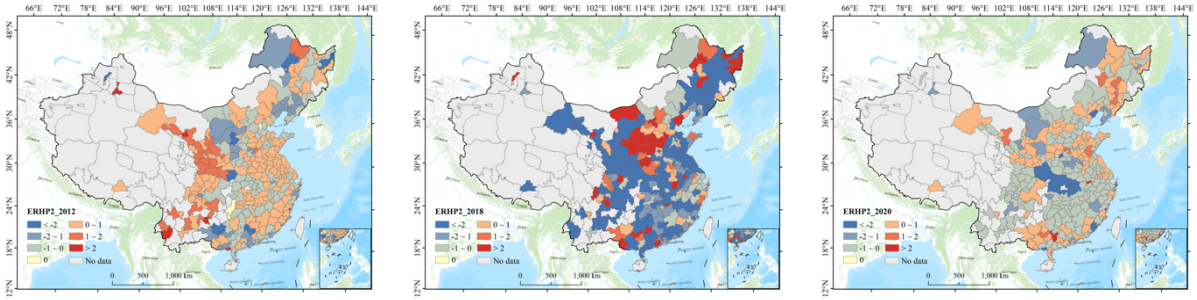

Figure 2 Economic resilience of 284 prefectural cities in China from 2011 to 2020

Figure 2 presents the economic resilience assessment results in the three economic cycles during 2011-202 with the natural break method applied in the geographical visualization. During the research period, from the first economic downturn to the first economic upturn, the evolution of regional resilience showed a trend of two-level differentiation. Regions that were initially more resilient became even stronger during the economic upturn, while regions that were initially less resilient became even weaker by the first economic upturn. By the second economic downturn, the resilience of all regions had decreased overall, falling below the level of the first period. This can be largely attributed to the impact of the COVID-19 pandemic.

And the growing disparity in regional economic resilience during the economic upturn can be explained by the following reasons: 1) Unequal distribution of resources. During periods of economic growth, resources and investments tend to concentrate in regions with higher competitiveness and attractiveness. This leads to regions with greater economic resilience becoming even stronger during the economic upturn. On the other hand, weaker regions fall behind in competition and experience reduced investments, resulting in a decline in their economic resilience.

2) Technological advancements and innovation. During periods of economic growth, technological advancements and innovation play a crucial role in regional economic development. Generally, regions with stronger economic resilience tend to attract and nurture high-tech enterprises more easily, thereby improving their own technological levels and innovation capabilities. In contrast, weaker regions often perform poorly in this aspect, leading to a decline in economic resilience.

3) Policy factors. Government policies play a significant role in economic development. In some cases, the government may formulate policies favorable to stronger regions, thereby increasing regional disparities. During economic downturns, the government may adopt austerity measures, which negatively impact the economic resilience of all regions.

3.2 Spatial autocorrelation patterns of economic resilience and Fintech level

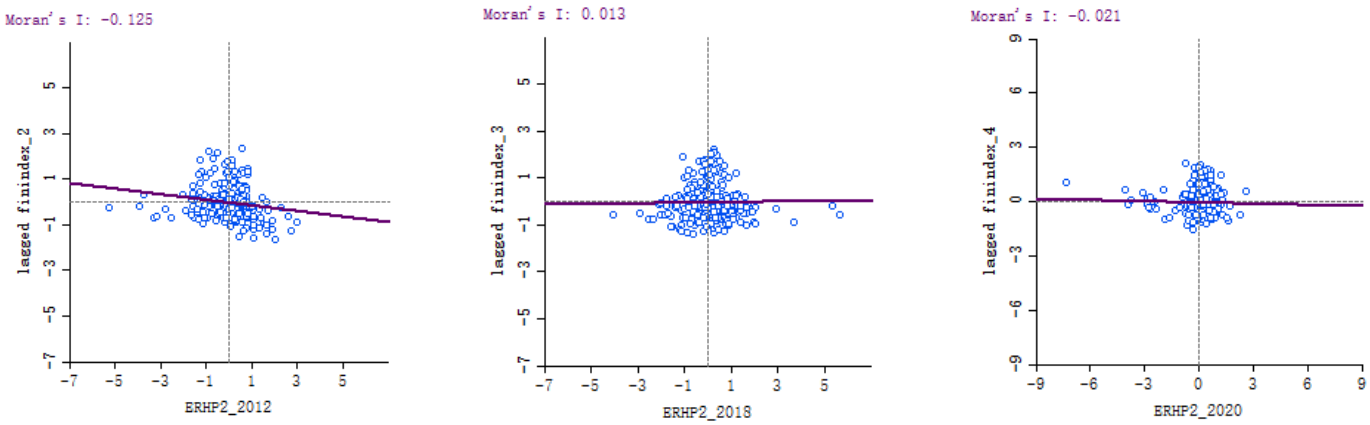

Figure 3 Bivariate Moran Scatter of urban economic resilience and Fintech level in 284 prefectural cities in China in 2012, 2018 and 2020

Economic resilience and Fintech are spatially negatively correlated in the downward economic period and positively correlated in the upward period. During economic downturns, the development of financial technology hinders the improvement of regional economic resilience, while during economic upturns, the development of financial technology promotes the enhancement of economic resilience. This shows the impact of Fintech on regional economic resilience depends on the economic context and the specific challenges faced during different economic cycles and can be approached from the following perspectives:

1) Risk Management: During economic downturns, financial institutions face increased risks, such as credit risk and market risk. The rapid development of FinTech may lead to a higher reliance on technology-driven risk management tools, which could fail to capture the complexity and interconnectedness of risks in a timely manner. This may result in delayed or inadequate responses to emerging risks, thereby hindering the improvement of regional economic resilience.

2) Financial Inclusion: In economic upturns, FinTech facilitates financial inclusion by offering more accessible and affordable financial services to a broader population. This helps in distributing resources more evenly across the region, leading to an

enhancement of economic resilience. However, during downturns, FinTech companies may face challenges in providing affordable services to those most affected by the economic crisis, thereby limiting the positive impact of financial inclusion on resilience.

3) Credit Availability: During economic upturns, FinTech enables more efficient credit assessment and allocation, which can lead to increased lending and investment, thereby promoting economic resilience. However, during downturns, credit availability may shrink as financial institutions become more risk-averse. FinTech-driven lending platforms might tighten their lending criteria, which could further limit credit availability, hindering the improvement of economic resilience.

4) Market Competition: In economic upturns, the development of FinTech spurs innovation and competition in the financial sector, which can enhance overall economic resilience. However, during downturns, some FinTech companies may struggle to survive due to reduced demand for their services or difficulty in raising capital, which could lead to reduced competition and innovation, impeding the improvement of economic resilience.

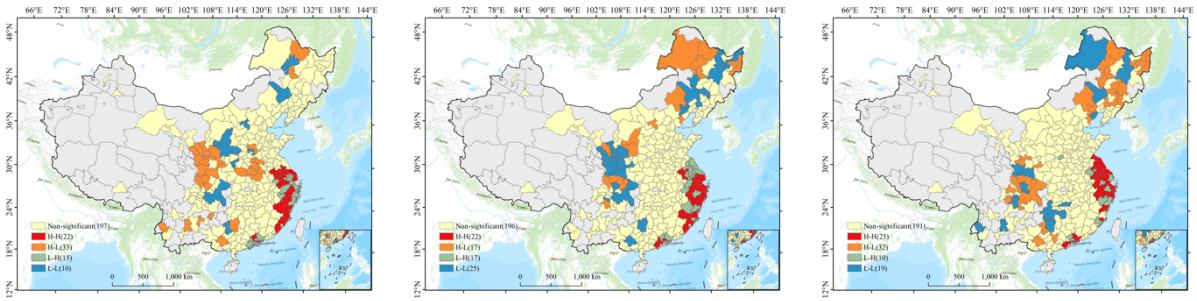

Figure 4 LISA cluster of urban economic resilience and Fintech level in 284 prefectural cities in China in 2012, 2018 and 2020

Further analysis of the spatial agglomeration of financial technology and economic resilience levels (Figure 4) shows that regions with high resilience and advanced financial technology development are concentrated in the southeastern coastal areas of China. The southeastern coastal areas of China have experienced rapid economic development in recent decades, driven by factors such as export-oriented manufacturing, foreign direct investment, and favorable government policies. This

economic growth has facilitated the development of a robust financial infrastructure and the adoption of advanced financial technologies, which in turn contributes to higher economic resilience. And with Hangzhou, a major hub of Fintech in China located in this region, further contributing to Fintech development and economic growth.

4. Fintech impact on economic resilience

4.1 Benchmark results

Table 2 The effects of financial innovation on regional economic development

	(1)	(2)	(3)	(4)	(5)	(6)
	RE	RE	RE	RE	RE	RE
lnfinindex2	1.1262***	0.7363*	1.1093***	0.5862	1.0248**	1.0229**
	(4.9611)	(1.9554)	(6.8045)	(1.1636)	(2.0196)	(2.0156)
lnfinindex	-11.2833***	-6.1257*	-11.2173***	-5.3881	-8.2507**	-8.2342**
	(-5.2427)	(-1.7784)	(-7.2677)	(-1.4611)	(-2.2212)	(-2.2163)
lnstud_1					0.1712*	0.1714*
					(1.7743)	(1.7757)
lngdp					-1.5202***	-1.5170***
					(-6.7510)	(-6.7324)
FDI					-0.0002	-0.0002
					(-1.2209)	(-1.2174)
fisdec					-2.6682***	-2.6604***
					(-2.8093)	(-2.8002)
lnconsu_1					0.1040	0.1075
					(0.5586)	(0.5770)
greenrate_2						-0.0194
						(-0.4698)
_cons	26.8030***	12.6387	27.8982***	12.8903*	25.2277***	25.1173***
	(5.3101)	(1.6230)	(7.5460)	(1.9138)	(3.1923)	(3.1764)
City FE	NO	NO	YES	YES	YES	YES
Time FE	NO	YES	NO	YES	YES	YES
N	2840	2840	2840	2840	2828	2828
R-Square	0.0153	0.0447	0.5565	0.5834	0.1153	0.1154

The relationship between Fintech and urban economic resilience is U-shaped. According to the regression, Fintech weakens urban economic resilience when Fintech is less than 56 and enhances urban economic resilience when Fintech is greater than 56.

When new things first emerge, the level of cognition is not high enough, the integration with the industry is not good, and regulation cannot keep up. Therefore, the development of financial technology does not promote the improvement of economic resilience. However, when financial technology develops to a certain level, it can promote the enhancement of economic resilience. With the current sample, Fintech is enhancing the economic resilience of most cities.

The double fixed effect without control variables was not significant, indicating that the control variables are helping to account for confounding factors and providing a clearer picture of the relationship between Fintech and the economic resilience. The results of Fintech coverage breadth, usage depth, and digitization level are not significant. This shows that there might be a joint effect of the three dimensions of Fintech that could potentially contribute to the regional economic resilience.

4.2 Robustness check

Table 3 The results of robustness checks

	(1) Provincial capital RE	(2) Non-provincial capital RE	(3) One-period lagged explanatory variable RE	(4) Winsorize RE
lnfinindex2	2.8402*	0.7363*		0.8441*
	(1.6974)	(1.9554)		(1.8344)
lnfinindex	-27.3520*	-6.1257*		-7.0091*
	(-1.8949)	(-1.7784)		(-1.8967)
L.lnfinindex2			1.8773***	
			(2.7421)	
L.lnfinindex			-13.3563***	
			(-2.8228)	
lnstud_1	0.2523		0.1077	0.2284***
	(1.0818)		(1.4144)	(3.0626)
lngdp	-2.1235***		-1.0888***	-1.3859***
	(-3.5708)		(-3.9543)	(-5.2423)
FDI	-0.0007*		-0.0001	-0.0003
	(-1.9339)		(-0.5512)	(-0.7708)
fisdec	-0.0406		-2.3049*	-2.5220**
	(-0.0256)		(-1.9543)	(-2.1143)
lnconsu_1	0.2207		0.1285	-0.1414
	(0.4827)		(0.5343)	(-0.4820)

greenrate_2	-0.3039		-0.0298***	0.4342
	(-0.1098)		(-8.2517)	(0.3368)
_cons	80.3397**	12.6387	29.2719***	25.1356***
	(2.2884)	(1.6230)	(3.3827)	(2.7341)
City FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
N	310	2840	2546	2828
R-Square	0.7073	0.0447	0.1046	0.1655

The results are robust after replacing the variables as well as replacing the samples with provincial capital and non-provincial capital cities and with sample whose economic resilience is one-period lagged and the replacement of extreme values with less extreme values.

4.3 Mechanism analysis

Table 4 The results of mediating effects

	(1) lnUgrmg_1	(2) ERHP2	(3) lnsavings_1	(4) ERHP2
lnfinindex2	0.1962***	0.9641*	-0.0476***	0.9118*
	(2.6350)	(1.8987)	(-3.2604)	(1.7965)
lnfinindex	-0.9969*	-7.9674**	0.6808***	-6.6451*
	(-1.8271)	(-2.1429)	(6.3668)	(-1.7781)
lnUgrmg_1		0.3206**		
		(2.3655)		
lnsavings_1				-2.3342***
				(-3.3848)
lnstud_1	0.0101	0.1612*	-0.0028	0.1648*
	(0.7115)	(1.6726)	(-1.0070)	(1.7112)
lngdp	0.1047***	-1.5382***	0.0103	-1.4928***
	(3.1699)	(-6.8270)	(1.5956)	(-6.6355)
FDI	0.0000	-0.0002	0.0000	-0.0002
	(1.4505)	(-1.2666)	(0.0418)	(-1.2171)
fisdec	0.3631***	-2.7878***	0.1852***	-2.2281**
	(2.6075)	(-2.9355)	(6.7724)	(-2.3290)
lnconsu_1	-0.0077	0.1102	0.0155***	0.1437
	(-0.2819)	(0.5928)	(2.8865)	(0.7712)
greenrate_2	-0.0037	-0.0182	0.0006	-0.0181
	(-0.6061)	(-0.4428)	(0.4634)	(-0.4396)
_cons	3.5438***	24.1247***	13.4766	56.5744***
	(3.0494)	(3.0428)	(59.2158)	(4.6403)
Sobel		0.06291*		0.1111***

		(1.76)		(2.348)
Effect size		0.06		0.108
City FE	YES	YES	YES	YES
Time FE	YES	YES	YES	YES
N	2824	2824	2828	2828
R-Square	0.7171	0.1174	0.9516	0.1194

There is a mediating effect of the number of green utility models on the relationship between Fintech and urban economic resilience. The presence of green utility models can contribute to the resilience of urban economies and that promoting green innovation can have positive effects on economic resilience. The green utility model number is catalytic after Fintech exceeds 12, and an increase in green innovation further enhances urban economic resilience. Beyond the 12 threshold of Fintech, the number of green utility models has a more significant impact on urban economic resilience. The explanatory role of innovation intermediation is 6%, which means that the number of green utility models accounts for 6% of the variation in the relationship between Fintech and urban economic resilience. This suggests that while the number of green utility models plays a role in mediating the relationship between Fintech and urban economic resilience, it is not the only factor involved. Other variables may also contribute to this relationship.

There is a mediating effect of financial institution deposits on the impact between Fintech and urban economic resilience. Fintech is catalytic to financial institution deposits at less than 12.75 and can alleviate financing constraints in the market. The estimated increase in financial funds further enhances urban economic resilience. This suggests that the presence of Fintech can contribute to improving access to finance and reducing financing constraints in the market, which can have a positive impact on economic resilience. The explanatory effect of alleviating financial constraints is 10.8%, indicating impact of Fintech on alleviating financial constraints accounts for 10.8% of the variation in the relationship between Fintech and urban economic resilience.

4.4 Heterogeneity analysis

Table 5 The results of city heterogeneity analysis (a)

	(1) High innovation level ERHP2	(2) Low innovation level ERHP2	(3) Large area ERHP2	(4) Small area ERHP2	(5) High population ERHP2	(6) Low population ERHP2
lnfinindex2	0.2222	2.6696***	0.3649	1.6098**	0.0315	1.7550**
	(0.2887)	(3.6024)	(0.5030)	(2.1060)	(0.0587)	(2.0702)
lnfinindex	-3.2470	-19.9838***	-4.4853	-11.8761**	0.2449	-14.7555**
	(-0.5877)	(-3.6735)	(-0.8606)	(-2.0546)	(0.0636)	(-2.3531)
lnstud_1	0.1421	0.0836	0.2633*	0.0966	0.1867**	0.1492
	(0.8402)	(0.6968)	(1.8787)	(0.7226)	(2.0307)	(0.8956)
lngdp	-1.0765***	-1.5126***	-1.4947***	-1.7632***	-1.2570***	-1.9419***
	(-3.1144)	(-4.7831)	(-4.9373)	(-4.9559)	(-5.9044)	(-4.7511)
FDI	-0.0005**	0.0005**	-0.0003*	0.0003	-0.0002*	0.0000
	(-2.3643)	(1.9975)	(-1.9138)	(0.9946)	(-1.9556)	(0.1711)
fisdec	0.6353	-5.8400***	-4.1546***	-2.1020	-3.0131***	-2.6232
	(0.4390)	(-4.1844)	(-3.0748)	(-1.5608)	(-3.3136)	(-1.5857)
lnconsu_1	0.1886	-0.0969	-0.0575	0.4801	0.0154	0.2222
	(0.7986)	(-0.2874)	(-0.2643)	(1.4076)	(0.0969)	(0.6251)
greenrate_2	-0.0301	-1.4171	2.5460*	-0.0205	-0.0238	0.1432
	(-0.7343)	(-0.8928)	(1.6829)	(-0.4716)	(-0.9209)	(0.0939)
_cons	16.3957	57.2183***	27.8103***	25.9576*	11.6259	44.5124***
	(1.3801)	(4.8299)	(2.6102)	(1.9310)	(1.5219)	(3.2056)
City FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
N	1420	1408	1411	1417	1419	1409
R-Square	0.6465	0.6700	0.6137	0.5841	0.6828	0.5829

Table 6 The results of city heterogeneity analysis (b)

	(1) High density ERHP2	(2) Low density ERHP2	(3) High financial deposits ERHP2	(4) Low financial deposits ERHP2	(5) High Fintech level ERHP2	(6) Low Fintech level ERHP2
lnfinindex2	0.2949	1.5899*	-1.1064	2.7244***	-7.1393	1.2387*
	(0.5156)	(1.8528)	(-1.5806)	(3.0152)	(-1.3233)	(1.8114)
lnfinindex	-2.5481	-12.7443**	10.5010*	-20.3362***	77.7901	-9.0158*
	(-0.6028)	(-2.0243)	(1.8185)	(-3.0658)	(1.2957)	(-1.8788)
lnstud_1	0.1400	0.2361	0.2617**	0.0819	-1.4409***	0.1051
	(1.4526)	(1.4187)	(2.4679)	(0.5105)	(-3.3625)	(1.0672)
lngdp	-1.0025***	-1.9300***	-0.8536***	-2.8804***	-0.7648***	-23.0321***
	(-3.9376)	(-5.0445)	(-4.1804)	(-5.5766)	(-2.8011)	(-21.4938)
FDI	-0.0002	-0.0001	-0.0000	-0.0002	-0.0001	0.0037***
	(-0.6940)	(-0.7361)	(-0.1349)	(-1.0784)	(-0.7232)	(3.7900)
fisdec	-1.0767	-4.2357**	-2.4887**	-1.7680	0.5430	4.7960***
	(-1.1798)	(-2.4307)	(-2.5176)	(-1.0052)	(0.2927)	(3.1536)
lnconsu_1	-0.6330**	0.2652	0.1448	0.1720	0.3561	-0.0432

	(-1.9957)	(1.0477)	(0.4873)	(0.6284)	(1.1643)	(-0.1743)
greenrate_2	-0.0195	2.2870	-0.0314	0.4887	-0.0289	-0.0934
	(-0.6846)	(1.2697)	(-1.0928)	(0.2665)	(-0.6281)	(-0.0780)
_cons	26.7317***	35.0380***	-19.1725	58.9607***	-1.9e+02	233.0512***
	(2.7422)	(2.6400)	(-1.3640)	(4.2467)	(-1.1450)	(17.6470)
City FE	YES	YES	YES	YES	YES	YES
Time FE	YES	YES	YES	YES	YES	YES
N	1420	1408	1424	1404	1415	1413
R-Square	0.6482	0.5882	0.6209	0.6086	0.6101	0.7200

According to the heterogeneity results, the inverted U-shaped effect of Fintech on urban economic resilience is more potent in cities with less innovation capacity, smaller areas, smaller populations, and less population density. This shows that the enhanced effect of Fintech on urban economic resilience is more potent in cities with fewer financial resources and lower levels of Fintech.

One possible explanation for this finding is that Fintech can have a more significant impact in cities with less developed innovation capacity, smaller areas, populations, and less population density because these cities may face greater challenges in accessing finance and other resources necessary for economic growth. In these cities, Fintech may help bridge the gap by providing alternative financing solutions and enabling access to financial services that were previously unavailable.

In larger and more developed cities, on the other hand, there may already be established financial institutions and greater access to finance and other resources, which could diminish the impact of Fintech. Additionally, larger and more developed cities may also have higher levels of competition, which could make it more difficult for Fintech firms to establish themselves and have a significant impact.

Overall, the heterogeneity results suggest that the impact of Fintech on urban economic resilience in China is not universal and can vary depending on the specific characteristics of the cities being studied. Understanding these variations is important for policymakers and investors looking to make informed decisions about where to allocate resources and invest in Fintech innovation.

5. Concluding remarks

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