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What Matters for Regional Economic Resilience Amid Multi Shock Situations: Structural or Agency? Evidence from Resource-Based Cities in China

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Abstract: This paper contributes to the study of regional economic resilience by analyzing the characteristics and mechanisms of resilience under different shock situations. The paper focuses on the resistance dimension of resilience and analyzes the mechanisms of influence from structural and agency-based factors. Our findings reflect that the regional economic resilience characteristics of resource-based cities in China in response to the 2008 financial crisis and the COVID-19 pandemic vary significantly. We find that the economic resilience has positive spatial autocorrelation characteristics. The regions with strong ability to deal with the shocks can promote resistance in the surrounding regions through their spatial spillover effect. Both structural and agency-based factors play significant roles in regional economic resilience under different shock situations, but the direction of the effect varies significantly. The agency-based factors have a more important role in regional economic resilience. The findings suggest that the nature of different shock situations deserves greater attention in the analysis of regional economic resilience. The mechanisms of structural and agency-based factors may change under different shock situations, and the spatial correlation characteristics of regional economic resilience and the spatial spillover effects should be taken into consideration.

Keywords: regional economic resilience; multi shock; structural factors; agency-based factors; resource-based cities; China

1. Introduction

In recent years, frequent and uncertain shocks such as the 2008 international financial crisis and the COVID-19 pandemic have had significant impacts on regional economies worldwide [1–4]. The shocks led to a recessionary trajectory in some regions and sluggish economic development, but other regions were able to resist the impact of the shocks and the regional economy recovered rapidly [5]. How regions resist shocks and resume development has attracted significant academic interest [6–10]. Regional economic resilience is considered a key element in explaining differences in regional outcomes in response to shocks [11]. Research on spatio-temporal differences in regional economic resilience and their mechanisms of influence has received widespread attention from academic fields such as regional studies and the policy circles. Based on the core set database of the Web of Science, we found that from 1998 to 2020, the annual growth rate of research papers with "regional resilience" and "economic resilience" as keywords is 22.8%, which suggests that regional resilience research has become a research hotspot.

Resilience was first applied in the field of engineering physics to reflect the ability of a system to recover to its initial state and was later introduced to the fields of ecology and economic geography. The concept of resilience has undergone the development process from

engineering resilience to ecological resilience to adaptive (evolutionary) resilience [12,13]. Holling introduced the concept of resilience to ecology and named it engineering resilience, which assumes that ecosystems have a single equilibrium stable state and reflects the ability of ecosystems to return to equilibrium after a shock [14]. In contrast, ecological resilience assumes that a system has multiple equilibrium stable states, and resilience is used to indicate the ability of a system to absorb the maximum shock before it is transformed from one equilibrium state to another after a shock [12,15]. Both engineering resilience and ecological resilience have the assumption of equilibrium stability, but for complex and massive systems such as the regional economy, which is in a long-term process of change, there is no equilibrium stability. Therefore, resilience was reinterpreted as adaptation (evolutionary) resilience after it was introduced into the regional system [16–19]. Resilience is used to indicate the ability of regional systems to adjust to shocks and shift to sustained regional development or recover to a more optimal path through structural reorganization. For regional economic systems, the conceptual connotation of adaptive resilience is more sensible. Based on this connotation, Martin defined regional economic resilience as the ability of a regional economic system to resist external shocks, to mitigate the impact of shocks, and to recover the pre-shock development trajectory of the region or shift to a new and better development trajectory through adaptation [12]. Regional economic resilience consists of four main interrelated processes: vulnerability, resistance, robustness, and recoverability. Vulnerability indicates the sensitivity of the regional economic system to shocks, whereas resistance denotes the extent to which the region responds to shocks. Both processes are influenced by long-term regional development paths. Robustness indicates the extent to which the regional economic system adapts to shocks, and recoverability signifies the extent to which the regional economic system recovers or shifts to a new development path. The structural and agency aspects play important roles in both processes [12,15,17].

Based on this connotation, most scholars choose two dimensions of resistance and recoverability to measure regional economic resilience [20–22], and typically select core variables such as employment and GDP to analyze [23–25]. Influenced by evolutionary economic geography, existing studies on the mechanisms of influence of regional economic resilience focus more on the structural factors such as industrial structure and less on the agency-based factors of actors such as enterprises and governments. However, agency-based factors play an important role in the process of regional adaptation and adjustment to shocks [26]. The role of agency-based factors on the economic resilience of resource-based regions should not be ignored [27–30]. Moreover, existing studies on the mechanisms of influence have paid insufficient attention to the spatial correlation characteristics of regional economic resilience [25], and the economic resilience of neighboring regions may have mutual influence. The determinants of regional economic resilience remain uncertain, especially in different shock situations, and must be further explored.

With this work, we also aim to broaden the study of regional economic resilience in terms of the nature of shocks. The existing research on regional economic resilience mainly focuses on the international financial crisis situation [10,12]. In recent years, the research on regional economic resilience under the shock of the COVID-19 epidemic has increased rapidly [4]. However, few studies have compared the temporal and spatial characteristics and mechanisms of influence of regional economic resilience under different shock situations. It should be noted that the characteristics of different shock situations are key elements of regional economic resilience. The differences in the scope of influence, degree, and duration of different shocks may lead to changes in the regional economic resilience [4,31].

The international financial crisis primarily affected newly established and export-oriented industries. In contrast, the COVID-19 pandemic affects more industries, especially those related to population. Do regions with a high ability to deal with the financial crisis also perform better in the COVID-19 pandemic? Do the adjustment and transformation measures taken by the region to deal with the financial crisis have a positive impact on the regional response to COVID-19? Does the economic resilience of neighboring regions

have the same spatial correlation under different shock situations? Does the effect of structural and agency-based factors on regional economic resilience change meaningfully under different shock situations? Answering these questions is the focus of our paper. The knowledge generated by this study can expand the research scope of regional economic resilience and provide a reference for regions to actively respond to a variety of uncertain shock situations in the future in order to maintain economic stability and sustainable development. There is an urgent need to conduct research on regional economic resilience under different shock situations.

Resource-based cities mainly rely on the exploitation and primary processing of natural resources such as forests and minerals. Resource-based cities, which have made a significant contribution to resource demand, are unique in the sense that the extractive industry has a high degree of specialization. Furthermore, the industrial structure of resource-based cities is typically rigid and singular, and the industrial development is highly dependent on resources. The industrial chain is relatively low-end, and environmental degradation is often serious in resource-based cities. As a result, resource-based cities are typically vulnerable to external shocks such as the global financial crisis [10]. At present, there are many studies on the regional economic resilience of China's resource-based cities in the context of financial crisis [28,30], but there are few studies on the economic resilience of resource-based cities in the context of the COVID-19 pandemic. Carrying out such studies can help us better understand the characteristics of regional economic resilience. In addition, the singular industrial structure of China's resource-based cities has possibly encouraged the existing research to focus more on the impact of structural factors on regional economic resilience in the context of financial crises. However, China's resource-based cities have a large proportion of state-owned economy and are deeply affected by the planned economy. The role of agency-based factors has been less studied, especially under pandemic shock. The agency-based factors, with the government as the main actor, play an important role in the mechanisms of influence of regional economic resilience [4]. It is necessary to explore these mechanisms and the differences in structural and agency-based factors on the economic resilience of resource-based cities under different shock situations.

Therefore, in this paper, we take resource-based cities in China as the research object to explore the differences in regional economic resilience characteristics and the mechanisms of influence under the international financial crisis and the COVID-19 pandemic. We provide evidence of how the regional economic system responds to different shock situations. This paper measures the resistance index through GDP, which reflects the regional economic resilience. The spatial econometric model was used to analyze the mechanisms of influence and the spatial spillover effect of regional economic resilience. This study is organized as follows. Based on the general overview of regional economic resilience in the introduction, Section 2 provides hypotheses about what matters for regional economic resilience to the financial crisis and the COVID-19 pandemic. Section 3 introduces the study area, methodology, and data. Section 4 discusses the determinants of regional economic resilience in resource-based cities in China under the shock situations. Section 5 concludes the paper by discussing the key implications of the findings.

2. Possible Influencing Factors of Regional Economic Resilience under Multi Shock Situations: Structural Factors and Agency-Based Factors

Regional economic resilience is influenced by multidimensional factors [15,32], including a range of factors such as industrial structure, labor market, government control, and financial environment [12,17]. Influenced by evolutionary economic geography, most studies emphasize the significant role of inherent and inherited structural factors in regional economic resilience. Such structural factors mainly include industrial structure, openness to the global economy, and organizational systems. Structural factors such as industrial structure and institutional forms formed by long-term path dependence affect the vulnerability of the regional economic system to shocks [18,30]. Moreover, agency-based factors play a role in adapting to structural factors, which in turn influence regional economic

resilience [12,17,27]. Studies find that regions with poorer structural factors could still have higher economic resilience, which is largely a function of the agency-based factors at play [33,34]. Especially for resource-based regions with a large share of the state-owned economy, government enablers play a more significant role in economic resilience [4,30,35]. However, current research has placed excessive emphasis on structural factors and less focus on agency-based factors [36,37].

The COVID-19 pandemic differs significantly from the 2008 financial crisis in terms of scope, magnitude, and duration of impact. COVID-19 is a public health emergency shock, which has no targeted industries, although industrial activities related to population movement and clustering are especially affected. Structural factors that contribute to regional economic resilience in financial crises may play a less significant role or even an opposite role in pandemic shocks [4,38]. Moreover, the series of measures taken by the government to control the spread of the epidemic, such as shutting down production, locking down cities, and limiting population clustering, have played an important role in the regional response to such shocks. The agency-based factors may be more significant compared to those of the financial crisis [39].

2.1. Structural Factors

2.1.1. Industry Structure

The industrial structure is considered a key factor affecting regional economic resilience [10,16,40]. Existing studies have mainly focused on debating whether a diversified or specialized industrial structure is more conducive to regional economic resilience. Most studies have found that a diversified industrial structure is more conducive to regional economic resilience, mainly because a diversified structure can play a "shock absorber" role, preventing industry-specific shocks from spreading to the entire regional system. Specialized industrial structures, on the contrary, are more likely to be exposed to shock, which can lead to the rapid spread of shocks to other industries, eventually causing regional economic recession and limiting regional economic resilience [41–43].

We believe that industrial structure plays an important role in the financial crisis and the COVID-19 pandemic. Because of the close relationship between industries, the specialized industrial structure may lead to the rapid spread of the shock to other departments, resulting in the weakening of regional economic resilience to deal with the shock. In the long run, diversified structures may be beneficial to regional resistance to COVID-19 pandemic, due to the role of "shock absorber". In a diversified industrial structure, some industries are less affected by the shock [38], and the regional economic resilience to the shock is higher. We thus hypothesize:

H1. *Industrial structure plays an important role in regional economic resilience. Compared to diversified industrial structures, regions with specialized industrial structures have lower regional economic resilience in both the financial crisis and COVID-19 shock situations.*

2.1.2. Basic Industrial Composition

The basic industrial composition reflects the structure of different industrial sectors in the regional economic system. It is generally believed that regions with a high ratio of secondary industries are less economically resilient to financial crises and, in comparison, regions with a high ratio of tertiary industries are more resilient to shocks [44]. The secondary industry has a high degree of integration into the global economy. For China's resource-based cities, the secondary industry is still dominated by traditional resource industries [10], and is more vulnerable to the demand of the international market. Under the financial crisis situation, the demand of the resource market decreases, and resource-based cities with a high proportion of the secondary industry may be more seriously affected by the shock, which limits the regional economic resilience [30].

However, under the COVID-19 shock situation, the role of industrial composition may change [4,38]. COVID-19 has a negative impact on both secondary and tertiary industries.

In fact, the tertiary industry, which is highly dependent on population concentration [45,46], is more severely affected by the impact of the epidemic. In response to the COVID-19 pandemic, China's secondary industry was the first to resume production, whereas the resumption of the tertiary sector activities came much later than that of the secondary industry. The path dependence of China's resource-based cities is serious, and the urban tertiary sector is still dominated by traditional service industries, which is closely related to population agglomeration. At present, the COVID-19 epidemic has not ended, and its impact on the tertiary industry in resource-based cities may be more lasting. With the resumption of industrial activities, the secondary industry in resource-based cities has developed moderately. Due to the impact of the epidemic, the value added of China's accommodation and catering industry in 2020 decreased by 13.1% compared to 2019. However, the value added of industry and construction increased by 2.4% and 3.5%, respectively, compared to 2019. We thus hypothesize:

H2. *The structural shares of the secondary and tertiary sectors have an impact on regional economic resilience of resource-based cities. However, under different shock situations, the impact of industrial composition on regional economic resilience may change significantly.*

2.1.3. Opening to the Global Economy

The degree of opening includes the degree of cooperation outside the region, and can also represent the degree of embedding in the global economy or participating in the global division of labor. A high degree of economic openness means that the region can attract external funds, technologies, and resources, export products, and services to the outside world, and improve the efficiency level of the regional economic system. A region relying on its excellent technological environment to promote innovation and adapt to the new environment can improve the regional ability to cope with shocks [20,23,47]. However, the degree of opening to the outside world is a double-edged sword in regional economic resilience. When the shock seriously affects the regional import and export departments, the regions with a high degree of economic openness may be more seriously impacted, which limits the regional ability to deal with the shock [31,48,49]. Both the 2008 financial crisis and the COVID-19 shock have the characteristics of a global crisis, and both have had a significant impact on the imports and exports of resource-based cities in China. We thus hypothesize:

H3. *Regions with a high degree of external openness are less resilient to shocks.*

2.2. Agency-Based Factors

2.2.1. Investment Decisions

In addition to the structural factors mentioned above, the role of agency-based factors in regional economic resilience is gaining increasing attention [44,50]. As a global shock, the investment of actors may be more important in regional responses to shocks [42,51]. Investment decisions can guide the optimization and adjustment of regional industrial structure to change the development mode and sustain continued economic development, and affect the level of regional economic resilience to cope with the shock [19,31,52]. Appropriate investment decisions by enterprises and industries can limit the influence of shocks on the economic system [12]. Timely investment decisions can help the regional economic system resist shocks, sustain development, and restore the original development path or create a new path, so as to improve the regional economic resilience to the shock [53]. We thus hypothesize:

H4. *The investment decisions contribute to regional economic resilience.*

2.2.2. Pandemic Control

　　The COVID-19 pandemic is a global public health emergency, and governments play the most critical role in controlling the spread of the outbreak and protecting human safety [4,54,55]. In response to the impact of the epidemic, the regional systems took a series of measures such as limiting the concentration and movement of people and shutting down production, which effectively controlled the spread of the pandemic [56–58], but also, as a result, led to a temporary stagnation of the regional economy [38]. However, as the pandemic was effectively controlled in China, the government actively encouraged and supported industrial enterprises to gradually resume work and production, actively responding to the impact of the pandemic through a series of measures. According to the National Bureau of Statistics, China is the only major world economy with a positive GDP growth rate in 2020. We thus hypothesize:

H5. *The government's pandemic control plays an important role in regional economic resilience. State agencies involved in the control of COVID-19 will promote regional resistance to the COVID-19 shock.*

3. Study Area and Research Methods

3.1. Study Area

　　China's resource-based cities can be defined in terms of extraction function intensity, output coefficient, and level of resource contribution. According to the "Plan of Sustainable Development for Resource-based Cities in China (2013–2020)" issued by the State Council, there are 262 resource-based cities in China, including 126 prefecture-level cities [30]. Considering the availability of data and the completeness of administrative divisions, we selected 114 prefecture-level resource-based cities as the research subjects (Figure 1). The stable economic development of resource-based cities plays an important role in the overall development of the country, with the GDP of 114 resource-based cities accounting for 23.4% and 19.5% of the country's overall GDP in 2007 and 2019, respectively. The proportions of the three industrial structures of resource-based cities in 2007 and 2020 are 13:55:32 and 12:42:46, respectively.
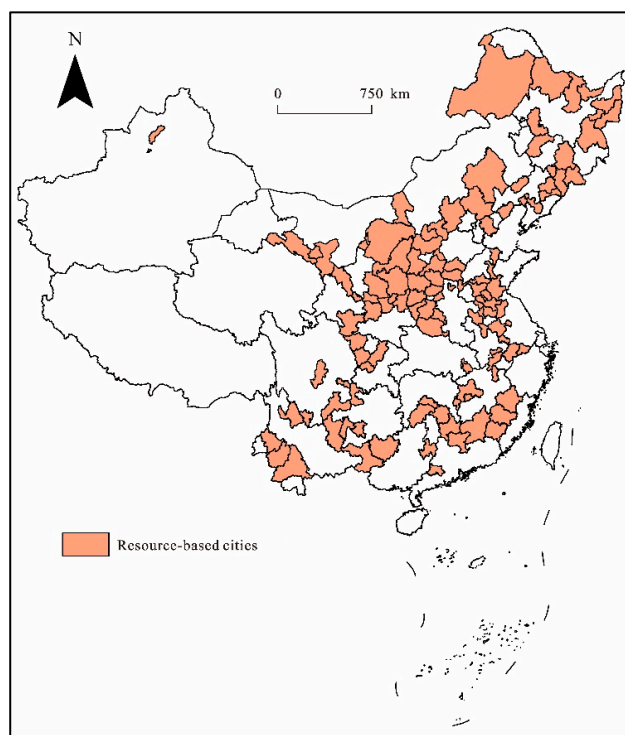
Figure 1. The location of resource-based cities in China.

3.2. Research Methodology

3.2.1. Regional Economic Resilience Measurements

Since the COVID-19 pandemic has not come to an end, the regional economic resilience is primarily about vulnerability and resistance, although it is partially about recoverability [4]. Moreover, in order to compare with the 2008 international financial crisis, we focus on the resistance dimension of regional economic resilience.

To quantitatively evaluate the resistance of cities, we followed the method proposed by Martin to compare the actual amount of change in urban GDP with the expected amount of change [17]. The calculation formula of urban expected economic output change is as follows:

$$\left(\Delta R_i{}^{t+k}\right)^{expected} = \sum_{j}^{n} R_{ij}{}^{t} \bullet G_n{}^{t+k} \tag{1}$$

where $R_{ij}{}^{t}$ is the output value of industry j in region i at starting time t, the base year, and $G_n{}^{t+k}$ is the change rate of the national output in $t + k$ time. Then, the resistance can be expressed as follows:

$$Resistance = \frac{\left(\Delta R_i{}^{contraction}\right) - \left(\Delta R_i{}^{contraction}\right)^{expected}}{\left|\left(\Delta R_i{}^{contraction}\right)^{expected}\right|} \tag{2}$$

$\left(\Delta R_i{}^{contraction}\right)$ is the actual change in the economic output of city i during the contraction period. A resistance that is larger than 0 means that the impact of the shock on the region is less than the national average, and vice versa.

Under the COVID-19 shock situation, 2019–2020 was chosen as the contraction period to be measured. Under the 2008 financial crisis situation, the GDP growth rate of resource-based cities was largely consistent with the evolution of China's GDP growth rate, which peaked in 2007 and then began to decline, reaching its first trough in 2009. Moreover, considering the comparison with the pandemic shock, we chose 2007–2009 as the contraction period to measure the regional economic resilience to financial crises.

3.2.2. Spatial Econometric Model

Spatial Autocorrelation Moran Index

Tobler's first law of geography proclaims that attributes are spatially interrelated. The closer the distance, the greater the correlation. Therefore, regional economic resilience among resource-based cities may not be independent of each other. Cities with a high regional economic resilience may affect the resilience of their surrounding cities because of the interaction and connection between them. In other words, there may be a spatial spillover effect on regional economic resilience; that is, the economic resilience of cities in the region may have a positive or negative spillover effect on the resilience of surrounding cities. Therefore, the spatial correlation of regional economic resilience needs to be tested, which requires the spatial autocorrelation Moran index. If the results are apparently spatially correlated, the mechanisms should be analyzed with a spatial econometric model that considers the spatial correlation characteristics of regional economic resilience. The Moran index is as follows:

$$Moran's\ I = \frac{\sum\limits_{i=1}^{n}\sum\limits_{j=1}^{n} W_{ij}\left(Z_i - \overline{Z}\right)\left(Z_j - \overline{Z}\right)}{S^2 \sum\limits_{i=1}^{n}\sum\limits_{j=1}^{n} W_{ij}}, S^2 = \frac{1}{n}\sum\limits_{i=1}^{n}\left(Z_i - \overline{Z}\right), \overline{Z} = \frac{1}{n}\sum\limits_{i=1}^{n} Z_i \tag{3}$$

where S^2 represents the variance, Z represents the mean, Z_i represents the observed value of the city i, n represents the number of research objects, and W_{ij} is the spatial weight matrix. We used the near-space weighted matrix; that is, the weight between adjacent areas is 1, and the weight between non-adjacent areas is 0. If *Moran's I* > 0, it indicates a positive

spatial autocorrelation; if *Moran's I* < 0, it indicates a negative spatial autocorrelation; and if *Moran's I* = 0, it indicates no spatial autocorrelation.

Spatial Econometric Model

The spatial econometric model considers the interaction between neighboring regions when the subjects are not independent. The most used spatial econometric models are the spatial lag model (SLM) and the spatial error model (SEM) [25,59], which can be expressed as Equations (4) and (5), respectively:

$$Y_{it} = \rho W Y_{it} + \beta X_{it} + \varepsilon_{it} \tag{4}$$

where Y_{it} is the dependent variable matrix of region i in the t period, X_{it} is the independent variable matrix of region i in the t period, and W_{ij} is the spatial weight matrix. β reflects the parameter values of variable X_{it}. ρ is the spatial autoregressive coefficient, and ρ reflects the influence of adjacent areas on the area i. In this paper, it indicates that the neighboring city with a high regional economic resilience may have positive or negative spillover effects on the resilience of city i through the communication and contact with city i. This spillover effect enhances or limits i city's economic resilience. ε is the residual value. The SLM mainly discusses whether the dependent variable of region i is affected by the spillover effect of its neighboring areas.

$$\begin{aligned} Y_{it} &= \beta X_{it} + \mu_{it} \\ \mu_{it} &= \lambda W \mu_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

where μ_{it} and ε_{it} are random disturbance terms, and λ is the spatial error autocorrelation coefficient, which reflects the influence of adjacent regions' error impacts on area i. It indicates that the adjacent high regional economic resilience city has spatial dependence due to the relevant factors not considered in the model error term. This leads to the error impact of cities with a high regional economic resilience, which has a positive or negative spillover effect on i city's economic resilience. The spatial dependence of the spatial error model exists in the error term, which measures the adjacent region's error impact on the dependent variable.

3.3. Indicator Selection and Data Description

Based on the exposition and assumptions explained in Section 2 and considering different shock situations characteristics, in this paper, we focus on the effects of structural and agency-based factors on the economic resilience of resource-based cities in China. Among them, structural factors include basic industrial composition, industry structure (including diversification and specialization), and economic openness. Agency-based factors include investment decisions and pandemic control. We chose GDP per capita and the number of hospital beds as the control factors to reflect the level of regional economic development and medical foundation. The specific contents of relevant indicators are shown in Table 1.

Table 1. Indicator system.

Variable	Definition	Unit
Regional economic resilience	The index of resistance	
Industrial composition	The ratio of the added value of secondary industry and territory industry (IND)	%
Specialization	The index of HHI (SPEC)	
Diversification	The index of EI (DIV)	
Economic openness	The proportion of total import and export trade in GDP (OPE)	%
Investment decisions	The ratio of fixed asset investment and GDP (FIX)	%
	The ratio of local fiscal expenditure and GDP (FIS)	%
Pandemic control	The number of confirmed cases (COF)	Person
Economic level	GDP per capita (GDP)	RMB/person
Medical foundation	The number of hospital beds (HOP)	Set

Firstly, the basic industrial composition reflects the characteristics and development stages of regional economic industrial activities. We use the ratio of the output value of the secondary and tertiary sectors as the reflective index. Secondly, the industry structure can be reflected by the degree of industrial specialization and diversification. Specialization is chosen as the Herfindahl–Hirschman index—the higher its value, the higher the degree of industrial specialization of the city. Diversification is chosen as the Entropy index—the higher its value, the higher the degree of industrial diversification of the city. Both are calculated by the number of employed persons in different industries. The specialization formula is as follows:

$$SPEC_i = \sum_{j=1}^{k} S_{ij}^2 \tag{6}$$

where $S_{i,j}$ is the proportion of employment in industrial j in total employment in city i.

The diversification index is calculated by the formula:

$$DIV_i = \sum_{j=1}^{k} V_{i,j} \bullet \left(ln \frac{1}{V_{i,j}} \right) \tag{7}$$

where $V_{i,j}$ is the ratio of the number of units employed in industry j in region i to the total number of units employed in region i.

Our data were derived from the *China City Statistical Yearbook* and the *China Statistical Yearbook* for 2007–2009 and2019–2020, and the National Health Commission.

4. Research Results

4.1. Differences in Regional Economic Resilience under Multi Shock Situations

Based on Equations (1) and (2), we measured the economic resistance under the international financial crisis and the COVID-19 pandemic; the results are in Figure 2.
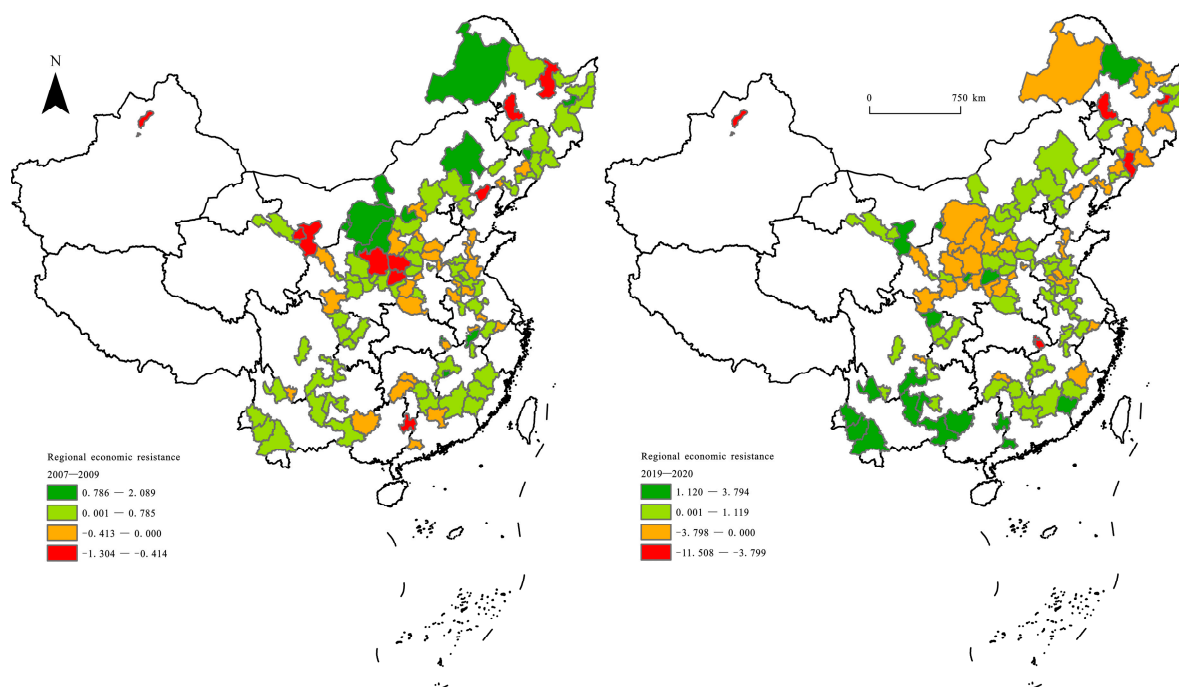
Figure 2. The distribution of economic resistance to financial crisis and COVID-19 shock.

The results show that China's resource-based cities have significant differences in their ability to cope with different shock situations. Some cities have high resistance in the financial crisis situation, but their resistance is low during the COVID-19 pandemic. This shows that different shocks result in significant differences in the regional ability to deal

with shocks. The structural adjustment and other measures taken by resource-based cities in response to the financial crisis may not have the expected roles in the COVID-19 shock situation. Furthermore, there may be significant differences in the mechanisms of influence of resource-based cities in response to different shock situations.

Under the financial crisis, China's resource-based cities typically have high economic resistance, and the average economic resistance is 0.228. Only 38 cities have a resistance of less than 0, accounting for 33% of the number of research units. The regional economic resilience shows a trend of agglomeration distribution in space. Cities with low economic resistance are mainly distributed in traditional old industrial cities such as Shanxi, Shaanxi, Guangdong, Guangxi, and Henan. In contrast, the economic resistance of China's resource-based cities is relatively poor under the COVID-19 pandemic shock, and the average economic resistance is 0.037. The economic resistance of 40 cities is less than 0, accounting for 35% of the number of research units. Cities with low economic resistance are mainly distributed in Shaanxi, Inner Mongolia, Liaoning, Jilin, and Heilongjiang. The regional economic resilience also shows the characteristics of spatial agglomeration distribution.

In order to verify whether the economic resilience of resource-based cities has spatial correlation characteristics, the Moran index of regional economic resilience is measured through Equation (3). The results are shown in Table 2.

Table 2. The results of the global Moran's index.

	2007–2009	2019–2020
Moran's I	0.310	0.270
p value	0.001	0.003

Table 2 shows that the spatial autocorrelation coefficients of regional economic resilience under different shock situations are positive and passed the significance test at the 1% level. It shows that the economic resilience of resource-based cities does not exist in isolation, and the economic resilience of adjacent regions is closely related. Resource-based cities with high or low economic resilience have a cluster distribution pattern, which suggests that regional economic resilience may have spatial spillover effect. When identifying the decisive factors of regional economic resilience, it is necessary to take the spatial correlation characteristics of regional economic resilience into account and analyze it with the help of the spatial econometric model. However, the global *Moran's I* cannot reflect the spatial distribution characteristics of economic resilience. Therefore, we visualized Moran scatter maps with the help of ArcGIS. The spatial agglomeration types of regional economic resilience are divided into four categories: high–high, low–high, low–low, and high–low, which represent the distribution of high local economic resilience and high economic resilience in surrounding areas, the distribution of low local economic resilience but high economic resilience in the surrounding areas, the distribution of low local economic resilience while low economic resilience in the surrounding areas, and the distribution of high local economic resilience but low economic resilience in the surrounding areas, respectively. The results are shown in Figure 3.

The results show that under different shock situations, the economic resilience of resource-based cities presents different types of agglomeration characteristics. Cities with high (low) levels of regional economic resilience tend to be concentrated, and there may be spatial spillover effects in regional economic resilience. Under the COVID-19 pandemic shock, cities with low economic resilience are mainly concentrated in Shaanxi and Northeast China.
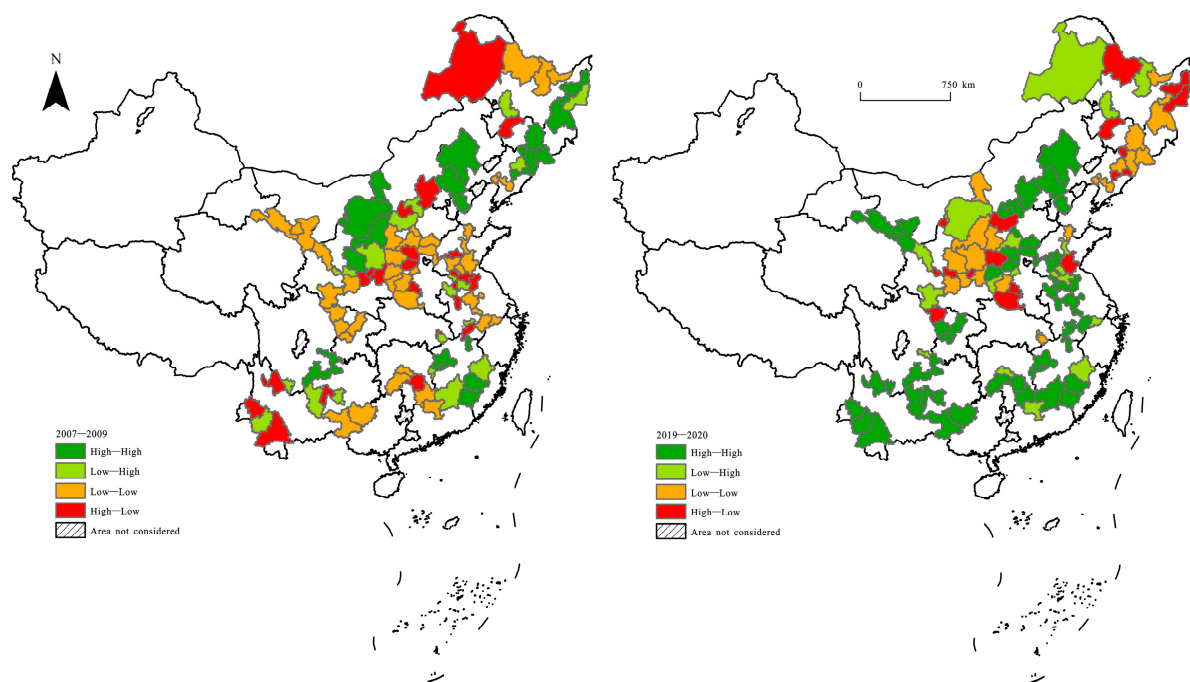
Figure 3. Moran scatter diagram of regional economic resistance.

4.2. Determinants of Regional Economic Resilience in Multi Shock Situations

Based on Equations (4) and (5), the influencing factors of regional economic resilience under different shock situations are analyzed through the spatial econometric model. The results are shown in Table 3.

Table 3. Regression results under different shock situations.

	Financial Crisis (2007–2009)			COVID-19 Shock (2019–2020)		
	OLS	**SLM**	**SEM**	**OLS**	**SLM**	**SEM**
constant	−1.685	−0.529	−1.682	27.918 ***	27.408 ***	28.493 ***
SPEC	−3.961 *	−4.227 **	−3.159 *	−11.159	−10.143	−10.473
DIV	−1.093	−1.251 *	−1.014	−4.723 ***	−4.108 **	−3.912 **
IND	−0.242 ***	−0.221 ***	−0.228 ***	0.825 **	0.872 **	0.792 **
OPE	0.022	−0.007	−0.009	0.683	0.665	0.774
FIX	1.020 ***	1.019 ***	1.137 ***	0.726 **	0.658 *	0.688 **
FIS	1.799 *	1.501	1.670	−9.799 ***	−9.728 ***	−9.827 ***
GDP	0.477 ***	0.389 ***	0.432 ***	−1.467 **	−1.521 **	−1.622 **
COF				−0.362 ***	−0.354 ***	−0.349 ***
HOP				−0.071	−0.078	−0.096
λ / ρ		0.239 ***	0.306 ***		0.146 *	0.137
R^2	0.364	0.424	0.437	0.301	0.327	0.318
Log-L	−66.051	−61.807	−61.405	−210.692	−209.013	−209.723
AIC	148.102	141.163	138.809	441.384	440.025	439.446
SC	169.991	166.239	160.699	468.746	470.124	466.808
LM-LAG	8.478 ***			3.961 **		
RLM-LAG	0.873			2.739 *		
LM-ERR	8.005 ***			1.902		
RLM-ERR	0.401			0.680		

***, **, * denote $p < 0.01$, $p < 0.05$, $p < 0.1$, respectively.

According to the criterion of Anselin [59], when LM-LAG is significant but LM-ERR is not significant, the SLM model is selected; otherwise, the SEM model is selected. When LM-LAG and LM-ERR are significant, and RLM-LAG is significant, the SLM model is selected; otherwise, the SEM model is selected. In addition, it can be judged in combination

with Log-L, AIC, and SC criteria. The larger the Log-L value, the smaller the AIC and SC values, and the better the model construction. Based on this criterion, in the following, the SEM model is selected under the financial crisis and the SLM model is selected for analysis under COVID-19 shock. At the same time, it can be seen that the regression models constructed after considering the characteristics of spatial correlation are better than the traditional OLS regression.

Table 3 shows that under the 2008 international financial crisis, structural factors had a significant effect on the economic resilience of China's resource-based cities. The specialized industrial structure is not conducive to regional resistance in this shock situation. This is mainly because the specialized structure leads to the excessively close connection between industries in resource-based cities. After the financial crisis, the resource industry in resource-based cities was seriously affected by the international market prices, resulting in the slow development of the extractive industry. Furthermore, the close relationship between industries allowed the shock to quickly spread from the specific industry to other related industries, causing economic decline and limiting the ability of the region to resist the shock. Furthermore, the increase in the secondary industry proportion is not conducive to regional resistance to this shock. The financial crisis has led to a decline in the demand for industrial products such as industrial raw materials in foreign markets. The path dependence of China's resource-based cities is significant, and the internal structure of the secondary industry is far from ideal, dominated by extractive industries and highly dependent on the import and export markets. In comparison, the proportion of high-end equipment manufacturing industry is low. For a long time, the increase in the proportion of the secondary industry has depended on the expansion of extractive industries, leading to the decline in the ability of resource-based cities to resist financial crisis. When the development of the secondary industry is limited, the tertiary industry can become the main force to maintain regional development and resist the shock.

Agency-based factors have a significant role in promoting regional economic resilience, and the degree of influence is higher than that of structural factors. The agency-based factor of investment decisions plays an important role in regional economic resilience. The improvement of fixed asset investment enhances the economic resistance of the region to deal with the financial crisis. A series of stimulus plans such as the "Four Trillion Revitalization Strategy" proposed by the Chinese government to resist the shock has promoted the development of real estate, stimulated the demand for industrial products in the domestic market, maintained the sustainable development of the economy, and helped enterprises resist the shock.

At the same time, the level of local economic development has a significant role in promoting regional economic resilience. The initiatives by different agencies need strong financial support, which is only possible with robust local economic development. Therefore, in the context of this shock, the level of economic development plays a promoting role. The spatial autocorrelation coefficient has passed the significance test and is positive, indicating that the regional economic resilience does not exist in isolation. Cities with high resistance can interact with surrounding cities through relevant processes not considered in the model. These processes that have not been considered have spatial spillover effects, which have a positive effect on the economic resilience of surrounding cities.

Under the COVID-19 shock situation, both structural and agency-based factors have a significant effect on regional economic resilience, but the direction of action is significantly different from the financial crisis. In the dimension of structural factors, a diversified industrial structure is not conducive to regional resistance to the pandemic shock. This is mainly because the impact of the pandemic is different from the financial crisis, and industries related to human agglomeration activities are significantly affected. The supply and demand of a diversified industrial structure are more complicated by the pandemic shock. This may also be related to the low degree of diversification of industrial structure in resource-based cities. In the short term, the diversified industrial structure plays a weak role as a shock absorber under the pandemic shock. In addition, the analysis should

take into consideration the difference between related and unrelated diversification. In China's resource-based cities, the diversification of industrial structure is dominated by related diversification. In other words, the different industries remain closely related in terms of technologies and products. Under the impact of the pandemic, the impact has spread through the relevant diversified industries, causing the decline in economic resistance. Furthermore, the increase in the ratio of secondary and tertiary industries has a significant positive effect. In order to cope with the COVID-19 shock, local governments have implemented a series of measures such as locking down cities and restricting the flow of people. This has had a significant impact on the tertiary industry characterized by high population agglomeration. In comparison, with the pandemic under control, the secondary industry in China's resource-based cities resumed production faster. At the same time, the pandemic has little influence on the resource and energy market. Therefore, resource-based cities with a high proportion of secondary industry are conducive to the improvement of economic resilience in the short term.

For agency-based factors, investment decisions, especially the improvement of fixed asset investment, still improve the economic resistance. However, the increase in local fiscal expenditure limits the economic resistance. This is mainly because, for a long time, local fiscal expenditure has not paid enough attention to medical care, and the increase in local fiscal expenditure has not increased the proportion of medical expenditure. In 2017, 2018, and 2019, the proportions of China's fiscal expenditure on medicine and health care were 7.12%, 7.07%, and 6.98%, respectively. The COVID-19 shock is a public health emergency, which is closely related to the regional medical and health level. Therefore, the increase in traditional local financial expenditure has not improved the level of economic resilience to deal with the pandemic shock. Under the COVID-19 shock, regional sustainable development still needs substantial investment support to help enterprises return to normal production, so as to improve the regional ability to resist the shock. The increase in the number of confirmed COVID-19 cases significantly limits the regional economic resilience. The number of confirmed COVID-19 cases can reflect the control level of the state agency. Areas with better pandemic control can recover industrial development faster and improve the ability to resist shock. This is closely related to the initiative of local governments, enterprises, residents, and other stakeholders. Cities that control the pandemic effectively can lift the restrictions on personnel mobility and agglomeration and promote the resumption of production of enterprises sooner. Effective pandemic control can also alleviate residents' fear of COVID-19, enhance their self-confidence, reduce unemployment, and improve the regional resistance to COVID-19.

The level of local economic development has a significant negative effect under the pandemic shock. This is mainly because areas with good economic development levels have a higher degree of population mobility and agglomeration, which is not conducive to the rapid interruption of the pandemic. The spatial autocorrelation coefficient has passed the significance test and is positive, indicating that the regional economic resilience under the pandemic shock still does not exist in isolation. The regions with good resistance to the pandemic shock have driven the improvement of the economic resistance of the surrounding regions through the spatial spillover effect. This spillover effect is mainly reflected in that the experience of cities with high resistance can be learned by nearby areas, which improves the economic resilience of surrounding cities.

Comparing the regression results under the two shock situations, it can be found that both structural factors and agency-based factors play an important role in regional economic resilience. However, under different shock situations, the decisive factors affecting regional economic resilience are quite different, and the direction of influence of some factors has even changed. The agency-based factors play a significant role in coping with different shock situations. This shows that the attributes of different shock situations play an important role in regional economic resilience. The same factor has different directions under different shock situations, which is of great significance to guide the regional economy to deal with different shock situations in the future and maintain economic de-

velopment. Under different shock situations, regional economic resilience has significant spatial autocorrelation characteristics, which is closely related to the surrounding areas. The regions with strong ability to resist the shock can drive the improvement of the economic resistance of the surrounding regions through their spatial spillover effects.

5. Conclusions and Discussion

Regional economic resilience is an important factor to explain the performance differences of regional economic systems in resisting and adapting to uncertain shocks. Especially in the context of COVID-19, a global public health emergency, regional economic resilience has attracted more and more attention from academia and policy circles. Current research on regional economic resilience and its mechanisms of influence focuses on the 2008 international financial crisis, while the research on other shocks is insufficient. Different shocks have considerable differences in attributes, such as targeted industry and duration [4,9]. Thus, regional resilience to different shocks may vary significantly. Whether the mechanisms of influence of regional economic resilience are consistent under different shock situations has not been adequately discussed. Furthermore, based on the theory of evolutionary economic geography, existing studies typically focus on structural factors such as industrial structure, ignoring the role of agency-based factors [30,36]. Therefore, in this paper, we focused on both the financial crisis and the COVID-19 shock situations and analyzed both structural and agency-based factors. Taking China's resource-based cities, which are vulnerable to shocks, as the research object, this paper contributes an in-depth discussion on the characteristics and influencing mechanisms of regional economic systems in response to different shocks, determining the decisive factors of regional economic resilience under different shock situations.

Based on our results, we draw the following conclusions. (1) There are significant differences in the economic resilience of resource-based cities in China under different shocks. The differences in the characteristics of different types of shocks lead to changes in regional economic resilience. (2) Under different shock situations, the regional economic resilience of China's resource-based cities in the early stage of the shock is higher than the national average [30]. However, in comparison, resource-based cities have a weaker ability to cope with the shock of COVID-19. (3) Under different shock situations, the economic resilience of resource-based cities has the characteristics of positive spatial autocorrelation. In term of space, cities with high (low) levels of economic resilience are clustered, and the regional economic resilience does not exist in isolation. Regions with a strong ability to deal with the shock can drive the improvement of the level of economic resilience of surrounding regions through their spatial spillover effects. (4) Under different shock situations, both structural and agency-based factors have significant effects on the economic resilience of China's resource-based cities, but the directions of influence under different shock situations are quite different. The high proportion of specialized structure and secondary industry is not conducive to the response of resource-based cities to the financial crisis, while the high proportion of diversified structure and tertiary industry is not conducive to the regional response to the COVID-19 shock. The agency-based factors play a more important role in regional economic resilience, especially in the context of the COVID-19 pandemic, where agency-based factors play an important role in controlling the pandemic and restoring normal economic activities.

This paper adds a new research perspective and contributes to the study of regional economic resilience by exploring the differences in the characteristics and influencing mechanisms of economic resilience in China's resource-based cities, a typical vulnerable region, in response to different shock situations. We argue that each shock has its own unique attributes, which have a significant impact on the regional economic resilience. There are significant differences in the economic resilience of resource-based cities to cope with the financial crisis and the COVID-19 shock. Both structural and agency-based factors have played a role in economic resilience of resource-based cities, but the role has changed significantly under different shock situations. For structural elements, in the context of

the financial crisis, the shock is more targeted at the extractive industry. China's resource-based cities have long relied on resource exploitation. Under this shock, the proportion of the secondary industry is exceedingly high, which limits the economic resilience of resource-based cities [31]. The specialized structure of resource-based cities leads to the rapid spread of the shock to the whole economic system [25], resulting in slow economic development. However, the shock of the COVID-19 pandemic has affected almost all industries. Therefore, the diversified structure does not play the role of "shock absorber", but instead has a negative effect on regional economic resilience in the short term. At the same time, measures taken to limit population agglomeration to control the pandemic have a serious impact on the tertiary industry. The tertiary industry in China's resource-based cities is developing slowly and is mainly dominated by traditional service, which is highly dependent on population agglomeration. In the short term, the increase in the proportion of the tertiary industry in resource-based cities may not be conducive to regional response to the COVID-19 pandemic [38].

The agency-based factor of investment decisions plays an important role in coping with the shock and restoring development [44]. Especially for China's resource-based cities, the proportion of state-owned economy is high, and the investment or support necessary for the economy to deal with the shock is greatly affected by the state. The government's relevant planning, restriction, and support measures can determine how and when the regional economic system resume development [55]. However, government expenditure has the opposite role in the two kinds of shock, mainly related to the shock characteristics of the COVID-19 pandemic. The long-term neglect of healthcare expenditure leads to the poor ability of resource-based cities to deal with the shock of public health security. The effect of pandemic control determines whether the regional economic system can resist the shock [4], and thus, the role of agency-based factors is more important. For China's resource-based cities, economic development still depends on labor-intensive industries. If the pandemic is effectively controlled, movement restrictions can be phased out and the regional ability to resist the impact will be improved.

From the policy perspective, future policies on the response of resource-based cities to shocks should pay attention to the characteristics of different shock situations [12]. The government should comprehensively consider the types of uncertain shocks that resource-based cities may face in the future, and take targeted and differentiated measures to improve the ability of regional economic resilience. In the process of future policy implementation, the government should pay attention to the initiative of different stakeholders and provide support by opening a window to improve the regional economic resilience to different types of shocks through the agency-based factors from top to bottom and from bottom to top [3]. The role of structural factors on regional economic resilience under different types of shocks is also worthy of in-depth discussion. Policy makers need to adopt corresponding industrial development policies according to the characteristics of different shock situations. Reasonable proportions of industrial structure, related diversification, and unrelated diversification structure may be another focus of regional development policies in the future. At the same time, policy makers should consider the correlation characteristics between adjacent regions, pay attention to the spillover effect of cities with high regional economic resilience, and drive the surrounding areas to actively respond to the shock.

Our research also has deficiencies. Due to the limitation of the research period, our research on COVID-19 pandemic shock is mainly reflected from the dimension of resistance in a short period of time. With the continuation of the pandemic shock, China has gradually evolved from the resistance stage to the recovery stage. Furthermore, when discussing the mechanisms of influence of economic resilience of resource-based cities, in this paper, we only examine some structural and agency-based factors. However, regional economic resilience is a complex and dynamic process. Due to the limitation of data collection, we ignored some potentially important factors, such as regional labor force, innovation ability, related diversification, unrelated diversification, culture, and political leadership. It is

recommended that future research on regional economic resilience under different shock situations will adopt a multidimensional perspective of resistance and recoverability, and further consider other influencing factors to explore the influencing mechanism of regional economic resilience.

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