Research on Development Assessment and Differentiation Paths of Second- and Fifth-Tier Cities Based on TOPSIS and Multidimensional Urban Resilience Models

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Abstract. Aiming at the development dilemma of second- and third-tier cities under the dual pressure of natural environment and economic fluctuation, this study proposes a comprehensive analysis method integrating TOPSIS and urban resilience assessment model. By quantitatively evaluating the industrial distribution and resilience performance of two typical cities, the study reveals the underlying mechanisms of their developmental differences: City 1 dominates in the field of community life services, but faces the challenges of lagging commercial finance and insufficient ecological resilience; while City 2 exhibits short-term economic vitality and planning efficacy, but weak production resilience and ecological management deficiencies constrain its ability to cope with risks. The study further proposes differentiated development paths: City 1 needs to strengthen the synergy between ecological management and industrial upgrading, while City 2 should prioritize strengthening the foundation of production resilience and gradually optimize public services. The model provides city managers with a decision-making tool that balances short-term efficiency and long-term sustainability through the allocation of multi-dimensional indicator weights and a dynamic evaluation mechanism.

Keywords: TOPSIS, urban resilience model, multi-dimensional indicator weights.

1. Introduction

In recent years, the frequent occurrence of extreme weather events around the world, coupled with the poor economic situation, has had a significant adverse impact on the comprehensive development of small and medium-sized cities [1]. Extreme climate events, including heavy rainfall, flooding, high temperatures and drought, have inflicted considerable damage on the economic and business operations of the affected geographic areas, propagating adverse impacts through industrial and supply chains to associated enterprises and regions. These events have also precipitated a range of energy and food security concerns. Moreover, for small and medium-sized cities, the uncertainty surrounding the economic situation has increased the pressure on urban development, making cities face more challenges in infrastructure construction, public service provision, job creation and other aspects [3]. In this context, it is particularly important to deeply analyse the service situation in different areas of the city. The establishment of a rational mathematical model is therefore imperative for the analysis and resolution of urban development issues.

Large cities have long been the focus of future development capacity and urban resilience assessments because they are centers of population, resources, and politics [4]. However, for most countries, small and medium-sized cities are still dominant, with high development potential, but poor resilience due to economic, demographic, and service level weaknesses, which in turn affects small and medium-sized cities' planning for future development [5-8].

The impact of natural conditions such as extreme weather is an integral part of urban resilience assessment. Existing studies rarely consider both natural and social factors in assessing urban resilience. In this study, the paper selected two representative second- and fifth-tier cities, inductively analyzed 14 different industries and their sub-programs in each city, and elucidated the strengths and weaknesses as well as development gaps of the two cities through the final scores of the TOPSIS method [9]. On this basis, this paper combines 14 industries and their sub-projects to assess the comprehensive urban resilience of the two cities through the aspects of urban production resilience [10], urban residents' life resilience [11], and urban ecological resilience [12], with the aim of providing more targeted and forward-looking suggestions for the development of small and medium-sized cities.

2. Fundamentals of model

2.1. The structure of TOPSIS

The TOPSIS method is a very commonly used comprehensive evaluation method, which can effectively utilize the information provided by the raw data and accurately reflect the differences between the various evaluation schemes in the results. The TOPSIS method has the following two basic concepts:

(1) Ideal solution: it is the hypothetical optimal solution, in which any attribute can reach the best value in the ideal solution.

(2) Negative Ideal Solution: it is the hypothesized worst solution in which any attribute can reach the worst value in the ideal solution.

The paper used the TOPSIS method to evaluate the strengths and weaknesses of the two cities based on the final scores. The steps of model construction are as follows:

(1) Normalize the obtained raw matrix.

(2) Identification of intermediate indicators.

(3) Matrix standardization.

(4) Calculate the scores and perform normalization.

$$\hat{x}_i = 1 - | x - x_{best} | \div M \tag{1}$$

$$M = \max\{| x_i - x_{best} |\} \tag{2}$$

$$Z_{ij} = x_{ij} \div \sqrt{\sum_{i=1}^{n} x_{ij}^{\ 2}} \tag{3}$$

$$Z^{+} = (Z_1^{+}, Z_2^{+}, ..., Z_m^{+}) \tag{4}$$

$$Z^{-} = (Z_1^{-}, Z_2^{-}, ..., Z_m^{-}) \tag{5}$$

$$D_i^{+} = \sqrt{\sum_{i=1}^{m} (Z_j^{+} - Z_{ij})^2} \tag{6}$$

$$D_i^{-} = \sqrt{\sum_{i=1}^{m} (Z_j^{-} - Z_{ij})^2} \tag{7}$$

$$S_i = D_i^{-} \div (D_i^{+} + D_i^{-}) \tag{8}$$

$$\hat{S}_i = (S_i \div \sum_{i=1}^{n} S_i) \times 100 \tag{9}$$

Where x_{ij} is the number of sub-projects in an industry, Z is the extremes, D is the distance between extremes, and S is the score.

2.2. The structure of urban resilience model

The urban resilience model can assess a city's resilience in the event of an unknown event, and its assessed value is a direct reflection of a city's overall capacity.

The modeling of urban resilience requires firstly the identification of the primary indicators required for urban assessment as the criterion layer, followed by stability, adaptability and diversity as the sub-criteria layer, and finally specific indicators as the indicator layer. This is shown in Figure 1. Next, the weights of the objective, criterion and indicator layers are determined separately, the significance of the indicators is assessed as positive or negative, and finally the spatial elasticity values are calculated.

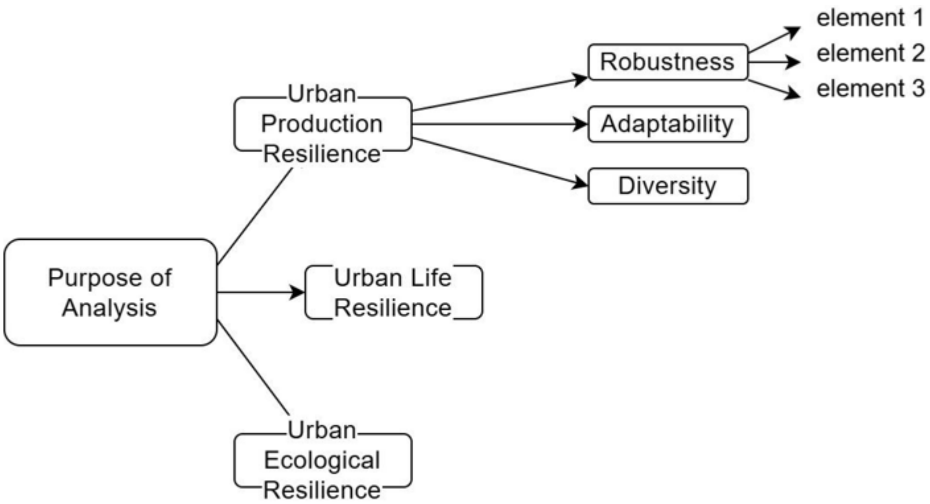


Figure l. The implementation process of the urban resilience model.

The value of the Urban Resilience Assessment is calculated by the following formula:

$$R = \sum_{k=1}^{n} a_k \times x_k \tag{10}$$

Where R is the final value of the resilience assessment, a_k is the industry sample weight, and x_k is the urban industry sample.

3. Results

3.1. The result of TOPSIS model

3.1.1. Data processing

The data sources for this paper are Changchun City and Shuozhou City, which are typical second-tier and fifth-tier cities, respectively. Henceforth, these cities shall be referred to as "City 1" and "City 2". A total of 14 representative industries were extracted from these two cities using a crawler website (https://get.brightdata.com/weijun). As demonstrated in Figure 2a, the distribution patterns of the number of industries in "City 1" and "City 2" are highly similar. Figures 2b and 2c demonstrate that retail, geographic information, life services, and restaurants collectively account for a substantial proportion of the 14 industries. The following section will analyse the unique characteristics of each city. City 1 has more indoor facility remodeling industries than City 2, while City 2 has more sports and recreation industries than City 1. Further analysis in conjunction with Figure 2(a) (b) (c) reveals that, with the exception of the public services industry, City 1 has a significantly larger number of industries than City 2. Conversely, City 2 has a larger number of public facilities than City 1, which may be indicative of the city's current demand for public facilities. The data for the restaurant, education, and retail sectors collectively indicate that City 1 possesses a more robust overall economy.

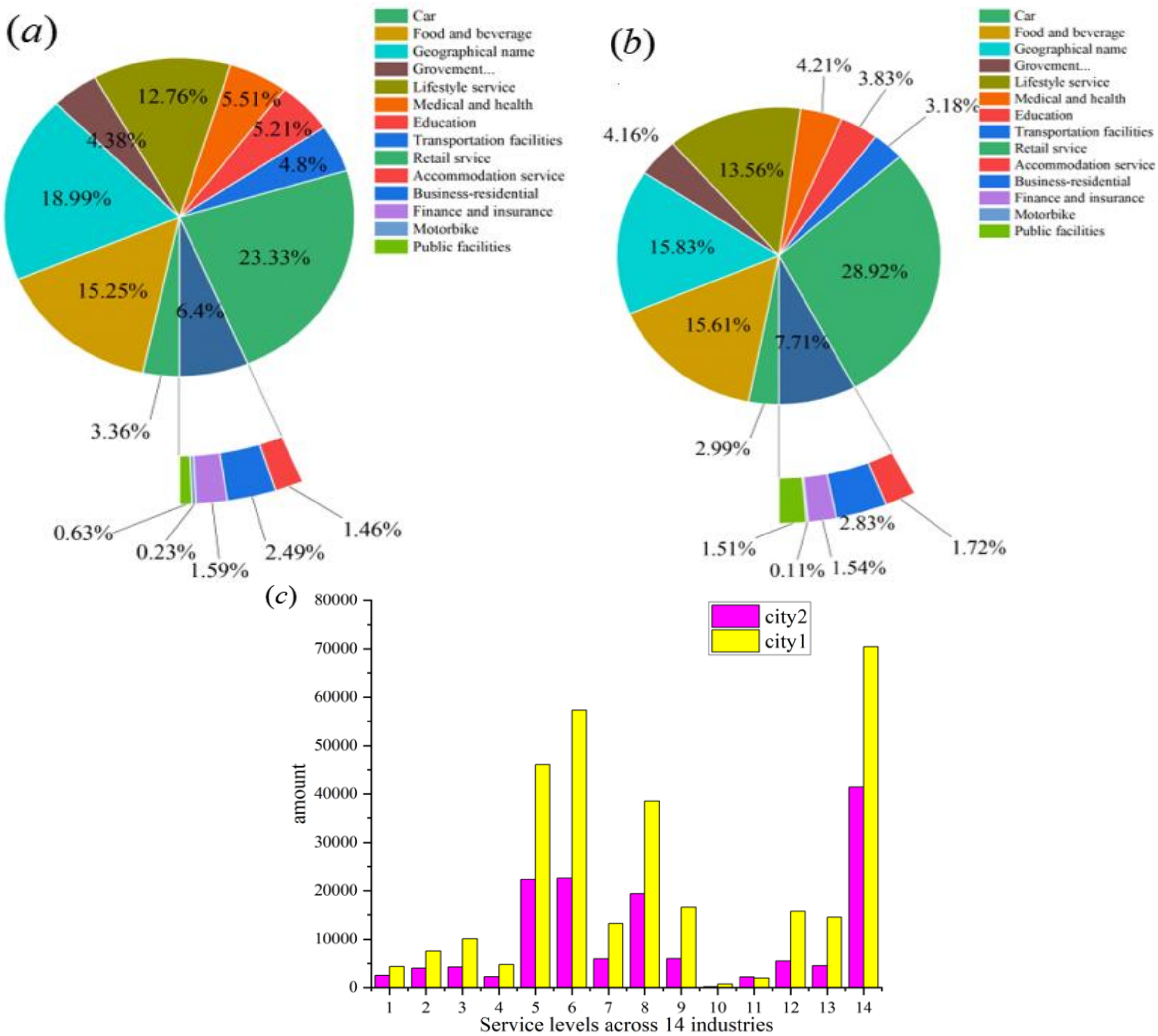


Figure 2. Analysis of data for 14 different types of industries: (a) share of each industry in city l; (b) Share of each industry in city 2; (c) number of industries in city l and city 2.

To better analyze the strengths and weaknesses of City 1 and City 2, this paper first categorize the underlying industry data as in Figure 3.

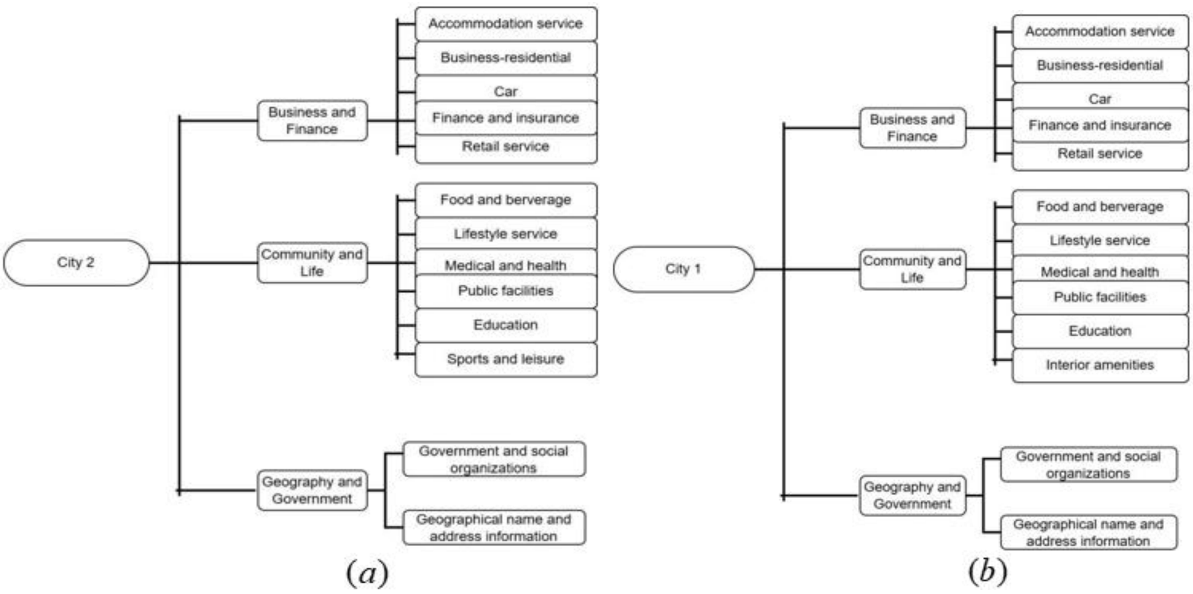


Figure 3. The basic data of the industry is divided into three main categories and their breakdowns: (a) cityl; (b) city2.

3.1.2. Result

In order to ensure the accuracy of the calculation results, the paper firstly assessed the different levels of development between the two cities and normalized the number of their respective industries to ensure fairness. Secondly, the paper comprehensively assessed the impact of each industry on the development of the cities and considered the presence of each industry as a benefit indicator. The final scores calculated by TOPSIS are presented in Table.1.

Table 1. Final TOPsIS scores for City 1 and City 2.

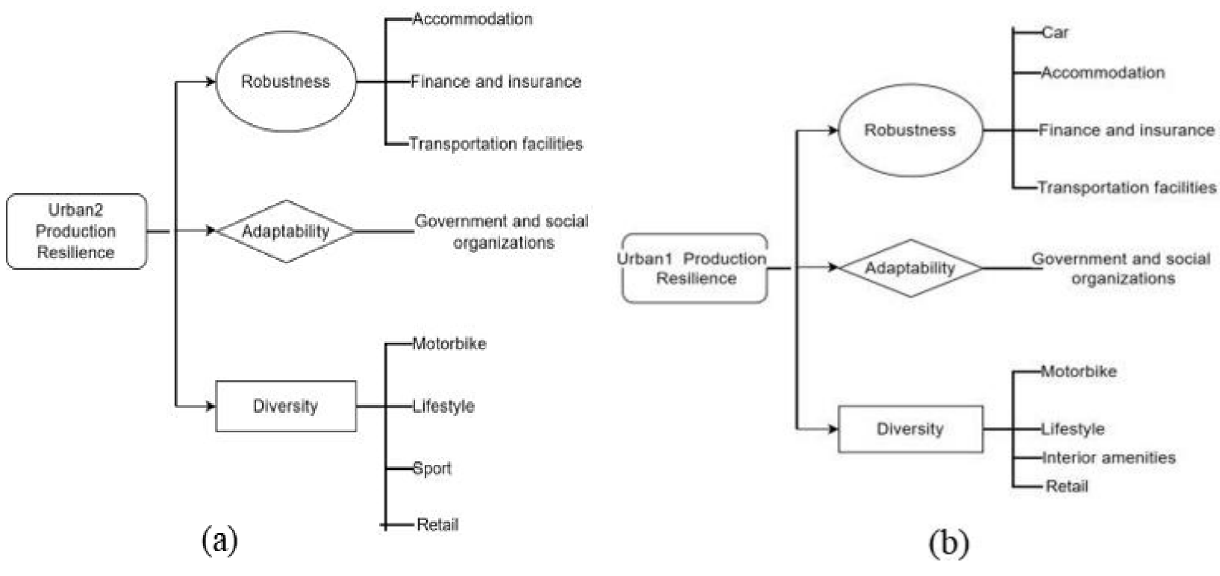
Final Score	Business and Finance	Community and Life	Geography and Government
City 1	25.15	54.22	45.78
City 2	64.84	48.76	51.24

The analysis of the final scores of the two cities in the three categories shows that City 1 outperforms City 2 in terms of community and living related industries, a result that suggests that City 1 places a greater emphasis on the quality of life of its residents and that the community and living industries are dominated by the tertiary sector, thus indirectly reflecting City 1's stronger economic base. The relatively low tertiary score is as expected given City 1's well-established base in planning and construction. However, the scores for commercial and financial industries are significantly lower than those of City 2, which may indicate that commercial development in City 1 has reached a bottleneck or that insufficient attention has been paid to commercial development at this stage. In terms of commerce and finance and geopolitics, City 2 scores higher than City 1, which suggests that City 2 has placed more emphasis on commercial development and urban planning and construction. This would greatly enhance economic strength, infrastructure and employment opportunities. On the contrary, the relatively low scores for community and livelihood-related industries suggest that City 2 may have neglected the development of community and livelihood industries due to heavy investment in the primary and tertiary sectors, which may have a negative impact on the quality of life of the urban population.

3.2. The result of urban resilience model

3.2.1. Data processing

The paper further break down the three main categories of the industry in the previous TOPSIS, as shown in Figure 4.



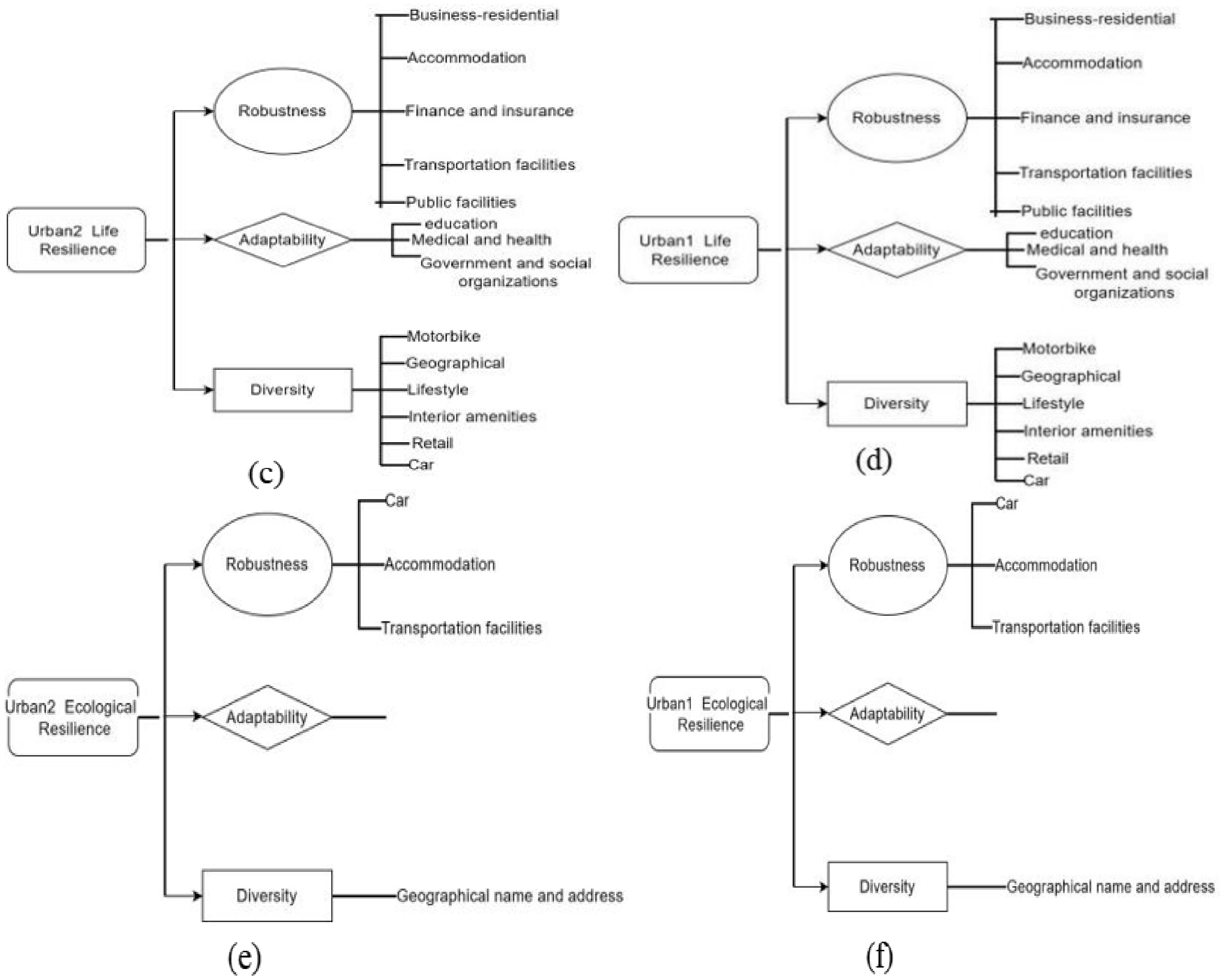


Figure 4. Breakdown of the 3 main types of industries in City 2 and City 1.

To facilitate the application of the urban resilience model, the paper categorize each sector and its sub-projects into three main resilience assessment objectives: urban living resilience, urban production resilience and urban ecological resilience.

3.2.2. Result

The calculation results using the urban resilience model are as Table.2.and Table.3.

Table 2. Urban Resilience Assessment Results for cityd.

Target	Criterion	Sub-indicator	Meaning	Weight	Merits Demerits
Life Resilience (1.011)	Robustness	Accommodation...	Living Conditions	0.417	+
	Adaptability	Education...	Convenience of Life...	0.216	+
	Diversity	Interior...	Rich Lifestyle...	0.378	+
Production Resilience (0.051)	Robustness	Finance...	Service-oriented Production..	0.017	+
	Adaptability	Government	Policy-driven Production	0.003	+
	Diversity	Retail...	Diverse Products...	0.031	+
Ecological Resilience (-0.079)	Robustness	Car...	Pollution degree	0.084	-
	Diversity	Geographical...	Ecological Diversity	0.005	+

Table 3. Urban Resilience Assessment Results for city2.

Target	Criterion	Sub-indicator	Meaning	Weight	Merits Demerits
Life Resilience (0.948)	Robustness	Accommodation...	Living Conditions...	0.381	+
	Adaptability	Education...	Convenience of Life...	0.194	+
	Diversity	Interior...	Rich Lifestyle...	0.373	+
Production Resilience (0.034)	Robustness	Finance...	Service-oriented Production..	0.03	+
	Adaptability	Government	Policy-driven Production	0.001	+
	Diversity	Retail...	Diverse Products...	0.003	+
Ecological Resilience (-0.069)	Robustness	Car...	Pollution degree	0.074	-
	Diversity	Geographical...	Ecological Diversity	0.005	+

The paper focused on assessing the ecological resilience of cities, but limited data resulted in negative scores for ecological resilience. This does not detract from our view that City 2 is better at ecological management than City 1. Cities often need to rely on higher resilience to cope with unforeseen events. Comparing the other aspects of resilience between the two cities, City 1 is significantly more resilient to production than City 2, almost twice as much. Combining these two points, we argue that City 2 is weaker than City 1 in coping with extreme weather and emergencies. In other words, City 2 is less resilient to extreme weather and emergencies, which will have a negative impact on City 2's future development.

Next, the paper will comprehensively assess the sustainability of the two cities and propose development plans accordingly. Combined with the above judgments, City 2's greatest weakness lies in its current production resilience, which is consistent with some of our earlier assessments of City 2. For the future development of City 2, the development of productive industries is undoubtedly crucial. In the short term, firms can temporarily concentrate their investments in the production sector to accelerate its development. As City 2 is also economically weak, more comprehensive development will need to be considered after the production-based industries have matured, including the lower quality of life, sparse industries on the north and south sides, and lower urbanization rate mentioned earlier.

For City 1: The weakness of City 1 compared to City 2 is its lower ecological resilience. The low value of ecological resilience is likely to lead to a decline in the quality of life of the residents due to environmental factors in the middle and later stages of the city's development. Therefore, in the future development of City 1, the government should pay more attention to the ecological environment. Considering that City 1 has better economic strength, it can realize the transformation and upgrading of some industries, such as the transfer of the automobile industry to new energy, while building the ecological environment. In addition, the proportion of financial industry in City One is relatively low, which may be due to the lack of domestic demand leading to vicious competition in some industries in the city. This is also an issue that needs to be considered for the long-term development of City 1.

4. Conclusions

This study proposes a novel framework for the assessment of small and medium-sized cities, integrating the TOPSIS methodology and the comprehensive urban resilience model. The study's findings reveal the mechanisms underpinning developmental differences among cities and propose differentiated paths for their development. The analysis demonstrates that City 1 exhibits exceptional performance in community life services but confronts the challenges of lagging commercial finance and inadequate ecological resilience. Conversely, City 2 demonstrates significant short-term economic vitality but experiences deficiencies in production resilience and ecological management, thereby substantiating the efficacy of the model in diagnosing the deficiencies of urban development and quantifying the resilience level. The methodology's capacity for adaptation to diverse urban resource endowments is enabled by the dynamic weight allocation mechanism and multi-dimensional indicator compatibility. The model provides managers with a decision-making tool that balances short-term efficiency and long-term sustainability by adjusting the priority of industrial, ecological and livelihood resilience indicators. In future research, the study could expand the resilience assessment dimension, optimize the dynamic time-series analysis capability, integrate high-resolution remote sensing and urban big data to improve the prediction accuracy of the model, and explore the resilience network construction mechanism under the scenario of collaborative development of urban agglomerations. This would provide a more systematic solution for coping with climate change and regional economic fluctuations.

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