

Original Paper

A Study on Economic Resilience of Mountainous Cities and Its Influencing Factors in the Context of Population contraction: A Case Study of the Central Guizhou Urban Agglomeration

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Abstract

In recent years, with the slowdown of regional economic growth and significant changes in population structure, the issue of population contraction has received widespread attention. At the same time, there are new pressures and challenges in enhancing the economic resilience of regions. Therefore, a thorough investigation into the impact of population contraction on economic resilience is of profound significance for the synchronized development of population and economy in regions. Based on this, this paper takes the mountainous cities in the central Guizhou urban agglomeration as the case study area, and comprehensively employs population change rate, entropy method, to study the spatio-temporal evolution pattern of population decline and economic resilience in the central Guizhou urban agglomeration from 2013 to 2022, and reveals the impact of population contraction on economic resilience. The results demonstrate the following: (1) In terms of population contraction, only Bozhou District of Zunyi City in the central Guizhou urban agglomeration experienced population shrinkage from 2013 to 2017; from 2018 to 2022, the number of areas experiencing population contraction increased to 11, presenting a distribution pattern approximately symmetrical on the east and west sides with the core area of the central Guizhou urban agglomeration as the axis. (2) Regarding economic resilience, there are significant differences in spatial distribution between the two periods. High-value areas show a spatial lock-in phenomenon, concentrated in Guiyang City, while low-value areas are distributed in the southern part of the central Guizhou urban agglomeration, highlighting the unbalanced development among regions. Additionally, due to the impact of COVID-19, the economic resilience level of the central Guizhou urban agglomeration decreased from 2018 to 2022.

Keywords

Population Contraction, Economic Resilience, Urban Agglomeration Of Central Guizhou, Mountain Cities

1. Introduction

Since the onset of the twenty-first century, China's urbanization has entered a "deep-water" phase. Regional development has become increasingly unbalanced and uncoordinated, and—driven by interregional economic disparities—production factors such as labor, natural resources, and capital have migrated toward more developed areas. This asymmetric developmental trajectory has, in turn, reshaped the patterns and spatial distribution of population mobility. Driven by the "siphoning effect" of economic growth, population persistently migrates from less-developed to more-developed regions, intensifying demographic contraction in the former. This trend is especially pronounced in the Southwest. Prior research has demonstrated that China experienced extensive population contraction between 1990 and 2000^[1]. From 2000 to 2010, the geographic extent of population loss expanded markedly, and from 2010 to 2015 it continued to grow, albeit at a slower pace^[2]. By the latter period, nearly 30 % of all towns and townships had registered population decreases^[3]. From the perspective of the contraction range, it exhibits characteristics marked by numerous contraction zones, broad spatial distribution, and multi-scale patterns. The central Guizhou urban agglomeration, serving as the primary urban area for mountainous development in Guizhou Province, is not only prone to population contraction but also exhibits high sensitivity in regional economic development to dynamic population changes. This is due to the combined effects of its unique geographical environment, significant disparities in resource endowments, and socioeconomic inequality. Mountainous urban areas demonstrate significant sensitivity to demographic shifts, as well as pronounced vulnerabilities in economic resilience. This dual vulnerability, operating through a complex feedback mechanism, ultimately drives urban economic and demographic development into a structural impasse. Economic resilience denotes a region's capacity to withstand, recover from, and adapt to external shocks; it is therefore essential for sustaining stable urban economic development and for enhancing a city's competitiveness. Amid China's current economic deceleration and demographic transition, mountainous urban areas—by virtue of their distinctive physiographic settings and development constraints—display pronounced economic vulnerability to external shocks. The resilience and adaptive capacity of their economic systems are therefore subject to heightened uncertainty. This uncertainty arises not only from topographically induced limitations on industrial configuration and the mobility of social-production factors, but also from the interplay of regional endowments, social capital, and institutional environments. Accordingly, this paper undertakes a rigorous analysis of the spatio-temporal dynamics of population contraction and economic resilience in the Central Guizhou urban agglomeration, and investigates the causal mechanisms through which population loss affects resilience. The findings offer policy-relevant insights for encouraging population return and strengthening regional economic

resilience.

Population contraction or outflow represents the primary indicator of a “shrinking city,” encompassing not only the emigration and physical out-migration of residents but also the demographic contraction attributable to an inadequate reproductive momentum within the existing population structure^[4]. As an imported concept, the term “shrinking cities” is easily overshadowed by the intuitively salient and deeply ingrained image of population outflow, thereby obscuring its structural-crisis essence. Moreover, Chinese scholarship has largely confined itself to phenomenological descriptions, leaving the term semantically ambiguous. A rigorous, context-sensitive definition grounded in China’s urban-development realities remains absent, inviting conceptual stretching and misapplication^[5]. When conducting research, one can easily conflate the normal population mobility and migration that occur during urbanization with population contraction, and mistake regional depopulation for urban shrinkage. Inconsistent demographic standards further distort perceptions of shrinking cities. Concentrating on superficial numerical shifts while overlooking the deeper structural crises driving population outflow, as well as ignoring the divergent contexts and stages at which shrinking cities emerge in China versus other countries^[5]. Population contraction denotes the sustained contraction—typically measured over five-year intervals—in a region’s permanent-resident population, household count, and labor force, thereby constraining the area’s economic and social development. Although population contraction constitutes the primary characteristic of a “shrinking city,” the concept fundamentally foregrounds the structural crisis and economic transition that underlie demographic loss. Consequently, any rigorous definition of a “shrinking city” must extend beyond the population variable to incorporate additional dimensions—most notably economic and spatial-landscape indicators. These include, *inter alia*, industrial contraction, employment erosion, fiscal revenue reduction, and the physical deterioration and qualitative degradation of urban space^[4].

Resilience—originally a physics concept—denotes the capacity of a material to return to its initial configuration after deformation. The term has since been adopted by disciplines such as biology and economics^[6]. Extant scholarship indicates that investigations of economic resilience are generally organized along three principal dimensions: First, the concept of economic resilience. Martin defined the meaning of economic resilience: the ability of a regional economic system to resist or restore its development state in response to external shocks^[7], specifically including crisis resistance capacity, adjustment and adaptation capacity, and recovery and transformation capacity^[8]. Second, the measurement of economic resilience levels. The most widely employed approach is the index-system method^[6], with each index’s score computed via the entropy-weighting technique^[9]. Some scholars argue that shocks do not persist in the long run; therefore, they use regional GDP growth rates as the metric and conceptualize economic resilience as comprising both long-term and short-term dimensions^[10]. Third, the determinants of economic resilience. Economic resilience is shaped by a confluence of factors, most notably external shocks and social determinants^[11–13]. External shocks are typically framed as the adverse effects triggered by economic crises^[12]. Regarding social determinants,

the prevailing view among scholars is that variables such as industrial structure, population distribution, and the unemployment rate exert significant influence on economic resilience.

The phenomenon of population contraction first garnered widespread attention in Western countries as a result of negative population growth and the intensification of population aging. In recent years, the spatial extent of population contraction has expanded markedly, driven by the deepening of globalization and the growing imbalance and lack of coordination in development. This same phenomenon has now emerged in China^[14]. Existing scholarship indicates that research on population contraction is principally articulated along four dimensions: First, the concept of population contraction. Some scholars argue that it is triggered by urban economic recession^[15-17], whereas others contend that contraction arises from contractions in aggregate population, household counts, and labor-force size. The latter definition has been widely adopted in contemporary research. Second, the characteristics of population contraction and its spatio-temporal evolution across different regions. Significant spatial disparities in population contraction are observed across China, with concentrations primarily in Hubei Province, Northeast China, northern Jiangsu, and parts of Fujian and Sichuan^[18]. In contrast, Hungary and Poland are experiencing pronounced population contraction^[19-21]. While the United States continues to exhibit population growth, Canada, also located in North America, confronts demographic contraction alongside declining fertility rates^[22-23]. Third, the driving factors behind population contraction. There are two primary explanations. ① The influence of economic and political factors is viewed as a linear process that ultimately results in population contraction^[24-25]. ② Certain factors initially trigger demographic changes, which in turn influence those same factors. Specifically, economic stagnation in a given region leads to population outflow as individuals seek new employment opportunities^[26]. This outflow further reduces the regional population, which in turn exacerbates economic pressures, resulting in continued population contraction and creating a vicious cycle. Fourth, the contraction effect resulting from population contraction^[27-29]. ① Population contraction does not necessarily trigger an overall labor shortage, yet it does reduce the stock of high-quality labor, thereby decelerating the growth—or precipitating an absolute contraction—of regional human capital. This contraction, in turn, erodes local capacity for economic innovation, dampens investment, and diminishes competitiveness in emerging industries. ② Population contraction will erode local market size and agglomeration economies, thereby diminishing industrial productivity and growth potential—particularly for manufacturing and market-oriented services such as retail, food-and-beverage, and small-scale production. As output and sales in these sectors contract, regional unemployment rises and household purchasing power falls, setting in motion a self-reinforcing downward spiral in economic development. ③ Population contraction decelerates economic growth by constraining infrastructure investment: it reduces expected demand, raises unit construction costs, and disrupts project continuity, thereby eroding a region's competitive potential. ④ Population contraction exerts a positive feedback effect on regions characterized by insufficient employment-supply capacity. When local economies are unable to generate adequate employment opportunities, the out-migration of

surplus labor removes individuals who would otherwise exert additional pressure on the job market. This outflow simultaneously raises household incomes through remittances and stimulates local consumption, thereby generating compensatory economic benefits. To conclude, the societal consequences of population contraction are multifaceted.

Although the existing literature on population contraction and economic resilience is relatively extensive, several gaps remain: (1) Most extant research on population contraction and economic resilience still focuses on the spatio-temporal evolution of macro-regions; mountainous urban agglomerations such as central Guizhou have received little scholarly attention, and the ways in which their distinctive regional-development attributes shape both demographic contraction and economic resilience remain unexplored. (2) Existing research has focused on the coupling between population and economy, while the underlying mechanisms linking the two remain underexplored. Drawing on this foundation, this study examines 33 counties and districts within the Central Guizhou urban agglomeration as case-study units to analyze the spatio-temporal dynamics of population contraction (contraction over a five-year interval) and economic resilience from 2013 to 2022. By delineating the pathways through which population contraction influences economic resilience, the findings advance theoretical understanding of the demographic drivers of resilience and furnish policy guidance for Guizhou Province as it deepens urbanization, balances population development, and strengthens regional economic resilience.

2. Overview of the Study Area, Research Methods, and Data Sources

2.1 Overview of the Study Area

Guizhou Province is situated in the southwestern part of China, on the eastern edge of the Yunnan–Guizhou Plateau. The topography is dominated by plateau mountains, intermontane basins, and extensive karst landforms. The Qianzhong Urban Agglomeration is situated in the central portion of Guizhou Province and is predominantly characterized by low-mountain and hill karst landforms. It encompasses 33 county- and district-level administrative units distributed across six prefecture-level cities—Guiyang, Zunyi, Anshun, Bijie, Qiandongnan, and Qiannan (Figure 1)—covering a combined terrestrial area of 53,800 km², equivalent to 30.54 % of the province’s total land area [30]. In 2017, the permanent-resident population totaled 16.45 million and the region’s GDP reached RMB 849.448 billion, equivalent to 45.97 % and 62.7 % of the provincial totals, respectively. By 2022, the permanent-resident population had risen to 18.85 million and regional GDP stood at RMB 1,159.914 billion, representing 48.9 % and 57.5 % of the provincial aggregates. Both indicators accounted for more than half of the province’s respective totals. As a focal region for implementing the country’s “13th Five-Year Plan” for new-type urbanization, the Qianzhong Urban Agglomeration has launched 743 major projects with a combined investment of 3.5 trillion CNY since the 2017 promulgation of the Qianzhong Urban Agglomeration Development Plan [31]. Nevertheless, constrained by resource endowments, natural environmental conditions, and policy orientations, the area has experienced

population contraction, which in turn has undermined its economic resilience.

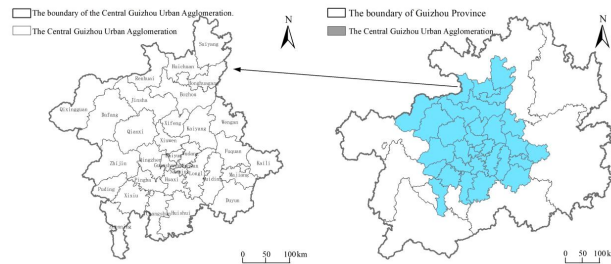


Figure 1. Location Map of Qianzhong Urban Agglomeration

2.2 Selection of Indicators for Economic Resilience in the Central Guizhou Urban Agglomeration

Empirical research on economic resilience centers on two core dimensions: its measurement and its determinants. Economic resilience is defined as the resistance, adaptability, and recoverability an economy—whether individuals, households, regions, or nations—exhibits when confronted with external risks and shocks. It unfolds as a cyclical process whose features vary across stages. Drawing on the scholarly literature and incorporating the current development status of the Central Guizhou Urban Agglomeration, this study—aligned with the “Development Plan for the Central Guizhou Urban Agglomeration”—conceptualizes the region’s economic resilience along three dimensions^[32–33]: First, crisis-resilience capacity denotes an economy’s ability—grounded in its structural attributes, policy frameworks, and stock of resources—to absorb and effectively counteract endogenous and exogenous shocks, thereby sustaining stable growth and preserving policy adaptability. Second, adaptability denotes a region’s capacity to anticipate and deliberately reconfigure its economic structure, policy orientation, and resource-allocation mechanisms in response to exogenous shocks or endogenous shifts, thereby sustaining competitiveness under changing conditions. Third, the restoration of adaptive capacity reflects a region’s ability—through industrial-structure optimization, market-mechanism refinement, and strengthened policy guidance—to return its economic system to its pre-shock configuration and to anticipate future shocks. This capacity is a critical determinant of the regional economy’s resilience and its ability to adapt to a post-crisis environment. In conclusion, drawing on the conceptual framework of regional economic-resilience development, this study establishes an urban economic-resilience evaluation index system for central Guizhou that comprises three dimensions—crisis-resistance capacity, adaptive-adjustment capacity, and recovery-transformation capacity—encompassing 12 indicators in total (Table 1).

Table 1. Evaluation Index System for Economic Resilience of the Qianzhong Urban Agglomeration

Criterion layer	Indicator layer	Indicator attribute	Indicator weight
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	Per capita GDP	+	0.0991
Crisis-resistant capacity	The ratio of per capita disposable income between urban and rural residents.	+	0.0589
	Added value of industrial enterprises above the designated size	+	0.1420
	Registered Urban Unemployment Rate	-	0.0427
	Income-to-expenditure Ratio	+	0.0558
	Total Retail Sales of Consumer Goods	+	0.0241
Adaptability and capacity for adjustment	Foreign Trade Dependence Ratio (Total Foreign Trade Investment)	+	0.2486
	Industrial Structure (Ratio of Secondary and Tertiary Industry Value to GDP)	+	0.0306
	Newly Employed Population	+	0.1161
Restore the capacity for transformation.	Degree of Industrial Upgrading (Ratio of Tertiary Industry Value to Secondary Industry Value)	+	0.0954
	Proportion of Local Fiscal Expenditure on Education	-	0.0346
	Total Power of Agricultural Machinery	+	0.0522

2.3 Research Methods

2.3.1 Identification of Population Contraction

This study adopts the mean annual rate of population^[34] change to delineate population contraction within the Central Guizhou Urban Agglomeration. The mean annual rate of population change denotes the proportional increase or contraction of a region’s population over a specified interval—typically five years. This study partitions the permanent resident population of counties within the Central Guizhou Urban Agglomeration into two sub-periods—2013–2017 and 2018–2022—according to the sign of the five-year mean annual growth rate, so as to identify county-level population contraction. The estimating equation is specified as follows:

$$P_{(t_1,t_2)} = \sqrt[n]{M_{t_2} / M_{t_1}} - 1 \tag{1}$$

In the formula, P (t1,t2) represents the per capita population change rate from t1 to t2, Mt1 and Mt2 are the permanent resident population of the region in t1 and t2 respectively, and n is the number of years between t1 and t2, where n is 5. To more clearly demonstrate the population changes in a region, generally speaking, when P (t1,t2) ≥0, it indicates that the population of the region has a non-shrinking (growing) trend during the period from t1 to t2; when P (T1-T2) <0, it indicates that the population of the region has a shrinking trend during the period from t1 to t2.

2.3.2 Entropy Method

Numerous established approaches exist for evaluating indicator systems. To ensure the rigor of the indicator set, this study adopts the comparatively objective entropy-weighting technique and applies it to determine the weights of the economic-resilience indicators for the Central Guizhou Urban Agglomeration. From 2013 to 2022, the economic resilience of the central Guizhou urban agglomeration was estimated using a weighted approach; the exact formula is provided in reference [35]. The computational procedure is as follows: ①Data standardization; ②Calculate the proportion of the JTH indicator value for the i-th year; ③Calculation of index information entropy; ④Calculation of information entropy redundancy; ⑤Determination of indicator weights

2.4 Data Sources

This paper draws all county-level permanent-population data for the Central Guizhou Urban Agglomeration for the years 2013, 2017, 2018, and 2022 from the Guizhou Statistical Yearbook. Socio-economic indicators are taken from the Guizhou Statistical Yearbook, the volume Guizhou in 70 Years, the Statistical Bulletins of National Economic and Social Development of individual counties, and the Guizhou Macro-Economic Database (<https://hgk.guizhou.gov.cn>). Where a given indicator is absent for a specific year, the missing value is estimated by linear interpolation.

2.5 Spatiotemporal Evolution Characteristics of Population contraction in the Central Guizhou Urban Agglomeration

This study quantifies county-level population contraction within the Central Guizhou Urban Agglomeration by computing the five-year per-capita population change rate. Counties are then assigned to one of two categories: those experiencing a non-negative change rate (≥ 0) and those experiencing a non-positive change rate (≤ 0). The resulting rates for all counties and districts are imported into ArcGIS 10.8 to generate a spatio-temporal map that visualizes the evolution of population contraction across the agglomeration (Figure 2).

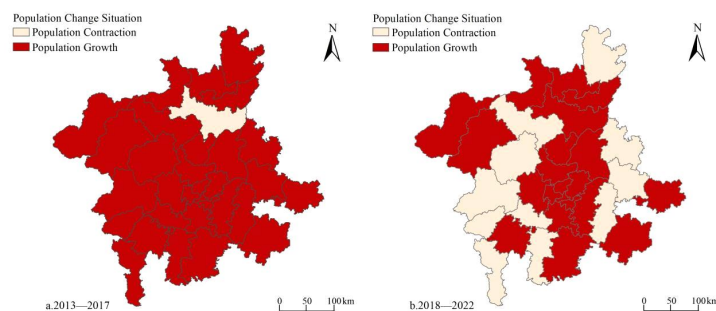


Figure 2. Spatial and Temporal Variations in Population Contraction within the Central Guizhou Urban Agglomeration

Note. This map was obtained from the standard map service system of the Department of Natural Resources of Guizhou Province. It is produced on the basis of the standard map reviewed under approval number Qian S (2022) 005. No boundary modifications have been made; the same applies to all subsequent maps.

As illustrated in Figure 2, pronounced population shifts occurred across the Central Guizhou Urban Agglomeration between 2013 and 2022. During 2013-2017, only Bozhou District experienced demographic contraction, whereas all remaining 32 counties and districts recorded net population gains. By contrast, during 2018-2022 the region exhibited an almost symmetric pattern of population contraction centered on the Huichuan-Honghuagang-Bozhou-Kaiyang-Wudang-Yunyan-Nanming-Huishui axis.

From 2013 to 2017, only one county-level unit in the central Guizhou urban agglomeration experienced population contraction, representing 3 % of the region's total number; the remaining 32 units recorded growth, accounting for 97 %. In terms of spatial distribution, Bozhou District exhibits a trend of contraction and is situated in the northeastern part of the central Guizhou urban agglomeration. Following the administrative reorganization of Zunyi City in 2016, the former Zunyi County was dissolved and reconstituted as a district, now known as Bozhou District. Population contraction in the district has been driven by factors such as changes in household registration and residential relocation. Additionally, Bozhou District's proximity to the provincial capital, Guiyang, and the central urban area of Zunyi City has enhanced its regional attractiveness, contributing to the observed population contraction. The remaining regions have exhibited a sustained pattern of population growth. As the primary locus of economic expansion in Guizhou Province, the Central Guizhou urban agglomeration has drawn a substantial influx of skilled personnel and labor from adjacent areas, driven by its accelerated economic performance. Concurrently, the provincial government implemented an extensive poverty-alleviation relocation program that transferred rural residents from ecologically fragile and development-constrained zones to newly established resettlement sites, thereby upgrading their living standards. By securing employment and income-generating opportunities for the resettled population, this policy has contributed to a measurable population increase in all prefectures except Bozhou District.

From 2018 to 2022, 11 counties within the Central Guizhou Urban Agglomeration experienced population contraction, constituting 33 % of the agglomeration's total county-level units. This figure represents a ten-fold increase relative to the 2013-2017 period. Conversely, 22 counties recorded population growth, accounting for 67 % of the agglomeration, a reduction of 10 counties (-31.3 %) compared with 2013-2017. From a spatial perspective, the areas undergoing contraction are distributed roughly symmetrically along the Huichuan-Honghuagang-Bozhou-Kaiyang-Wudang-Yunyan-Nanming-Huishui axis, flanking the economic core of the central Guizhou urban agglomeration. These areas are predominantly counties distant from prefectural- and municipal-level centers; they are characterized by weaker economic performance than the core, limited employment opportunities, declining regional attractiveness, and net population outflow. Moreover, because the province's key educational and medical resources are concentrated in Guiyang and Zunyi, some residents relocate to these cities in search of superior schooling and health-care services, reinforcing the pattern of population contraction. The remaining

twenty-two counties and districts exhibit a sustained pattern of demographic expansion. Since the adoption of China’s Thirteenth Five-Year Plan, the state has formally designated the Central Guizhou Urban Agglomeration as a strategic growth pole, mandating the concurrent development of the Guiyang and Zunyi metropolitan regions. The commissioning of an integrated high-speed rail matrix has transformed Guiyang into the principal transport hub of the southwest, intensifying connectivity between the Central Guizhou agglomeration and neighboring provinces, deepening inter-regional economic integration, and facilitating the return of migrant workers. Consequently, the core zone has registered consistent population growth.

3. An Analysis of the Spatio-temporal Evolution of Economic Resilience in the Central Guizhou Urban Agglomeration

This study quantifies the economic resilience of the Central Guizhou urban agglomeration by means of the entropy-weighted technique. After estimating the changes in the resilience index for all 33 constituent counties, the resultant values are imported into ArcGIS 10.8 to generate a spatio-temporal map that visualizes the evolving patterns of economic-resilience levels across the study area (Fig. 3).

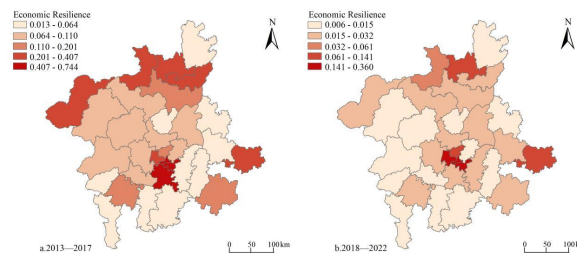


Figure 2. Spatial and Temporal Variation of Economic Resilience in Central Guizhou Urban Agglomeration

As illustrated in Figure 3, the economic resilience of the central Guizhou urban agglomeration exhibited pronounced variation over the study period, with substantial heterogeneity across counties. Spatially, resilience contracted monotonically from the core to the periphery. Areas exhibiting high economic resilience are concentrated primarily in the provincial capital of Guiyang, the city of Zunyi, and the urban core of Bijie, with Guiyang displaying the strongest performance. Conversely, counties characterized by low economic resilience are located mainly far from urban centers, principally within the Qiandongnan and Qiannan autonomous prefectures. A comparative analysis of the two periods reveals that Nanming District recorded the highest economic-resilience score (0.744) from 2013 to 2017, whereas Yunyan District registered the peak value (0.360) from 2018 to 2022, representing a 51.6 % contraction relative to the preceding interval. Conversely, Majiang County exhibited the lowest resilience level in both sub-periods: 0.013 in 2013–2017 and 0.006 in 2018–2022, the latter figure constituting a 53.8 % reduction from the former. The above results indicate that the economic core of

the central Guizhou urban agglomeration is located in the central area of Guiyang City. Specifically, Nanming District and Yunyan District exhibit high urbanization rates, concentrated resources, robust economic development, and strong economic resilience. In contrast, Majiang County—situated between Kaili (the capital of Qiandongnan Prefecture) and Duyun (the capital of Qiannan Prefecture)—suffers from weak regional attractiveness, experiences significant out-migration to surrounding cities, and displays underdeveloped economic conditions coupled with low economic resilience. These findings underscore a pronounced disparity and extreme imbalance in economic-resilience levels within the central Guizhou urban agglomeration. From 2013 to 2017, the standard deviation of economic-resilience indices was 0.187. Following the 2017 promulgation of the “Development Plan for the Central Guizhou Urban Agglomeration”, Guiyang accelerated its integration with Guian New Area and adjacent counties by synchronizing light-rail and expressway construction, thereby tightening inter-regional economic linkages and raising the economic-resilience level of metropolitan Guiyang. Zunyi, situated in the northern sector of the agglomeration and serving as a key node to the Sichuan–Chongqing region, has likewise intensified cross-jurisdictional exchange and cooperation. Bijie, leveraging its distinctive agriculture and tourism, has sustained steady economic growth. These dynamics have underpinned resilient expansion in the core urban zones of both Zunyi and Bijie, yielding comparatively high economic-resilience readings; nevertheless, substantial inter-regional development disparities persist. From 2018 to 2022, the standard deviation of regional economic-resilience indices was 0.089. Following the onset of COVID-19, regional economies were severely disrupted: manufacturing and service activities virtually ceased, and both high- and low-resilience zones recorded contractions exceeding 50 percent. This contraction has markedly impeded regional economic development, with most areas exhibiting a downward trajectory in resilience. Owing to prior investments in infrastructure and the digital economy, however, Nanming, Yunyan, and Guanshanhu districts in Guiyang have remained within the high-resilience category and experienced comparatively limited adverse effects. The southern part of the central Guizhou urban agglomeration has, owing to constraints imposed by the natural environment and resource endowments, persistently remained in a low-resilience economic zone.

4. Discussion

As the core engine of economic development in Guizhou Province, the central Guizhou urban agglomeration is predominantly mountainous; its market scale is constrained by both location and resource endowments. Consequently, the region is more susceptible to internal and external shocks, displays a comparatively weak capacity for economic recovery, and exhibits a low level of economic resilience. Population, as a critical determinant of economic development, not only supplies the Guizhou Central Urban Agglomeration with abundant labor throughout the development process, thereby stimulating the expansion of the consumer market and accelerating industrial structural upgrading, but also exerts an indirect influence on the enhancement of the region’s economic

resilience. As a growth pole of the regional economy, the central Guizhou urban agglomeration internally drives the province-wide socio-economic development and externally represents the province in economic competition and cooperation. Nevertheless, the region's rugged topography and distinctive karst landforms have retarded its development and raised construction costs. Moreover, the concentration of production factors in the core cities of Guiyang and Zunyi has produced pronounced inter-regional economic disparities. Therefore, amid the ongoing economic restructuring and the concomitant reconfiguration of population mobility, mitigating the adverse effects of demographic contraction on the resilience of regional economies and securing the coordinated evolution of population and economic systems are of immediate policy relevance for fostering balanced development within the Central Guizhou urban agglomeration. Compared with existing studies, this paper adopts population contraction as its analytical point of departure to examine the pathways through which shrinking populations influence economic resilience, thereby augmenting scholarly understanding of the population contraction–economic resilience nexus in mountain cities. However, this article also has certain limitations: First, the selection of indicators for economic resilience and their determinants is, by necessity, incomplete. Data availability and the current state of the literature constrained both the indicator system and the choice of explanatory variables. Going forward, the indicator framework and determinants for the Central Guizhou urban agglomeration should be updated dynamically to reflect the latest policy directives and emerging regional development trends, thereby remedying the limitations of the present study. Secondly, following the declared end of the COVID-19 pandemic, the regional economy has transitioned into a phase of recovery and reconstruction. Future scholarship must therefore extend its analytical horizon beyond 2022 to illuminate emerging trajectories of population change within the Central Guizhou urban agglomeration, to evaluate the adaptive capacities exhibited during economic revitalization, and to furnish a more comprehensive assessment of the intertwined dynamics of demographic and economic development in the region. Therefore, based on the research findings and discussions, this paper proposes the following recommendations for promoting regional population return and enhancing economic resilience:

(1) Foster and expand the central Guizhou urban agglomeration, accelerate development of the Guiyang–Gui'an–Anshun and Zunyi metropolitan regions, and use these poles to catalyze and sustain growth of the entire central Guizhou agglomeration. Upgrade the integrated transport network to intensify inter-regional economic exchange, stimulate development of peripheral counties and districts, adopt a unified approach to industrial spatial planning and resource allocation, and coordinate the planning and construction of infrastructure and public-service facilities. Ensure harmonized development across the urban agglomeration.

(2) The level of economic development is the key determinant of economic resilience. By leveraging distinctive industries—such as big data, high-end equipment manufacturing, health-pharmaceuticals, advanced materials, eco-characteristic food, new-energy vehicles, and the phosphorus-chemical sector—new growth poles should be cultivated to strengthen the competitiveness of urban

agglomerations. We will deepen the “Thousand-Enterprise Introduction” and “Thousand-Enterprise Transformation” initiatives, foster a diversified and high-quality economic structure, and inject fresh momentum into industrial upgrading.

(3) By culturally empowering local communities and systematically building distinctive brands, we can convert the cultural and red-tourism resources of ethnic-minority areas into high-profile cultural-and-tourism calling cards. Doing so will attract creative talent, upgrade supporting visitor services, and generate new employment opportunities. Concurrently, we will expand vocational education and skills training, purposefully developing a local labor force for tourism services, advanced manufacturing driven by big-data analytics, and chemical engineering. Targeted job-matching programs will then align this workforce with the pillar industries of the Central Guizhou urban agglomeration, thereby curbing outward labor migration.

(4) Using the Guiyang–Gui’an–Anshun and Zunyi metropolitan regions as anchors, systematically channel the rural population toward urban centers, leverage county seats as the pivotal interface between city and countryside, and redress deficits in public services and infrastructure so that nearby rural residents can relocate locally. Accelerate the absorption of externally transferred industries, upgrade the economic and cultural milieu of the urban agglomeration, and incentivize out-migrants to return home for employment. Introduce targeted talent-recruitment policies, refine supporting guarantees, eliminate hukou barriers, and thereby attract high-caliber professionals to live and work in the central Guizhou urban agglomeration.

5. Conclusion

This paper first measures the economic resilience index system of the central Guizhou urban agglomeration based on the entropy method. Secondly, it identifies the population contraction of the central Guizhou urban agglomeration by using the average annual population change rate. Finally, it explores the impact of population contraction on economic resilience by using the geographic detector model and analyzes other influencing factors. The following main conclusions are drawn:

Regarding population contraction: Between 2018 and 2022, the extent of population contraction in the Central Guizhou urban agglomeration intensified relative to the 2013-2017 period. During 2013-2017, only the Huichuan district experienced contraction, representing 0.3 % of the region’s total area and located in the northeastern sector. By 2018-2022, the number of shrinking districts had risen to eleven—33 % of the region—arranged in an approximately symmetric pattern along the Huichuan–Honghuagang–Bozhou–Kaiyang–Wudang–Yunyan–Nanming–Huishui axis.

Regarding economic resilience: From 2018 to 2022, the spatial pattern of economic resilience across the Central Guizhou urban agglomeration differed markedly from that observed during 2013-2017. Throughout the study period, Nanming and Yunyan districts in Guiyang consistently registered the highest resilience values, whereas low-resilience clusters were concentrated in the southern portion of the agglomeration and remained persistently depressed, evidencing a pronounced spatial lock-in effect.

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