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Data Factor Empowers Economic Resilience: Evidence from China

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Abstract

In recent years, the rapid development of data factor has brought about brand-new mechanism pathways and power sources for the enhancement of regional economic resilience. Based on the construction of a theoretical framework for how data factor empowers the enhancement of economic resilience, this paper employs two-way fixed effects and mediating effects panel data models, utilizing provincial panel data from China spanning from 2011 to 2023, to empirically analyze the impact mechanism of data factor on economic resilience. The study finds that data factor has a significant and robust driving effect on economic resilience. Heterogeneity analysis reveals that the impact of data factor on economic resilience exhibits distinct spatial gradient characteristics. Meanwhile, regions with weaker data factor foundations but higher economic resilience demonstrate a greater impact of data factor on economic resilience. Mechanism analysis indicates that data factor indirectly empowers the enhancement of economic resilience through pathways such as promoting innovation-driven development, improving digital finance, and optimizing industrial structure. This study contributes to revealing the underlying theoretical logic of how data factor empowers economic resilience and provides references for formulating policies to better leverage the value of data factor and enhance economic resilience.

Keywords

Data Factor, Economic Resilience, Innovation-Driven Development, Digital Finance, Industrial Structure

1. Introduction and Literature Review

Against the backdrop of a significant increase in global economic uncertainty and increasingly severe external risks and challenges, enhancing regional economic

resilience has emerged as a core strategy for sustainable development. Economic resilience not only manifests as a region's ability to maintain the stability of its system structure and functions when subjected to external disturbances, such as financial crises and public health emergencies, but also emphasizes the dynamic process of achieving rapid recovery through self-adaptive adjustments and promoting the transformation of the economic structure towards more advanced forms during such shocks (Martin, 2012; Yang & Shao, 2022; Eichengreen et al., 2024). Traditionally, capital accumulation, labor input, and technological progress have been regarded as the three key drivers of economic development. However, with the in-depth evolution of the digital economy wave, data, as a new type of critical production factor, has increasingly highlighted its strategic position and has gradually become a core force in reshaping the global competitive landscape. Data factor refers to the digital information that, after being collected, processed, and organized in social production activities, can be input into the economic system as the independent or integrated production factor. By synergistically integrating with traditional factors, it generates amplification, superposition, and multiplication effects, thereby creating economic value and driving productivity development. Its typical characteristics include non-rivalry, strong synergy, strong complementarity, reusability, and significant spillover effects. In 2024, the global data production volume reached a staggering 154 ZB, with China's total data production amounting to 41.06 ZB, accounting for 26.67% of the global total and showing a 25% increase from 2023. Leveraging its unique attributes of replicability, shareability, strong permeability, and increasing marginal returns, data factor has broken through the scarcity and exclusivity constraints of traditional factors, profoundly reshaping the structure and operational logic of regional economic development (Zhang & Xu, 2024).

Numerous studies have indicated that digital transformation driven by data as the core, the talent agglomeration effect accompanying the flow of high-end factors, and the innovation effect brought about by the optimization and upgrading of the industrial structure are key pathways for enhancing economic resilience (Pan et al., 2023; Oyadeyi et al., 2024; Sun & Zhu, 2024). Additionally, factors such as the strategic reserve of high-quality human capital (Sun et al., 2023), the integration and empowerment of advanced technologies like artificial intelligence (Liu et al., 2024), and tax structure reforms aimed at incentivizing innovation (Zheng et al., 2024) have also been widely confirmed to significantly promote economic resilience. Among the numerous driving factors, data factor is regarded as one of the key carriers for empowerment and connectivity. The flow, agglomeration, and market-oriented allocation of data factor provide new mechanism pathways and power sources for enhancing regional economic resilience. In the literature, there is relatively little academic research directly addressing the relationship between data factor and economic resilience. Most studies primarily use policy variables related to data factor to examine the impact pathways and mechanisms of data factor on economic resilience, focusing mainly on areas

such as urban economies, agriculture, and exports (Sitinjak et al., 2018; Demartini et al., 2019; Zheng & Chen, 2023; Zhang & Xu, 2024; Cheng et al., 2024; Luo et al., 2025; Mao et al., 2025; Shi & Yang, 2025; Wang, 2025). These studies collectively reveal from different perspectives, such as allocation mechanisms, agglomeration effects, and infrastructure support, that data factor is profoundly shaping the resilience and stability of regional economic systems through various channels, including marketization, clustering, and infrastructure development. However, there is still significant room for improvement in systematically elucidating the theoretical analysis framework for how data factor empowers economic resilience enhancement and in scientifically constructing statistical indicators to measure the development levels of data factor and economic resilience.

Drawing on existing research, this paper systematically examines the impact effects and underlying mechanisms of data factor on economic resilience using provincial panel data from China. The study finds that data factor significantly empowers economic resilience and exhibits distinct spatial gradient characteristics. Regions with a stronger foundation in data factor but lower economic resilience demonstrate a smaller impact effect of data factor on economic resilience. Data factor can indirectly enhance economic resilience levels by promoting innovation-driven development, improving digital finance, and optimizing industrial structure.

The marginal contributions of this paper are mainly reflected in the following three aspects: Firstly, from a theoretical and logical perspective, it systematically analyzes the direct and indirect pathways through which data factor empowers the enhancement of economic resilience, thereby expanding the theoretical framework for research on economic resilience in the era of the digital economy. Secondly, from the three dimensions of regional distribution, development stage, and transmission mechanism, it deeply reveals the heterogeneous characteristics and multi-channel mechanisms of how data factor affects economic resilience, providing useful policy implications for promoting coordinated regional development and implementing digital strategies tailored to local conditions. Thirdly, from the three dimensions of foundational support, application level, and transformation efficiency, it constructs a multidimensional and comprehensive evaluation system for scientifically measuring the development of data factor.

The research arrangement for the remaining content of this paper is as follows. The second section will systematically elaborate on the theoretical framework for how data factor empowers economic resilience enhancement and propose theoretical hypotheses to be tested. The third section presents the research design of this paper, mainly introducing the proposed research methods, models, indicators, and data. The fourth section is the empirical analysis, which uses provincial panel data from China to analyze in detail the pathways and mechanisms through which data factor affects economic resilience. The fifth section concludes with conclusions and policy recommendations.

2. Theoretical Analysis and Research Hypotheses

Data factor can enhance economic resilience not only through direct pathways, but also through indirect pathways such as boosting innovation-driven capabilities, improving digital finance, and optimizing industrial structures.

2.1. Direct Pathways of Data Factor Empowering Economic Resilience Enhancement

The direct impact effects of data factor on regional economic resilience are manifested across multiple dimensions, realized through various institutional arrangements and practical pathways. Firstly, abundant data factor can contribute to enhancing information transparency and decision-making scientificity. Enterprises can utilize various digital platforms and sensors to collect real-time data on market dynamics, consumer demands, supply chain conditions, and other aspects, directly aiding in the scientific formulation of production plans and market strategies to cope with complex and diverse economic shocks. Government departments can also leverage big data technology to integrate data resources from different fields and departments, comprehensively and timely understanding economic operating conditions, including macroeconomic indicators, industrial development trends, and regional economic disparities, to accurately predict economic trends and formulate more targeted and scientific policy measures, improving the effectiveness and precision of macroeconomic regulation. Secondly, the market-oriented allocation of data factor, characterized by the establishment of data trading platforms, can significantly enhance regional economic resilience by strengthening economic resistance and recovery capabilities, adaptability and adjustment capabilities, and innovation and transformation capabilities. This allocation method reduces information asymmetry, optimizes the flow efficiency of production factors, and enables the regional economic system to exhibit greater stability and recovery capacity when facing external shocks. Thirdly, the agglomeration of data factor formed through the establishment of comprehensive big data pilot zones can have a direct and significant growth effect on regional economic resilience. This agglomeration effect not only promotes the large-scale utilization of data resources but also fosters a virtuous cycle of technological innovation and industrial upgrading, injecting new vitality into regional economic development. Finally, the construction and improvement of the data factor market itself, as a fundamental institutional arrangement, provides a fundamental guarantee for the full release of data value by establishing data property rights, pricing, and trading rules, and its construction process is itself an important force driving economic resilience enhancement (Shi & Yang, 2025). In summary, as a new type of critical production factor, data factor can directly enhance the ability of regional economic systems to resist external shocks and strengthen the robustness and resilience of economic development. Based on this, this paper proposes the following hypothesis:

H1: The development of data factor has a positive driving effect on the enhance-

ment of regional economic resilience.

2.2. Indirect Pathways of Data Factor Empowering Economic Resilience Enhancement

The role of data factor in enhancing regional economic resilience through the "innovation-driven effect" has been supported by numerous empirical studies. The core mechanism lies in the fact that the agglomeration of data factor injects strong impetus into regional innovation systems. Specifically, firstly, the agglomeration of data factor can effectively guide governments and enterprises to increase R&D investment. Taking the establishment of national-level big data comprehensive experimental zones as an example, such policies have significantly attracted the clustering of high-tech enterprises by providing financial support and creating a favorable innovation environment, thereby expanding the scale of regional innovation activities (Zhang & Xu, 2024). Secondly, data factor helps uncover innovation points and enhance the scientificity and efficiency of the innovation process. Vast amounts of market data, user data, and technological data contain rich information. Through big data analysis, artificial intelligence, and other technological means, enterprises and research institutions can discover potential market demands, technological pain points, and innovation opportunities from these data, conduct precise market research and technological route planning, and optimize R&D decisions, thereby reducing the uncertainty and trial-and-error costs of innovation activities. Thirdly, the circulation and sharing of data factor can promote the formation of knowledge spillovers and a collaborative innovation ecosystem. The construction of infrastructure, such as data trading platforms breaks down information barriers, provides a platform for in-depth interactions among enterprises, universities, and research institutions, accelerates the creation and diffusion of new knowledge and technologies, and speeds up the commercialization process of innovation achievements. In summary, data factor can systematically enhance regional scientific and technological innovation capabilities through multiple pathways, and innovation, as the core driving force for economic systems to cope with shocks and achieve transformation and upgrading, will ultimately be transformed into stronger resistance, adaptability, and recovery capabilities of regions in the face of external risks, namely, higher economic resilience. Based on this, this paper proposes the following hypothesis:

H2: Data factor can enhance economic resilience by promoting innovation-driven development.

As the core production factor of the digital economy, data factor significantly enhances the risk resistance and recovery adjustment capabilities of economic systems by empowering the development of digital finance, becoming an important pathway for enhancing economic resilience (Oyadeyi et al., 2024). Firstly, data factor can drive the development of digital finance through the "property rights determination-trading-financialization" pathway, thereby enhancing economic stability. Data capitalization can transform data into tradable assets, empower dig-

ital financial innovation in credit assessment and risk pricing models, optimize capital allocation efficiency, improve the precision and inclusiveness of financial credit services, and effectively enhance the resistance and recovery capabilities of regions in the face of external shocks (Liu & Tang, 2025; Fan & Zhang, 2025). Secondly, digital finance can alleviate information asymmetry between enterprises and financial institutions, reduce factor transaction costs, assist financial institutions in scientifically developing financial products and services that better meet market demands, and enhance the adaptability and transformation capabilities of regional economies through mechanisms such as improving entrepreneurial activity, strengthening enterprises' ability to cope with risks, and narrowing the urban-rural income gap. It should be noted that the promoting effect of digital finance on economic resilience exhibits structural differences and time-series increasing characteristics, with its empowering effect being more significant in regions with higher levels of technological innovation and deeper digital integration (Luo et al., 2024). In summary, data factor can systematically enhance the comprehensive capabilities of regional economies in resisting shocks, rapid recovery, and structural transformation by driving the deepening development of digital finance, providing key support for building a highly resilient economic system. Based on this, this paper proposes the following hypothesis:

H3: Data factor can enhance economic resilience by improving digital finance.

As the core driving force for economic development, data factor significantly enhances regional economic resilience by promoting the optimization of industrial structure, a key mediating pathway. Data factor can freely flow and be shared among different industries, breaking down industry boundaries, promoting cross-industry integration, and giving rise to new business forms such as smart manufacturing and industrial internet; they can combine with other technologies and resources to breed a series of emerging industries, such as big data, cloud computing, artificial intelligence, and blockchain industries; they can also drive the digital transformation of traditional agriculture and service industries, achieving improvements in production efficiency, cost reduction, and product quality. Industrial structure optimization is not a single-dimensional upgrade but a systematic evolution of the industrial system towards higher efficiency, stronger adaptability, and better coordination, playing an irreplaceable role at different stages of economic resilience. Specifically, during the resistance period, data-empowered industrial structure optimization enhances the resistance of economic systems to external shocks by improving resource allocation efficiency and risk dispersion capabilities; entering the recovery period, the optimized industrial structure accelerates resource reorganization and path innovation, promoting rapid economic recovery through its good industrial linkages and techno-economic connections; and during the adjustment period, industrial structure optimization provides stronger structural transformation capabilities for economic systems, driving the formation of new growth paths (Zhao et al., 2020). Industrial structure optimization plays a key mediating role in enhancing economic resilience in the region,

and data factor systematically enhances the resistance, recovery, and reconstruction capabilities of regional economies through this pathway, laying a solid industrial structure foundation for building a highly resilient economic system (Yin et al., 2023). Based on this, this paper proposes the following hypothesis:

H4: Data factor can enhance economic resilience by optimizing industrial structure.

3. Research Design

3.1. Model Construction

This paper empirically examines the impact of data factor on economic resilience by constructing a benchmark regression model as shown in Equation (1), aiming to provide empirical evidence for understanding its role in responding to economic shocks.

$$\mathrm{RES}_{it} = \alpha_0 + \alpha_1 \mathrm{DAT}_{it} + \alpha_2' C_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{1}$$

where, i and t represent province and year, respectively; RES_{it} denotes the level of economic resilience; DAT_{it} is the core independent variable, representing the development of data factor; C_{it} is a series of control variables; α_0, α_1, and α_2 are the parameters to be estimated in the model; μ_i and λ_t represent province and time fixed effect, respectively; and ε_{it} is the random disturbance term.

To verify the mediating roles of three mechanism variables, namely, innovation-driven effect, digital finance level, and industrial structure optimization, models as shown in Equation (2) and Equation (3) are constructed to test the mediating effects of these variables (Jiang, 2022).

$$\mathrm{M}_{it} = \beta_0 + \beta_1 \mathrm{DAT}_{\mathrm{it}} + \beta_2' \mathrm{C}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{2}$$

$$\mathrm{RES}_{it} = \gamma_0 + \gamma_1 \mathrm{M}_{it} + \gamma_2' \mathrm{C}_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{3}$$

where, M_{it} represents the mediating variable, which includes innovation-driven effect (IDE), digital finance level (DFL), and industrial structure optimization (STR), respectively. To depict the regional innovation level, the proportion of internal R&D expenditure in gross domestic product (GDP) is used as a proxy variable for the innovation-driven effect. The digital finance directly utilizes the Digital Inclusive Finance Index released by Peking University. For measuring industrial structure optimization, this paper adopts the method used by Gan et al. (2011) and constructs a composite indicator based on the labor productivity and value-added share of each industry. The specific formula is shown in Equation (4):

$$\mathrm{STR}_{it} = \sum_{j=1}^{j} \mathrm{G}_{ijt} \times \mathrm{L}_{ijt} \tag{4}$$

where, j represents the primary, secondary, and tertiary industries; G_{ijt} denotes the proportion of the value-added of the j-th industry in region i in year

t to the regional GDP; L_{ijt} represents the labor productivity of employees in the j-th industry in region i in year t, that is, the ratio of the value-added of each industry to the total employment of that industry. The meanings of the remaining variables in Equation (2) and Equation (3) are the same as those in Equation (1).

3.2. Variable Explanation

3.2.1. Dependent Variable: Economic Resilience (RES)

This study utilizes the economic resilience index and its data constructed by Huang and Zhang (2025). The index establishes a comprehensive evaluation system comprising 26 indicators across four core dimensions: risk resistance, risk recovery, adaptive adjustment, and innovation transformation.

3.2.2. Independent Variable: Development of Data Factor (DAT)

To overcome the direct quantification challenges of data factor due to their implicit characteristics and external environmental dependencies, this study constructs a multidimensional comprehensive evaluation system based on the research frameworks of Pan et al. (2025) and Tao & Ding (2022). The system encompasses three dimensions: foundational support, application level, and transformation efficiency (see Table 1). This indicator system is designed to systematically unveil the entire production and application process of data factor, spanning from foundational conditions to practical applications and culminating in ultimate value creation. In doing so, it comprehensively reflects the development of regional data factor, with measurements conducted through the entropy-weighted TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method.

Table 1. Indicator system for the development of data factor.

Target index	Primary indicator	Secondary indicator	Attribute
Development of data factor	Foundational support of data factor	Number of broadband access ports	Positive
		Number of Internet domain names	Positive
		Number of Internet web pages	Positive
		Number of IPV4 addresses	Positive
		Number of websites per 100 enterprises	Positive
	Application of data factor	Installation density of industrial robots	Positive
		Proportion of e-commerce sales in GDP	Positive
		Proportion of enterprises with e-commerce activities	Positive
		Digital inclusive finance - Digital payments	Positive
		Digital inclusive finance - Digital insurance	Positive
		Digital inclusive finance - Degree of digitization	Positive

Continued

	Transformation efficiency of data factor	Sales revenue from new products in high-tech industries ratio	Positive
		Software product revenue ratio	Positive
		Information technology service revenue ratio	Positive
		Technology market turnover ratio	Positive

3.2.3. Control Variables

To control for the influence of other potential factors on economic resilience and mitigate omitted variable bias, this study selects the following variables as control variables: 1) Industrialization level (IND): measured by the proportion of industrial added value in regional GDP; 2) Urban economic density (ECO): characterized by GDP per unit of land area; 3) Financial development level (FIN): represented by the proportion of financial industry added value at the end of the year in regional GDP; 4) Urbanization (URB): measured by the proportion of urban population in the total population; 5) Degree of fiscal decentralization (REV): measured by the ratio of local budgetary revenue to budgetary expenditure.

3.3. Data Description and Descriptive Analysis

The data used in this paper consists of panel data from 30 provinces in China spanning from 2011 to 2023 (due to data availability, the sample excludes Tibet, Hong Kong, Macau, and Taiwan regions of China). Data on economic resilience, data factor, and control variables are sourced from the *China Statistical Yearbook*, *China Statistical Yearbook on Science and Technology*, *China Population and Employment Statistical Yearbook*, as well as statistical yearbooks of various provinces, statistical bulletins on national economic and social development of various provinces, and Mark Database (https://www.macrodatas.cn/). Missing values are filled in using the linear interpolation method. Descriptive statistical results for each variable are presented in Table 2. Based on the regional classification standards of National Bureau of Statistics of China, this paper divides China's 30 provinces into four major regions (eastern, central, western, and northeastern) for analysis.

Table 2. Descriptive statistics of variables.

Variable category	Variable	Total (N = 390)	Eastern region (N = 130)	Central region (N = 78)	Western region (N = 143)	Northeastern region (N = 39)	Standard deviation	Maximum	Minimum
Dependent variable	RES	0.209	0.281	0.198	0.162	0.167	0.098	0.605	0.095
Independent variable	DAT	0.129	0.211	0.101	0.079	0.091	0.104	0.675	0.017
Mediating variables	IDE	0.018	0.028	0.016	0.012	0.015	0.012	0.068	0.004
	DFL	254.532	283.047	250.707	235.713	236.137	110.685	498.280	18.33
	STR	14.165	17.636	12.117	12.679	12.139	6.186	39.497	4.448

Continued

Control variables	IND	0.331	0.321	0.376	0.319	0.322	0.080	0.574	0.100
	ECO	4.901	4.809	6.507	4.627	3.002	2.416	12.668	0.874
	FIN	0.073	0.093	0.052	0.068	0.068	0.032	0.198	0.026
	URB	0.606	0.705	0.550	0.539	0.637	0.120	0.896	0.350
	REV	0.488	0.693	0.447	0.354	0.382	0.187	0.931	0.151

Overall, significant disparities exist in the development of economic resilience across regions, with the eastern region demonstrating relatively strong performance, while the western and northeastern regions lag behind. This reflects the uneven regional development characteristics and underscores the importance of in-depth exploration of mechanisms to enhance economic resilience. From the perspective of the core explanatory variable, the development level of data factor in the eastern region is significantly higher than that in other regions, reflecting the leading position of this region in digital transformation. Regarding mediating variables, the overall regional differences in the innovation-driven effect are relatively low, whereas digital finance levels and industrial structure optimization exhibit more pronounced gradient differences. Additionally, various control variables, such as the level of industrialization, urbanization, and fiscal decentralization, also exhibit substantial structural differences across regions, providing an important foundation for subsequent regional comparisons and empirical analyses.

4. Empirical Analysis

4.1. Analysis of Benchmark Regression Results

To investigate the impact of development of data factor on economic resilience, this paper establishes a two-way fixed-effects model for analysis. As shown in Table 3, the model presented in Column (1) does not control for time and province fixed effect and does not include control variables. The coefficient for the development of data factor is 0.836, which is significant at the 1% level. After introducing two-way fixed effects in the model shown in Column (2), the coefficient remains at 0.855, with no change in significance, demonstrating strong robustness. Further, after incorporating control variables into the model shown in Column (3), the regression coefficient for the development of data factor remains significantly positive, indicating its stable promoting effect in enhancing economic resilience. This thereby validates the research hypothesis H1 proposed in this paper.

Table 3. Benchmark regression results.

Variable	(1)	(2)	(3)
	RES	RES	RES
DAT	0.836***	0.855***	0.824***
	(0.039)	(0.087)	(0.080)

Continued

IND			−0.315***
			(0.071)
ECO			0.006***
			(0.002)
FIN			0.303
			(0.219)
URB			0.040
			(0.095)
REV			−0.046
			(0.050)
_cons	0.102***	0.099***	0.157**
	(0.004)	(0.011)	(0.077)
Time fixed	No	Yes	Yes
Province fixed	No	Yes	Yes
R^2	0.788	0.934	0.944
Observations	390	390	390

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Values in parentheses are standard errors. The same applies below.

4.2. Endogeneity and Robustness Tests

To ensure the reliability of the benchmark regression conclusions, this paper conducts a series of tests targeting potential endogeneity issues and estimation robustness.

4.2.1. Endogeneity Test

To mitigate endogeneity issues in the benchmark model, this paper employs the Two-Stage Least Squares (2SLS) method, selecting the number of fixed-line telephones in 1984 as an instrumental variable for the development of data factor (Zhao et al., 2020). The rationale for this choice is as follows. On the one hand, due to the significant path-dependence mechanism in technological development, the early fixed-line telephone networks, as physical carriers for information transmission, shaped the layout of subsequent Internet infrastructure and the trajectory of technological adoption. Studies by researchers such as Huang et al. (2019) suggest that the popularization of the Internet in China technically originated from the widespread adoption of fixed-line telephones, and regions with historically high fixed-line telephone penetration rates are also likely to have high Internet penetration rates in recent years. Therefore, selecting this variable as an instrumental variable satisfies the relevance hypothesis. On the other hand, with technological iterations, the direct impact of traditional communication tools like fixed-line telephones on the current economy has diminished, meeting the exogeneity condition. Since this variable is cross-sectional data and cannot be directly used in a panel model, it is multiplied by the number of Internet users in the pre-

vious year to construct an instrumental variable with a temporal dimension. To enhance the robustness of the test results, the first-order lag of the development of data factor is also used as another instrumental variable (Xia et al., 2023). The test results are shown in Table 4. The regression results in Column (1) and Column (3) both indicate a significant correlation between the instrumental variable and the independent variable. Meanwhile, both the under-identification test (Kleibergen-Paaprk LM) and the weak identification test (Cragg-Donald Weak Wald F) significantly reject the null hypothesis, indicating that the selection of instrumental variables is reasonable and effective. Based on this, the estimation results in Column (2) and Column (4) show that the impact of data factor on economic resilience remains significantly positive at the 1% level, suggesting that the core conclusion of the benchmark regression still holds after controlling for endogeneity issues.

Table 4. Test results (2 SLS).

Variable	(1)	(2)	(3)	(4)
	DAT	RES	DAT	RES
DAT		1.778***		0.845***
		(0.158)		(0.050)
IV1	0.177***			
	(0.025)			
IV2			1.023***	
			(0.013)	
_cons	−0.108***	0.175***	0.003	0.077***
	(0.023)	(0.031)	(0.006)	(0.017)
Under-identification test (Kleibergen-Paaprk LM)	44.826***		43.021***	
	(0.000)		(0.000)	
Weak identification test (Cragg-Donald Weak Wald F)	56.509		5908.741	
	(16.38)		(16.38)	
Control variables	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes	Yes
R^2	0.684	0.459	0.979	0.822
Observations	390	390	360	360

4.2.2. Time Lag Test

To further examine the credibility of the benchmark regression results, this paper applies a second-order lag to the core independent variable (the development of data factor) to capture the persistence of its impact and reduce concurrent interference. The test results are shown in Table 5. The regression results in Column (1) indicate that after introducing the lagged term, the development of data factor

still significantly promotes economic resilience, which is consistent with the benchmark regression conclusion.

Table 5. Robustness test results.

Method	(1) Second-order lag of independent variable	(2) Adjusting the sample size	(3) Replace the independent variable	(4) Replace control variables	(5) Adjusting the sample scope
Variable	RES	RES	RES	RES	RES
DAT	0.824***	0.824***	0.084***	0.644***	1.014***
	(0.088)	(0.088)	(0.005)	(0.085)	(0.112)
*L*2.DAT	0.696***				
	(0.097)				
_cons	0.128	0.157*	−0.003	0.151***	0.331***
	(0.114)	(0.081)	(0.062)	(0.028)	(0.089)
Control variables	Yes	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes	Yes	Yes
R^2	0.939	0.944	0.958	0.949	0.936
Observations	330	390	390	390	338

4.2.3. Adjusting the Sample Size

Considering that the sample size may affect estimation accuracy, this paper employs the bootstrap method for repeated sampling to enhance the robustness of the inferences. The results in Column (2) of Table 5 indicate that the estimated coefficient of the development of data factor remains significant in the simulated samples, suggesting that the core conclusion of the benchmark regression is less affected by sample randomness.

4.2.4. Replacing the Independent Variable

To mitigate potential interference from variable measurement methods on the results, this paper re-measures the development of data factor using principal component analysis and conducts regression tests again. The regression results in Column (3) of Table 5 show that the core conclusion of the benchmark regression still holds, indicating that the conclusion exhibits good robustness to different measurement methods for independent variables.

4.2.5. Replacing Control Variables

To control for the impact of potential omitted factors that evolve over time on economic resilience, this paper interacts all control variables in the benchmark model with time trend terms (using 2010 as the base year) to form a new set of control variables for estimation. The regression results in Column (4) of Table 5 demonstrate that, after considering the temporal heterogeneity of variable impacts, the coefficient for the development of data factor remains significantly pos-

itive.

4.2.6. Adjusting the Sample Scope

Finally, to enhance the generalizability of the benchmark regression conclusion, this paper re-estimates the model after excluding samples from municipalities directly under the central government, which may possess unique characteristics. The regression results in Column (5) of Table 5 reveal that, after adjusting the sample, the positive impact of development of data factor on economic resilience remains robust, indicating that the core conclusion of the benchmark regression exhibits good generality across different sample scopes.

4.3. Analysis of Regional Heterogeneity

To thoroughly investigate the regional heterogeneity in the impact of development of data factor on economic resilience, this paper conducts examinations from three dimensions: the geographical location, the development of data factor, and the foundational level of economic resilience itself.

Firstly, from the results of the regional heterogeneity test (see Table 6), there are significant regional differences in the impact of development of data factor on economic resilience. In the eastern, central, and western regions, the coefficients of development of data factor are all positive at the 1% significance level, indicating a robust enhancing effect on economic resilience. In the northeastern region, the coefficient of development of data factor fails to pass the significance test, preventing us from making statistically meaningful inferences. Among them, the central region has the highest coefficient, reflecting that data factor may have a stronger marginal effect in this region. This outcome may be related to the characteristics of the industrial structure and development stage in the central region. In recent years, the central region has been at a critical juncture of transitioning from traditional industries to digital and intelligent ones. The input of data factor can significantly enhance its industrial efficiency and optimize resource allocation, thereby unleashing greater incremental effects. In comparison, the eastern region has already reached a relatively mature level in terms of digital infrastructure and utilization of data resources, resulting in relatively diminishing marginal effects. Meanwhile, constrained by its relatively poor foundational conditions and level of industrial agglomeration, the western region experiences a relatively weaker driving effect from the data factor. In summary, the impact of data factor development on economic resilience exhibits notable spatial gradient characteristics, suggesting that relevant policies should be tailored to regional realities and implement differentiated strategies when promoting data factor development.

Secondly, to examine the heterogeneity in the impact of differences in the level of data factor development on economic resilience, this study divides the sample into a "high-level data factor development group" and a "low-level data factor development group" based on the data factor development level of each province, using the national average as the dividing standard. Regression tests are then conducted separately to reveal differences in the impact of development of data factor

on economic resilience at different development stages. The results are shown in Columns (1) and (2) of Table 7. In the high-level data factor development group, the coefficient of DAT is 0.785, while in the low-level group, it is 0.957, indicating that the promoting effect of data factor development on economic resilience is more pronounced in regions with lower levels of data factor development. This may imply that in regions with weaker foundations in data factor, improving the level of data factor development can bring greater marginal benefits, thereby more effectively enhancing economic resilience.

Table 6. Results of geographical location heterogeneity test.

Variable	(1)	(2)	(3)	(4)
	RES (eastern)	RES (central)	RES (western)	RES (northeastern)
DAT	0.825***	1.108***	0.880***	−0.008
	(0.111)	(0.196)	(0.138)	(0.133)
Control variables	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes	Yes
R^2	0.943	0.949	0.930	0.978
Observations	130	78	143	39

Table 7. Results of heterogeneity test on development of data factor and economic resilience.

Region	(1)	(2)	(3)	(4)
	High-level data factor development group	Low-level data factor development group	High-level economic resilience group	Low-level economic resilience group
Variable	RES	RES	RES	RES
DAT	0.785***	0.957***	0.781***	0.376***
	(0.109)	(0.130)	(0.121)	(0.115)
Control variables	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes	Yes
R^2	0.937	0.930	0.948	0.898
Observations	130	260	143	247

Finally, to further analyze the impact mechanism of differences in economic resilience levels on how the development of data factor empowers the enhancement of economic resilience, this study divides the sample into a "high-level economic resilience group" and a "low-level economic resilience group" based on the varying levels of economic resilience across provinces. Subsequent analyses are then conducted separately to explore the differences in the enhancing effect of data factor development on economic resilience at different stages of economic resilience development. The results are shown in Columns (3) and (4) of Table 7.

The results indicate that the coefficient of development of data factor in the high-level economic resilience group is significantly larger than that in the low-level group. This not only suggests that in regions with weaker economic resilience, the enabling role of data factor may be constrained by local overall development conditions but also implies that in regions with inherently stronger economic resilience, data factor can be more efficiently absorbed and utilized, thereby further consolidating and enhancing their economic resilience, presenting a development trend of "the strong getting stronger."

In summary, we can identify a dual pathway through which the data factor exerts its influence. First, in regions with a relatively low initial level of data factor development, the development of data factor exhibits a pronounced "catching up" effect by addressing foundational shortcomings. Given that the digital infrastructure and data resource systems were originally relatively weak, the investment in the data factor represents a process of building from scratch or strengthening from a weak base, which can significantly enhance information circulation efficiency and resource allocation capabilities in the short term, thereby yielding higher marginal benefits. Second, in regions with inherently high levels of economic resilience, the development of data factor primarily manifests as a synergistic effect that "adds icing on the cake." These regions typically possess a more robust innovation ecosystem and complementary conditions, such as an abundant human capital base, active innovation entities, and high levels of capital accumulation, enabling the data factor to integrate more rapidly and fully into industrial chains and governance systems, and efficiently translate into improvements in economic resilience.

4.4. Test of the Mediating Mechanism

To delve deeper into the pathways through which the development of data factor influences economic resilience, this paper conducts a mechanism test from three dimensions: innovation-driven development, digital finance, and industrial structure optimization, based on the mediating effect models presented in Equation (2) and Equation (3). The results are shown in **Table 8**. Specifically, Columns (1) and (2) examine the mediating role of the innovation-driven effect (IDE). The development of data factor significantly promotes innovation-driven development, which in turn significantly enhances economic resilience. This indicates that data factor can strengthen the adaptability and recovery capacity of the economic system by stimulating scientific and technological innovation activities. Research Hypothesis H2 is thus validated. Columns (3) and (4) investigate the transmission mechanism of the digital finance level (DFL). The development of data factor significantly elevates the digital finance level, and digital finance, as a modern financial infrastructure, further exerts a significant positive impact on economic resilience. This demonstrates that digital finance is an important channel through which data factor empower economic resilience. Research Hypothesis H3 is validated. Columns (5) and (6) analyze the mediating role of industrial structure op-

timization (STR). The development of data factor significantly drives the evolution of the industrial structure towards a more advanced level, and industrial structure optimization also significantly enhances economic resilience. This reflects that the development of data factor indirectly elevates the level of economic resilience by optimizing resource allocation among industries and promoting industrial upgrading. Research Hypothesis H4 is validated.

Table 8. Results of the mechanism test.

Variable	(1)	(2)	(3)	(4)	(5)	(6)
	IDE	RES	DFL	RES	STR	RES
DAT	0.576***		0.285***		0.648***	
	(0.053)		(0.026)		(0.064)	
IDE		0.494***				
		(0.049)				
DFL				1.143***		
				(0.093)		
STR						0.341***
						(0.043)
_cons	−0.190**	0.464***	0.433***	−0.142	−0.105	0.431***
	(0.091)	(0.092)	(0.045)	(0.101)	(0.111)	(0.097)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.977	0.914	0.997	0.922	0.964	0.906
Observations	390	390	390	390	390	390

In summary, the results of the mechanism test indicate that the development of data factor not only directly promote the enhancement of economic resilience but also indirectly contribute through three pathways: stimulating innovation vitality, improving digital financial services, and promoting industrial structure optimization, forming a multi-dimensional and interconnected transmission mechanism.

5. Conclusion and Policy Recommendations

This paper constructs a theoretical analysis framework for how the data factor empowers the enhancement of economic resilience and explores the impact mechanism of data factor on economic resilience using provincial panel data in China from 2011 to 2023. Although this paper strives for rigor in data analysis and model construction, the conclusions may still have certain limitations due to issues such as the insufficient representativeness of the provincial panel data at the micro level and potential subjective biases in index construction. The main con-

clusions are as follows:

1) The development of data factor significantly enhances the level of economic resilience. This core conclusion remains valid after controlling for bidirectional fixed effects, incorporating a series of control variables, and conducting various robustness tests, indicating that the data factor, as a new production factor, plays a fundamental and non-negligible role in enhancing the resistance, recoverability, and adaptability of the economic system to shocks.

2) There are significant regional and developmental stage differences in the impact of data factor on economic resilience. In terms of spatial dimensions, the enhancing effect of data factor on economic resilience exhibits a distinct spatial gradient pattern. The enhancing effect in the central region is higher than that in the western and eastern regions, indicating that the development of data factor in the central region has a stronger driving force in empowering economic resilience. In terms of development level dimensions, the empowering effect of data factor is more pronounced in regions with lower levels of data factor development, suggesting its value in providing "timely assistance" to less developed regions; whereas in regions with high levels of economic resilience, the empowering effect of data factor is stronger, revealing a synergistic promoting relationship between data empowerment and the foundation of regional economic development.

3) Data factor indirectly strengthens economic resilience through multidimensional mechanisms. The results of the mechanism tests indicate that data factor not only directly promotes the enhancement of economic resilience but also exerts indirect effects through three mediating pathways: innovation-driven development, digital finance, and industrial structure optimization. On the one hand, data factor can significantly stimulate the vitality of scientific and technological innovation, thereby enhancing the adaptability and recovery capacity of the economic system; on the other hand, data factor can drive the development of digital finance, improve financial infrastructure, and enhance the efficiency of resource allocation in economic operations; simultaneously, data factor can promote the evolution of industrial structures towards higher levels and optimization, improving overall resilience through structural adjustments and factor reorganization. Thus, the process by which data factor empowers economic resilience is a systematic, multi-level transmission mechanism encompassing technological innovation, financial deepening, and industrial upgrading.

Based on the aforementioned conclusions, this paper proposes the following three policy recommendations:

First, accelerate the construction of data factor infrastructure to solidify the foundation for the development of economic resilience. It is essential to further improve the data infrastructure system and promote the high-quality aggregation, sharing, and circulation of data resources. Relevant departments need to expedite the cultivation of the data factor market, establish a property rights system for data factor that aligns with promoting economic resilience, and enhance the efficiency of data resource allocation. Meanwhile, it is crucial to elim-

inate "data silos" and facilitate the orderly cross-regional and cross-industry flow and integrated application of data, providing a solid institutional guarantee and market environment for data factor to comprehensively empower economic resilience.

Second, implement differentiated and precise regional advancement strategies to overcome the bottleneck of spatial heterogeneity. On the one hand, it is essential to prioritize support for the central region, where the enabling effect of data factor is significant, and develop it into a national data hub with far-reaching influence. On the other hand, for the western and northeastern regions with relatively low levels of data factor development, a "timely assistance" approach should be adopted to strengthen investment in digital infrastructure. Meanwhile, the eastern region, which has a higher level of data factor development, should be encouraged to explore cutting-edge applications, thereby forming a pattern of graded development and collaborative progress.

Third, focus on key transmission channels and establish a collaborative promotion system of "data factor-mechanism-resilience". It is essential to fully leverage the role of data factor in promoting economic resilience through three pathways: innovation-driven development, digital finance, and industrial structure optimization. Firstly, closely adhere to the "innovation-driven" mechanism. Strengthen the construction of an innovation ecosystem empowered by data factor, encourage enterprises to utilize data factor for technological research and development and product innovation, and enhance the efficiency of transforming scientific and technological achievements. Secondly, facilitate the transmission pathway of "digital finance." Accelerate the development of the digital finance system, refine the regulatory framework for financial technology, promote the integration of data and capital factors, and enhance the inclusiveness and flexibility of financial services. Thirdly, effectively leverage the mediating effect of "industrial structure optimization." Promote the optimization and upgrading of the industrial structure, encourage the deep integration of data technology into manufacturing, service, and emerging industries, and elevate the digitalization level and shock-resistance capacity of the entire industrial chain, thereby forming a highly resilient economic system with data factor as its core support.

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Conflicts of Interest

The authors have no competing interests to declare that are relevant to the content of this article.

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