Modeling and Measuring Economic Resilience of Small and Medium-Sized Cities
Taking Chengdu-Chongqing Economic Circle city as an Example

Shi Zheng[1,a,*], Qin Gu[2]

[a,*] jjxysz@163.com, [2] guq_uestc@163.com

[1] School of Accounting, Sichuan University Jinjiang College, Meishan, China

[2] School of information and communication Engineering, UESTC, Chengdu, China

Abstract—Different cities will show different adaptability when facing external shocks. Cities with higher shock resistance are often the first to get out of the quagmire of recession and achieve industrial upgrading and industrial structural transformation. Therefore, there is increasing number of researches focusing on the economic resilience of first-tier cities. Due to the lack of data samples, there are few studies in small and medium-sized cities. This paper selects M City, a city in the Chengdu-Chongqing economic circle, and a small and medium-sized city close to Chengdu, the capital of Sichuan Province, as a case study. At the same time, this paper uses empirical research by selecting the GDP and consumer index as well as national and provincial data in 2019-2020, comparing the real economic output and actual output changes based on regression prediction model, using the linear weighting method and the global spatial autocorrelation index model to carry out an empirical measurement of the urban economic resilience. According to the results, it shows the relationship between the industrial agglomeration, industrial diversification and urban economic resilience.

Keywords- Small and Medium-sized Cities; Urban resilience; Industrial structure reform

1 INTRODUCTION

Urban resilience, as an emerging perspective in the field of urban sustainability research, has become a hot issue in geography, disasters, sociology, and ecology areas. With the increasing instability of the global ecological environment and social politics, urban economies often face sudden shocks. The key to whether economic shocks will lead to economic recession lies in local economic resilience which can be divided into shock resistance and resilience. The strength of economic resilience directly affects the subsequent economic recovery and development, and the key factors affecting economic resilience are also the reference indicators for the adjustment of industrial structure. Most of the existing researches mainly focus on the research and measurement of urban economic resilience in first-tier cities. Small and medium-sized cities are

often ignored by scholars due to the lack of data. However, restricted by a single industrial structure and limited resources, small and medium-sized cities need to enhance their economic resilience through industrial structure optimization. Oriented by the development of urban and rural economy, this article is to testify the urban resilience of small and medium sized cities and analyze industrial factors influencing the urban resilience.

2 THEORETICAL ANALYSIS AND RESEARCH MODEL

2.1 Urban economic resilience

The word resilience is derived from the Latin root "resilire", which describes the ability of a system to respond to shocks and disturbances. Regarding the definition of the connotation of economic resilience, the academic community has not yet reached a unified consensus. Some scholars believe that economic resilience mainly refers to the ability of the economic system to recover from shocks or destruction; some scholars also define economic resilience as the ability to resist risks and manage instability [1]. In general, neither of these two types of knowledge is comprehensive enough. The former believes that economic resilience is mainly the resilience of the economic system after a shock [4], while the latter believes that economic resilience is mainly the resistance of the economic system to shocks. However, resistance and resilience obviously have a strong correlation and are less affected by shocks [3]. Regions often recover from shocks more quickly, so economic resilience should include both resistance and resilience.

In the existing researches, the most accurate and recognized definition of economic resilience comes from the research of Martin et al. (2016), which believes that the resilience of the regional economy in response to recession shocks should include four aspects, these are resistance, resilience, readjustment ability and recreate ability. Resistance represents the sensitivity and degree of regional economic response to recession shocks. Resilience indicates the speed and degree of recovery of the regional economy from recession shocks. Readjustment ability shows the ability of the regional economy to re-adjust the structure of industries, technology, labor, in the face of recession shocks, and recreate ability means the ability to create economic growth paths or to open a new stable growth path after the regional economy suffers a shock.

2.2 Urban economic resilience measurement

Regarding the empirical measurement of economic resilience, there are mainly two methods: single-dimensional index measurement and multi-dimensional index measurement.

Sensitivity analysis is used for a single indicator, and the difference between the actual variable and the trend value after an impact is used for measurement[7]. The calculation formula of the regional sensitivity index is as follows:

$$b_r = (\Delta E_r/E_r)/(\Delta E_N/E_N) \tag{1}$$

- $\Delta E_r/E_r$ and $\Delta E_N/E_N$ represent the rate of change of the regional and the national gross product or employment in the fluctuating period, respectively.

- br is the regional sensitivity. The lower the sensitivity index, the stronger the regional economic resilience.

Another method is to build a comprehensive index system. The multi-dimensional index measurement method believes that economic resilience is a composite concept, so it tries to measure economic resilience by constructing an index system. In general, the index system can comprehensively reflect the characteristics of economic resilience, but there are big differences in index selection, index weight determination, and index measurement methods in literatures, which may lead to different or even completely opposite research results[6].

3 METHODOLOGY

3.1 Research Area

In January 2020 China proposed the construction of the Chengdu-Chongqing economic circle (CCEC) between Chongqing and Sichuan Province in the southwest, motivating scholars to conduct related research. The CCEC, located in the core area of Sichuan Basin, is the largest and most developed region in western China. According to the China Statistical Yearbook (2019), 90% of the GDP (6104.132 billion yuan) of Chongqing and Sichuan Province is contributed by the CCEC. However, industrial division, low radiation capacity of core areas, and imbalanced development have rendered a low degree of urban integration [7]. In this regard, we chose M city which is located in the middle of Sichuan province and close by Chengdu, the capital city of the province, as the case to measure the economic resilience after economy shocks.

Figure 1. Location of the M city

3.2 Method of analysis

This article mainly reference the research method of Martin et al. (2016), and calculates the urban economic resilience by comparing the changes in the real economic output of the city with the expected output changes. This method not only distinguishes the resistance and resilience to shocks more scientifically, which well reflects the dynamic change process of economic resilience. In addition, this method has low requirements on the data used in the calculation process. It only needs the actual output value data of the city and the country's three industries, thus avoiding statistical analysis. Calculation errors caused by objective factors such as imperfect

data. At the same time, this article adds provincial-level data comparison based on previous studies, which is more in line with the characteristics of regional economy.

According to the analysis, the calculation formula of the city's expected economic output changes is as follows:

$$\Delta GDP^{pt} = \sum GDP_i^t \times g_n^t \tag{2}$$

- ΔGDP^{Pt} represents the city's expected economic output change during the shock period (t_0) or recovery period (t_1) based on the province's or national economic conditions;

- GDP_i^t represents the city's economic output of industry i in period t;

- g_0 represents the rate of change of economic output of the whole province in period t;

- g_1 represents the rate of change of economic output of the whole country in period t.

The calculation formula of resistance is:

$$R_s = \frac{\Delta GDP^{t_0} - \Delta GDP^{pt_0}}{|\Delta GDP^{pt_0}|} \tag{3}$$

- ΔGDP^{t_0} represents the actual change in economic output of the city during the shock period;

- ΔGDP^{pt_0} represents the change in the city's expected economic output during the shock period.

The calculation formula of recovery is:

$$R_c = \frac{\Delta GDP^{t_1} - \Delta GDP^{pt_1}}{|\Delta GDP^{pt_1}|} \tag{4}$$

- ΔGDP^{t_1} represents the change in the actual economic output of the city during the recovery period;

- ΔGDP^{pt_1} represents the change in the expected economic output of the city during the recovery period.

The indicator resistance or resilience greater than 0 indicates that the city's economic resistance or resilience in the face of shocks is higher than the provincial or national average level, and less than 0 indicates that the city's economic resistance or resilience in the face of shocks or recovery after shocks. The power is lower than the provincial or national average.

3.3 Data

To measure the economic resilience, data should include both the resistance and recovery of the economy to shocks. Therefore, before measuring economic resilience, the research interval needs to be divided into shock period (t_0) and recovery period (t_1). Regarding the division of the shock period and the recovery period, existing studies have not formed a unified view[2]. Due to the "package" stimulus policy and the "new normal" stage of economic structural adjustment, China stepped into a period of stable economic growth in China. Therefore, it is difficult to accurately divide the economic fluctuation range at the national level. Some scholars measure the economic resilience of Chinese cities based on the level of urban employment and other relevant indicators in their research. However, from the perspective of China's actual economic development,

China's state-owned enterprises that provide stable employment dominate, and employment continues to grow, which is less affected by the economic recession. In addition, China's urban employment data is not perfect, and many cities lack complete employment data. For these reasons, we choose to observe the actual GDP to determine the shock period and recovery period [6].

This article selects GDP of M city from the third quarter of 2019 to the second quarter of 2020 for judgment. At the same time, in order to eliminate the inflation factor, comparable values are selected for the GDP for comparison. The specific data is shown in the following table:

Table 1 GDP of M city from Q2(2019) TO Q2(2020) a

Indicators	Q2 of 2019	Q3 of 2019	Q4 of 2019	Q1 of 2020	Q2 of 2020
Tatol GDP	218585.4	227899.1	248038.7	183669.3	225495.5
Primary industry	13540.1	19754.5	24587.1	8014.6	13992.8
secondary industry	88895.8	89306.1	99574.4	67968.9	93094.7
tertiary industry	116149.5	118838.6	123877.2	107685.8	118408

a. sourced by China Statistical Yearbook (2019) and NBS

According to the trend of quarterly GDP, this article divides the study period into growth period, shock period and recovery period. The specific division is shown in the Fig 2:
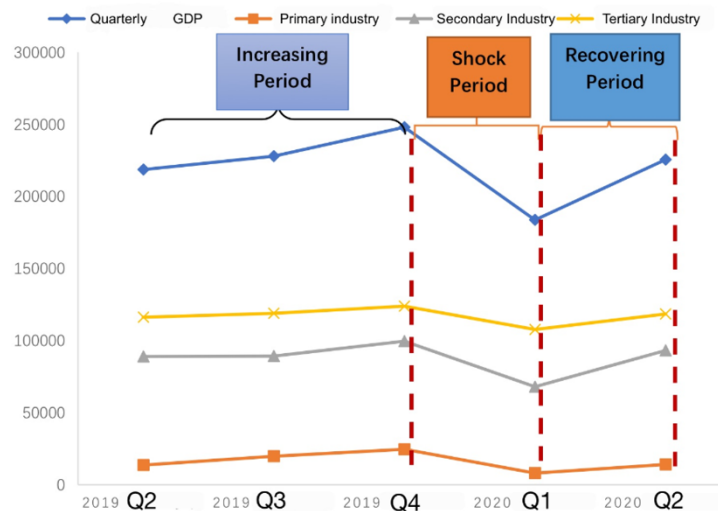

Figure 2. division of shock period and recovery period

4 RESULTS AND ANALYSIS

4.1 Evaluation of overall economic resilience of M City

This article takes the influence of the COVID 19 epidemic on the urban economy as a test period. It is planned that the first quarter of 2020 will be the shock period t_0, and the second quarter of 2020 will be the recovery period t_1. The amount of economic change is measured by the regional GDP. According to formula (2) (3), the results are shown in the following table:

Table 2 Urban Economic Resilience Index of M City.

	Shock period (t_0)		Recovery period (t_1)	
Regional results	ΔGDP^{pt_0}	-8.50272	ΔGDP^{pt_1}	12.97012
	ΔGDP^{t_0}	-6.2843	ΔGDP^{t_1}	13.27179
	Rs	0.260907	Rc	0.023259
National results	ΔGDP^{pt_0}	-19.4854	ΔGDP^{pt_1}	11.3684
	ΔGDP^{t_0}	-6.2843	ΔGDP^{t_1}	13.27179
	Rs	0.677487	Rc	0.167428

4.2 Evaluation of the economic resilience of the three major industries in Meishan City

In order to further analyze the contribution value of different industries in M City to the economic resilience, we estimate the expected output value of different industries in M City according to the economic growth rate of different industries in the province and the economic growth rate of different industries in the whole country, and compares with the actual output value. The results are as follows:

Table 3 Comparison of the province's average expected value and actual value of the three major industries

Indicator	Q1 of 2020			Q2 of 2020		
	Actual	*Expected*	*Deviation*	*Actual*	*Expected*	*Deviation*
Primary industry	34.71	34.67	0.10%	49.48	48.77	1.45%
secondary industry	112.39	110.78	1.44%	144.29	141.80	1.75%
tertiary industry	145.87	145.27	0.41%	155.47	147.27	5.56%

Table 4 Comparison of national average expected value and actual value of the three major industries

Indicator	Q1 of 2020			Q2 of 2020		
	Actual value	*Expected value*	*Deviation rate*	*Actual value*	*Expected value*	*Deviation rate*
Primary industry	34.71	34.01	2.06%	49.48	49.73	-0.50%

secondary industry	112.39	103.67	8.40%	144.29	146.27	-1.35%
tertiary industry	145.87	141.83	2.84%	155.47	150.67	3.18%

4.3 Analysis

According to Table 2, the results of R_S and R_C are both greater than zero regardless of the provincial or national control indicators, indicating that the overall economic resilience of M city is higher than the provincial and national averages in terms of resistance and resilience.

From the analysis of the province's data (see Table 3), the three major industries in M City are higher than the provincial average in terms of resistance and resilience. However, the resilience is better than the resilience. Among them, in terms of resistance, the secondary industry's ability to resist shocks is more significant, while the primary industry is weak; in terms of resilience, the tertiary industry has the strongest resilience, which is significantly higher than the provincial average.

From the comparison between the national average expectation and the actual output value of the three major industries in M City (see Table 4), the resistance of the three major industries in M City is significantly higher than the national average when facing economic shocks, but the recovery ability during the recovery period is relatively lagging, which is mainly reflected in the primary and tertiary industries. The recovery capacity of the tertiary industry is 3% higher than the national expected level.

To summary, the overall economic resilience of M City is higher than the provincial and national averages. From the perspective of industrial structure, the secondary industry (industry and construction) of M City has excellent resistance to economic shocks, but its performance is weak during the recovery period, which is lower than the national average; the tertiary industry is expected to come from the province. The resistance is lower than the resilience, but both are higher than the national average; the resistance and resilience of the primary industry are at the provincial average, but from the national level, the resilience is slightly lower than the average.

5 DISCUSSION

Based on the results of urban resilience from M city, the diversification of the industrial structure is conducive to reducing the instability of economic development for small and medium sized cities, while diversifying the risks caused by shocks and reducing overall economic losses. A diversified industrial structure helps to alleviate the region's over-reliance on a certain industry, especially the primary industry or durable goods industries with high income elasticity, thereby avoiding the potential for strong productivity shocks or sharp fluctuations in prices and income caused by the instability of economic development.

Therefore, to enhance small and medium sized city's economic resilience is to improve industrial diversities and competitiveness. Industrial competitiveness mainly includes innovation capabilities, productivity levels, and management levels other than the industrial structure. Therefore, it is necessary to increase investment in science and technology, promote intellectual property protection, and stimulate innovation vitality. To improve the quality of innovation, take

innovation as the first driving force to improve the competitiveness of the industry, and at the same time pay more attention to the improvement of "quality" rather than the expansion of "quantity" in the process of industrial development, and strive to improve the level of industrial productivity and management.

• In the post-economic crisis period, the competitiveness of the tertiary industry is the main determinant of economic resilience. Therefore, it is necessary to promote the optimization and upgrading of the industrial structure through means such as information and management innovation, and improve the proportion of the added value of the service industry in China's industrial development. The "three lows" phenomenon of low employment rate and low per capita value added will vigorously develop the producer service industry and advanced service industry, and promote the development of the service industry to be stronger and better.

• The decline in the competitiveness of the secondary industry is the main reason for the weakening of economic resilience. It is important to focus on the development of the real economy, effectively resolve overcapacity, promote the coordinated development of secondary and tertiary industries, and promote the coupling and coordination of manufacturing and producer services. An important way to effectively enhance economic resilience.

6 CONCLUSION

Urban economic resilience plays a crucial role in the urbanization and industry construction. However, there still exist problems in the process of small and medium sized city. In this article, the economic resilience has been estimated based on the models and statistics of M city, CCTE, China, providing an alternative to measure the urban resilience by limited data. In practice, two suggestions are provided for improving the development for small-medium sized cities, including industry diversification and enhancing the competitiveness in manufacturing industry.

REFERENCES

[1]   James S, Ron M (2010). The economic resilience of regions: towards an evolutionary approach. Cambridge Journal of Regions, Economy and Society, 3(1):27-43.

[2]   Martin.R. Sunley. P. Gardiner. B (2016). How Regions React to Recessions: Resilience and the Role of Economic Structure. Regional Studies, 50(4):561-585.

[3]   Martin.R, Sunley.P(2015). On the notion of regional economic resilience: conceptualization and explanation. Journal of Economic Geography,15 (1):1-42

[4]   Fingleton, B., Garretsen, H., & Martin, R.. (2012). Recessionary shocks and regional employment: evidence on the resilience of u.k. regions*. Journal of Regional Science, 52(1), 109-133..

[5]   Florin Oprea, Mihaela Onofrei, Dan Lupu, et al (2020). The Determinants of conomic Resilience. The Case of Eastern European Regions. 12(10)22-35.

[6]   Guo Jiang, Xu zeqing(2019). Research in The influence of Industrial Related Variety on regional economic resilience- Analysis of Threshold effect based on regional innovation level(in chinese). Science & Technology Progress and Policy. 36(13):39-47.

[7]   Brown L, Greenbaum R.T.(2017). The role of industrial diversity in economic resilience: an empirical examination across 35years. Urban Studies. 54 (6) :1347-1366.