

## Article

# The Impact of Population Shrinkage on Economic Resilience in Mountain Cities: A Case Study of Guizhou Province, China

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**Abstract:** With the recent changes in population structure and continuous urbanization, the degree of population shrinkage in mountain cities has increased, especially under the impact of the COVID-19 epidemic, and the economic development of such mountain cities has become a prominent issue. The epidemic has not only exposed the vulnerability of these cities to economic development but also aggravated the negative impact of population contraction, bringing about new challenges and pressures related to regional population development and economic resilience. This change has become an important topic in the study of mountain cities. Therefore, taking Guizhou Province as a case study, this work applies the population change rate, the entropy method, and a mediation effect model to study the spatiotemporal evolution of population shrinkage and economic resilience, and it explores how population shrinkage influences economic resilience. The results reveal the following: (1) Few counties experienced population shrinkage in Guizhou Province from 2013 to 2017, indicating a sporadic distribution pattern, whereas the degree of population shrinkage increased rapidly from 2018 to 2022, revealing an east–west symmetrical distribution pattern, with Guiyang city located on the central axis. (2) There are significant regional differences in the spatial distribution of the level of economic resilience between the two periods. Under the impact of COVID-19, from 2019 to 2022, although the overall level of economic resilience increased, the level of resilience in most counties tended to decrease. (3) Regarding the mediating effect, population shrinkage affected the level of economic resilience through general public budget expenditure, foreign trade investment, new urban employment, and GDP. The abovementioned findings are helpful for providing theoretical support and empirical guidance for the sustainable development of mountain cities in the face of population contraction, economic challenges, and promoting regional coordination.

**Keywords:** population shrinkage; economic resilience; mediating effect; mountain city; Guizhou Province



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## 1. Introduction

Population shrinkage is a social phenomenon that is widely associated with a decrease in the regional population and increasing aging. From a global perspective, the scope of population shrinkage is expanding. Population shrinkage occurs not only in developed countries but also in some parts of developing countries, and it has become a global problem [1]. In China, with large-scale population migration occurring between regions and the gradual decline of the natural population growth rate, the population shrinkage–age phenomenon has occurred in most regions. According to the data of the Fifth, Sixth, and Seventh Population Censuses, 28% of cities nationwide experienced population contraction from 2000 to 2010, and 78% of cities experienced population contraction from 2010 to 2020. In terms of the scope of contraction, the shrinking areas are characterized by large numbers, wide distributions, and multiple scales. The population shrinkage phenomenon has become a stumbling block to high-quality regional development and new-type urbanization in China. To effectively cope with the changes in the population of population regions, the Chinese government issued the National Population Development Plan (2016–2030) in 2016,

which clearly points out that understanding the new trend of population development and strengthening the important position of population factors in the social development system is highly important for promoting balanced regional development. Given their special type of urban development, mountain cities have many vulnerabilities linked to their geographical location, resource endowment, and wealth gap, and they experience a more profound impact of population changes than other regions do. The accumulation of multiple factors intensifies the risk of population shrinkage in mountain cities [2]. The vulnerability of mountain cities affects not only population change but also regional resilience and sustainable development.

In recent years, against the backdrop of complex and volatile global economic environments and the frequent occurrence of multiple risks, the concept of economic resilience has received widespread attention in economic research. The term “resilience” originated in physics and engineering. In early research, Holling [3] pioneered the concept of “engineering resilience” to describe the capacity of ecosystems to recover from external shocks. Reggiani [4] and colleagues were the first to introduce the concept of resilience into spatial economics research, which is an innovation that has led to its gradual familiarity and application in fields such as regional economics and economic geography. Now, talking about economic resilience refers to the ability of an economy (at the individual, household, enterprise, regional or national level) to respond to external risks, as well as to recover, adapt, and transform when such risks occur [5,6]. Economic resilience is not the same as economic stability. Economic stability focuses on an economy’s steadiness in the face of external shocks, emphasizing the stability of economic indicators. In contrast, economic resilience pertains to an economy’s internal ability to adapt and adjust when confronted with external shocks, achieving long-term stability and sustainable development through adaptive adjustments and structural changes. Economic resilience refers to the relationship between the internal complexity and stability of the economy and the promotion of stability and sustainable development through various complex factors within the economy [7,8]. This concept encompasses various aspects of an economy’s capacity, including economic structure, market mechanisms, policy responses, and resource allocation across regions. With the accelerating process of globalization, the economy is increasingly likely to face external shocks, such as the impact of epidemics, natural disasters, and financial crises, which will have a profound impact on economic development. In particular, in recent years, China’s economic growth has slowed, the urban–rural dual structure has gradually disappeared, the population structure is constantly changing, and the uncertainty and vulnerability of the economic development of mountain cities after external shocks have become increasingly prominent [9].

Owing to the influence of geographical location, poor resource endowment, and limited market size, economic development is more vulnerable to the impact of external risk, the speed of economic recovery is slower, and the degree of economic resilience is lower in mountain cities than in other cities. As the basic factor of the economic and social development of mountain cities, population plays a crucial role in the development process. Population affects not only the labor supply and market scale of mountain cities but also the industrial structure and level of technological innovation, thus indirectly affecting the improvement in economic resilience. How to realize the synchronous development of regional populations and economic resilience, break the pattern of uncoordinated and unbalanced development between regions, and promote high-quality regional development has become an important issue in the development process of mountain cities. Compared to other regional cities, mountain cities have unique characteristics in terms of population and economic development, due mainly to their unique terrain, resources, and environmental factors. These characteristics present mountain cities with both special challenges and opportunities. Currently, the academic research on population shrinkage and economic resilience has focused mainly on plain or metropolitan areas, with relatively few studies addressing mountain cities. Therefore, on the basis of previous research, this paper analyzes in depth the spatiotemporal evolution characteristics of mountain cities with

respect to population contraction and economic resilience and attempts to elucidate the driving mechanisms involved. This analysis not only lays the foundation for such research but also has important practical significance and value for promoting the coordinated development of the population and economic resilience in mountain cities. Through an in-depth discussion of the inner connections and development paths of these unique cities, this study aims to provide useful insights for relevant policymaking and urban planning.

As two important components of the social system, the population and the economy are both independent and interrelated, and their relationship has been widely studied. In terms of population shrinkage, scholars have focused on the following three points: (1) The definitions of population shrinkage and identification of population shrinkage. Some scholars believe that population shrinkage is a social phenomenon caused by regional economic decline [10,11]. Other scholars believe that population shrinkage is caused by a decline in the total number of people, families, and labor force, as well as a deepening of aging [12]. Based on previous research, this paper defines population shrinkage as a continuous decline in the resident population of an area over a period (usually divided into 5-year segments). (2) Trends of population shrinkage and its spatiotemporal evolution in different regions [13–15]. In China, population contraction is a social phenomenon caused by declining fertility rates and large-scale inter-regional population migration, such as population reduction in North China, Northeast China, the Yangtze River Economic Belt, and the Shandong Peninsula [16,17]. (3) Driving factors of population shrinkage. Scholars believe that the factors affecting population shrinkage mainly include the geographical environment, the location of economic bases, government policies, social culture, etc. [18–20]. For example, in the Yangtze River Economic Belt, population shrinkage is influenced mainly by the industrial structure, regional development level, and public service quality. In the cities of the Loess Plateau, population shrinkage is primarily affected by the levels of regional urbanization and industrialization, whereas some urban areas are impacted by the uneven distribution of production factors, leading to further population decline. In Heilongjiang Province, which is located in Northeast China, population shrinkage is driven mainly by the level of urban development and the availability of production resources. However, economic factors have the greatest impact on population shrinkage, whereas natural factors have the lowest impact [21]. The above research results have made great contributions to the concept and development trend of population contraction, but the specific impact of population contraction on social development needs to be further explored.

In terms of economic resilience, scholars have focused mainly on three points. (1) The following two main methods are used for measuring the degree of economic resilience: the core variable method and the multivariable comprehensive measurement method. The core variable method selects indicators that can directly reflect the development level of regional economic resilience. For example, Giannakis E [22] used GDP to study the difference in the levels of economic resilience between cities and rural areas within the EU, and Davies [23] used the employment rate to analyze the degree of recovery of European countries after the economic recession from 2008 to 2010. Zhang [24] measured the degree of economic resilience of different regions in China through the industrial structure by drawing on Martin's framework. For the multivariable comprehensive measurement method, social, economic, financial, and other factors are selected to construct an indicator system to assess regional economic resilience. Briguglio [25] was one of the first scholars to establish an indicator system to measure the degree of regional economic resilience, which provides indicators for reference for subsequent research on resilience. Perez [26] used regional GDP, the employment rate, industrial production, service output, investment, labor productivity, etc., to create a comprehensive index to understand the capacity of each region to resist and recover from an economic crisis. (2) Scholars have shown that the factors influencing the development of regional economic resilience include the industrial structure, technological innovation, government regulation, etc., but different factors influence economic resilience in different regions at different times. Rocchetta [27] explored how the technological coherence of regional economies affects their adaptability and resilience, highlighting

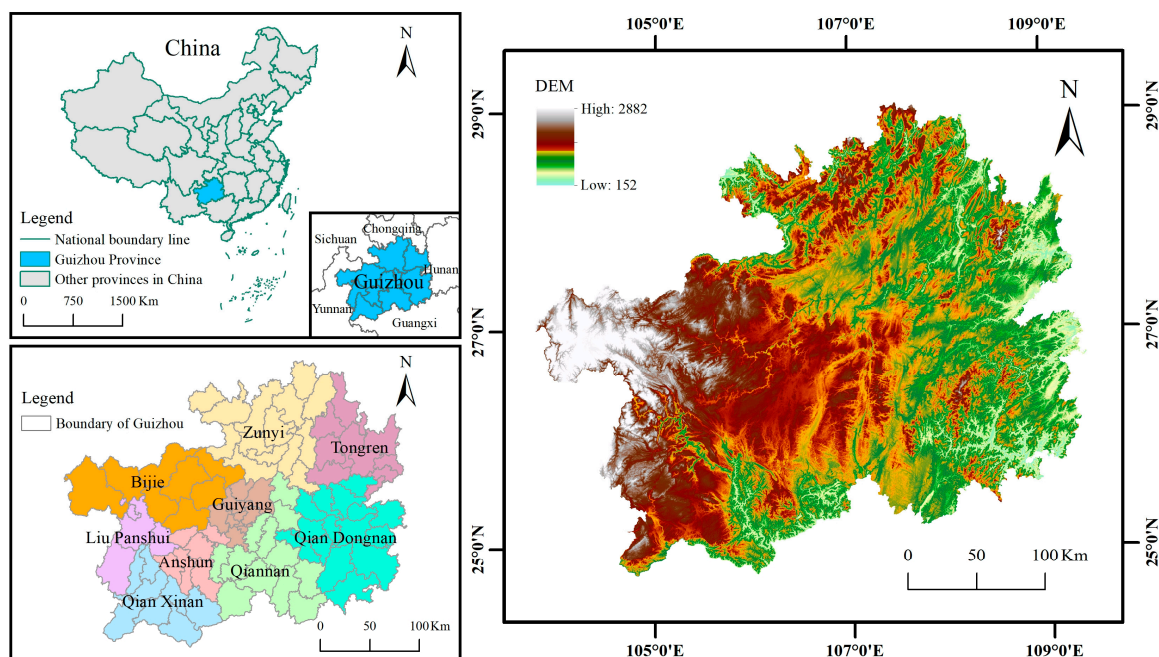
the important role of the coordination of technology and industry in economic stability and growth. Zhang [28] reported that the main factors affecting brokerage resilience in different provinces in China include the GDP growth rate, unemployment rate, fiscal revenue and expenditure, and infrastructure investment. Lund [29] explored the role of local food systems in enhancing regional economic resilience, highlighting their important contributions to economic stability, job creation, and social capital building. On the basis of empirical data from 285 cities in China, Du [30] revealed the key role of digitally inclusive finance in enhancing the resilience of urban economies by supporting and promoting digital financial services to increase the degree of economic resilience. (3) Scholars have studied the coupling and coordination between economic resilience and production factors according to key characteristics of the period under study, such as the coupling and coordination between economic resilience and land use efficiency, the digital economy, and technological innovation. Bai [31], Jin [32], and Garcia [33], through empirical analyses of cities in different regions, emphasized the key role of optimizing land use planning and improving the level of the digital economy and social science and technology in improving economic stability and adaptability.

Although the above studies have effectively explored population shrinkage and economic resilience, with the continuous change in population structure in mountain cities in recent years, population shrinkage has become increasingly serious. The research on how population shrinkage is linked to economic resilience is still limited, and shortcomings remain: (1) The existing research on population shrinkage and economic resilience focuses only on the spatiotemporal evolution characteristics of large-scale regions, without reflecting the development characteristics of different regions and without considering whether the vulnerability of urban development in mountainous regions has an impact on the spatial–temporal evolution between characteristics. (2) Studies consider only the coupling and coordination relationships between the population and economy but do not highlight the connection between population shrinkage and economic resilience or explore how population shrinkage affects economic resilience. (3) As a typical mountain city in Southwest China, the population and economic development of Guizhou Province are strongly constrained by resources and the environment, the industrial structure is relatively backward, the development gap between different regions is large, and regional vulnerability is high. Taking the mountain city in Guizhou Province as the research object can well reflect the particularity of economic resilience and population development. Therefore, in the context of the changes in population structure and economic development mode and using 88 counties in Guizhou Province as the research object, this paper systematically analyzes the spatiotemporal evolution characteristics and influencing mechanism of population contraction and economic resilience in mountain cities. This study not only aids the economic development of a single mountain city but also serves as a reference for similar areas, promoting regional coordination and balanced development.

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

### 2.1. Overview of the Study Area

Guizhou Province is located in southwestern China—southeast of the Yunnan–Guizhou Plateau, north of Sichuan Chongqing, south of Guangxi, west of Yunnan, and east of Hunan—and is referred to as “Qian” or “Gui”. The terrain is complex and diverse and includes mainly plateau, basins, and karst landforms. Mountainous areas account for 92.5% of the total area of the province, and karst landforms account for 61.9% of the total area of the province. The terrain is high in the west and low in the east, with large undulations in the northeast and southwest regions and severe surface fragmentation. The average altitude is 1100 m, and the total area of the province is 176,167 square kilometers, accounting for 1.8% of the total area of the country. Guizhou Province has a subtropical monsoon climate, with more precipitation, an obvious rainy season, and fewer sunshine days (Figure 1).



**Figure 1.** Guizhou Provincial location map. Note: The map is downloaded from the standard map service system, and the approval number is GS (2019) 1822 standard map. The boundary is not modified.

## 2.2. Selection of Economic Resilience Indicators for Mountain Cities in Guizhou Province

Regional economic resilience refers to the ability of economies or systems to resist, adapt, and recover in the face of external risks and shocks. Resilience is a cyclic and continuous development process with different characteristics at different stages [34]. On the basis of the previous research and the development status of mountain cities in Guizhou Province, this paper summarizes the development connotation of economic resilience in Guizhou Province into the following three aspects according to the 14th Five-Year Plan of Guizhou Province [35–37]. First, crisis resistance reflects the degree of damage that the economic development of mountain cities can withstand in the face of external shocks. It has a certain passivity, resistance, and fluctuation and is manifested by the stability of the regional economy and society, as well as the adaptability of policies. Second, the ability to adapt and adjust reflects the ability of the economy of mountain cities to adapt to a crisis after facing external impacts and concerns the internal adjustment ability of the economic system, which is manifested in the adjustment of fiscal policy, the continuous adaptation of the market operation mechanism, and the flexibility of the economic and industrial structure. Third, the ability to transform reflects whether the economic system of mountain cities can recover to the pre-shock state after an external shock and the ability to prevent shocks in advance, which is manifested in the reconstruction of infrastructure, adjustment of the industrial structure, and potential innovation of the regional economy. In summary, according to the concept of economic resilience, this paper constructs an economic resilience evaluation index system for mountain cities in Guizhou Province on the basis of their crisis resistance ability, adaptability and adjustment ability, and recovery and transformation ability, which contains 12 indicators (Table 1).

**Table 1.** Economic resilience evaluation index system of mountain cities in Guizhou Province.

Criterion Layer	Indicator Layer	Indicator Source	Indicator Attributes
Crisis resistance ability	Per GDP	Li [35]	+
	Ratio of per capita disposable income of urban and rural residents	Li [37]	−
	Growth rate of industrial enterprises above the designated size	Xie [36]	+
	Newly increased urban unemployment rate	Xie [36]	−
Adaptive and adjustment ability	Regional financial self-sufficiency (ratio of local government revenue to local government expenditure)	Wang [34]	+
	Total retail sales of consumer goods	Wang [34]	+
	Investment in fixed assets	Wang [34]	+
	Industrial structure	Xie [36]	+
Recovery and transformation ability	Capital subscribed by actual foreign investors	Wang [34]	+
	The degree of industrial upgrading (ratio of the value added by the tertiary sector to the regional GDP)	Li [37]	+
	Proportion of local fiscal expenditure on education	Tan [5]	+
	Added value of agriculture, forestry, animal husbandry, and fishery	Tan [5]	+

### 2.3. Research Methods

#### 2.3.1. Identification of Population Shrinkage

In this work, the average annual population change rate is used to identify the population shrinkage of mountain cities in Guizhou Province. The average annual population change rate refers to the growth or shrinkage of the regional population in a certain period, usually within 5 years. To identify county population shrinkage in Guizhou Province, the average annual change rates of the county resident population in Guizhou Province are considered over 5-year periods: from 2013 to 2022 is divided into two periods, from 2013 to 2017, and from 2018 to 2022 [38]. The formula is as follows:

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

In the above formula,  $P_{(t_1,t_2)}$  is the population change rate during  $t_1-t_2$ ,  $M_{t_1}$  and  $M_{t_2}$  are the resident populations of the region in years  $t_1$  and  $t_2$ , respectively, and  $n$  is the number of years between  $t_1$  and  $t_2$ , where  $n$  is 5. To more clearly show the regional population change, when  $P_{(t_1,t_2)} \geq 0$ , it means that the population of the region during  $t_1-t_2$  presents a non-shrinking (growing) trend; when  $P_{(t_1,t_2)} < 0$ , it means that the population of the region during  $t_1-t_2$  presents a shrinking trend.

#### 2.3.2. Entropy Method

The entropy method is an objective weighting method that determines the degree of dispersion of indicators on the basis of the magnitude of entropy. It is a mathematical method that uses the basic principles of information entropy to determine weights, comprehensively assessing the impact of estimated results. Using the entropy method to calculate weights can not only prevent bias caused by the subjective weighting method, but also solve the problem of information overlap between multiple variables, as well as provide a strong basis for the comprehensive evaluation of indicators. Therefore, this paper uses the entropy method to calculate the economic resilience level of mountain cities in Guizhou Province [39,40].

### 2.3.3. Hypothesis of the Chain Mediation Effect Model

The mediation effect refers to the process in which the independent variable  $X$  influences the dependent variable  $Y$  through one or more intermediary variables  $M$  in the process of statistical analysis. In the intermediary effect model, the independent variable  $X$  first affects the first intermediary variable  $M_1$ , then  $M_1$  affects the second intermediary variable  $M_2$ , etc. Finally,  $M_X$  affects the dependent variable  $Y$ . Through such a chain intermediary effect, the relationship between the independent variable and the dependent variable can be further understood. The calculation of a chain mediation effect usually involves the product of multiple chain path coefficients, such as the effect of the independent variable  $X$  on the first mediator variable  $M_1$  ( $a_1$ ), the effect of the first mediator variable  $M_1$  on the second mediator variable  $M_2$  ( $a_2$ ), and the effect of the second mediator variable  $M_2$  on the dependent variable  $Y$  ( $b$ ). The implementation method of the chain mediation effect is tested via structural equation modeling (SEM) or the bootstrap method [41–43]. Therefore, the bootstrap method was used to construct a chain mediation effect model to explain the impact of population shrinkage ( $X$ ) on economic resilience ( $Y$ ) in mountain cities of Guizhou Province and reveal its underlying mechanism. In terms of the selection of intermediary variables, according to previous research [44], general public budget expenditure ( $M_1$ ), foreign trade investment ( $M_2$ ), the new urban employment population ( $M_3$ ), and GDP ( $M_4$ ) were selected. To explore whether there is a chain relationship between these four intermediary variables, the following mediation effect model was established. The formula is as follows [45]:

$$X \xrightarrow{(M_1)} Y = a_1 M_1 + b_1 + \tau_i + \varepsilon_i \quad (2)$$

$$X \xrightarrow{(M_1, M_2)} Y = a_1 M_1 + d_2 M_2 + b_2 + \tau_i + \varepsilon_i \quad (3)$$

$$X \xrightarrow{(M_1, M_2, M_3)} Y = a_1 M_1 + d_2 M_2 + d_3 M_3 + b_3 + \tau_i + \varepsilon_i \quad (4)$$

$$X \xrightarrow{(M_1, M_2, M_3, M_4)} Y = a_1 M_1 + d_2 M_2 + d_3 M_3 + d_4 M_4 + b_4 + \tau_i + \varepsilon_i \quad (5)$$

$$X \rightarrow Y = c_0 + \tau_i + \varepsilon_i \quad (6)$$

In the above formula,  $a_{1-4}$ ,  $b_{1-4}$  and  $d_{1-4}$  are the intermediate effect coefficients;  $c_0$  represents the direct effect of population shrinkage on economic resilience in mountain cities of Guizhou Province;  $\rho_i$  and  $\tau_i$  are the individual and time fixed effects; and  $\varepsilon_i$  is the disturbance term.  $a_1 \times b_1$ ,  $a_1 \times d_1 \times b_2$ ,  $a_1 \times d_1 \times b_2 \times b_3$ , and  $a_1 \times d_1 \times d_2 \times d_3 \times b_4$  are the products of the chain mediation effect coefficients. This model can cover 15 influence paths with four intermediaries as nodes, and only 5 are listed in this paper. The influence paths of the other intermediary variables are consistent with those of the above basic model.

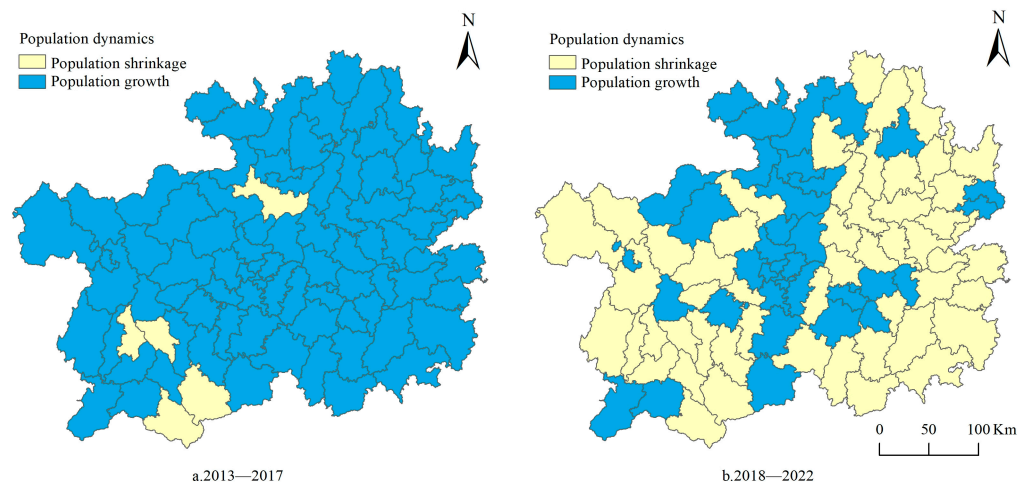
### 2.4. Data Sources

In this paper, the resident population data of Guizhou counties in 2013, 2017, 2018, and 2022 are all from the “Statistical Yearbook of Guizhou Province”. The social and economic development data come from the “Guizhou Province statistical yearbook”, “Guizhou in 70”, “Guizhou macroeconomic database” (<http://hgk.guizhou.gov.cn/>) (accessed on 1 July 2024), and the communique of national economic and social development. Some data are missing during the selected period, and the linear interpolation method is used for processing.

## 3. Spatial and Temporal Evolution Characteristics of Population Shrinkage in Mountain Cities in Guizhou Province

On the basis of the average annual rate of population change, this paper measured the level of population shrinkage of the permanent population in the mountain cities of Guizhou Province over 5-year periods. After the population shrinkage situation of each county was obtained, the population change rate was divided into two categories:  $\geq 0$  or  $< 0$ . The population change rate of mountain cities in Guizhou Province was imported

into ArcGIS10.8 to draw a spatial–temporal evolution differentiation map for visualization research (Figure 2).



**Figure 2.** Spatial and temporal variations in population shrinkage in mountain cities in Guizhou Province. Note: The map is downloaded from the standard map service system of the Guizhou Provincial Department of Natural Resources, and the approval number is Qian S (2022) 005 standard map. The boundary is not modified. The same is the case for the following figures.

Overall, according to Figure 2, the level of population shrinkage in the two selected periods changed greatly. From 2013–2017, the counties in Guizhou Province with population shrinkage presented a scattered distribution, and most areas exhibited a trend of population growth. From 2018–2022, the areas in Guizhou Province with population shrinkage presented an approximately symmetrical distribution pattern along the line formed by “Chishui, Xishui, Renhuai, Bozhou, Xifeng, Kaiyang, Yunyan, Nanming, Huishui, Luodian”.

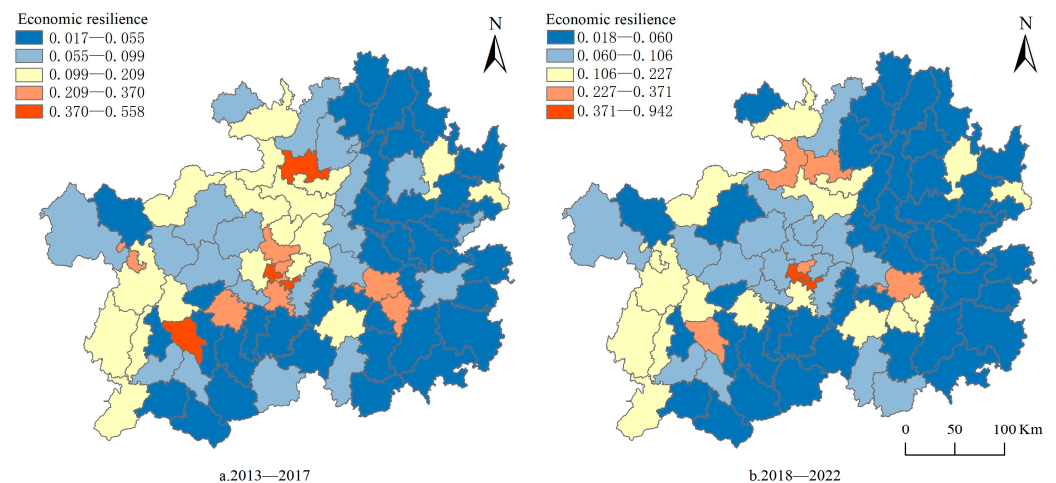
From 2013–2017, there were 5 regions with a shrinking population, accounting for 5.7% of the total number of counties in Guizhou Province, and 83 regions with an increasing population, accounting for 94.3% of the total counties. From the perspective of spatial distribution, the regions presenting population shrinkage were Bozhou, Guanling, Ceheng, Wangmo, and Qinglong, which are distributed mainly in the southwestern Guizhou Province, where the rocky desertification phenomenon is serious, the radiation range of the central city is limited, and regional economic and social development is relatively slow. Bozhou District is close to the provincial capital Guiyang and the downtown area of Zunyi, which is highly attractive within the region. Therefore, the population in these areas is shrinking. The remaining regions showed a trend of population growth, mainly due to the influence of the 12th Five-Year Plan and 13th Five-Year Plan of Guizhou Province, which succeeded in improving regional economic development and people’s living standards. Moreover, the rise of the digital economy and digital industry provided new vitality supporting the economic development of counties in Guizhou Province. In addition, from 2013 to 2017, Guizhou Province constantly adjusted and improved its railway network lines to improve the railway transportation efficiency and service level. During this period, the Guiyang–Guangzhou high-speed railway, Guiyang–Kunming high-speed railway, and Nanchang–Kunming railway were opened successively, which greatly decreased the distance between Guizhou Province and Guangzhou, as well as between Yunnan and Guangxi; they also promoted social and economic exchanges in the region and reduced the cost of regional population flow. This promoted the return of the population to Guizhou Province, increasing the population in most areas. From 2018 to 2022, there were 52 counties in Guizhou Province where the population decreased, accounting for 59.1% of the total county-level areas in Guizhou Province. This number increased by 47 compared to the figure for 2013–2017, representing a growth rate of 940%. There were 36 areas where the population increased, accounting for 40.9% of the total county-level areas in Guizhou



Province. This number decreased by 47 compared to 2013–2017, with a decrease rate of 56.6%. From the perspective of spatial distribution, the areas showing population shrinkage are to the east and west of the “Chishui, Xishui, Renhuai, Bozhou, Xifeng, Kaiyang, Yunyan, Nanming, Huishui, Luodian” line, except for the centers of cities and states. The main reasons for this are the outbreak of the COVID-19 pandemic at the end of 2019, which persisted until the end of 2022. The COVID-19 pandemic had major effects on infrastructure construction and industry during this period, leading to production and construction halts. Regional economic development grew slowly during this period compared to 2013–2017. Moreover, while the labor force increased annually, local employment opportunities were insufficient to meet the demand for jobs. The reduced commuting costs accompanied a significant outflow of population, leading to a population shrinkage trend. The remaining regions showed a trend of population growth, mainly due to the continuous optimization of urban space during the period; the construction of the Qianzhong urban agglomeration and Zunyi metropolitan area; the acceleration of the urbanization of Guiyang–Gui'an, Qixingguan–Dafang, and Zhongshan–Shuicheng; and the continuous promotion of the construction of regional central cities, which reduced the impact of the COVID-19 pandemic to a certain extent. As a result, the population in the central area increased.

#### 4. Spatial and Temporal Evolution Characteristics of the Economic Resilience Level of Mountain Cities in Guizhou Province

On the basis of the average annual rate of population change, this paper measured the level of population shrinkage of the permanent population in the mountain cities of Guizhou Province over a 5-year period. After the population shrinkage situation of each county was obtained, the population change rate was divided into two categories:  $\geq 0$  or  $< 0$ . The population change rate of mountain cities in Guizhou Province was imported into ArcGIS 10.8 to draw a spatial–temporal evolution differentiation map of the population shrinkage of mountain cities in Guizhou Province for visualization (Figure 3).



**Figure 3.** Spatial and temporal variations in the economic resilience of mountain cities in Guizhou Province.

Overall, according to Figure 3, the level of economic resilience varies greatly among counties, and the spatial distribution shows a depression in the middle, gradually decreasing from west to east. The high-value areas are distributed mainly in Guiyang city and the central areas of cities and states, while the low-value areas are distributed mainly in the Miaoling Mountain area in southern Guizhou Province and the Wuling Mountain area in eastern Guizhou Province; the spatial distribution is obviously locked in. Comparing the two sets of data, in 2022, the high-value areas increased by 0.384 compared to those in 2017, with a growth rate of 68.8%, and the low-value areas increased by 0.001, with a growth rate of 5.9%. This indicates that the overall economic resilience level increased in

2022 compared to 2017. Compared with that in 2017, the standard deviation increased from 0.113 to 0.151, which is an increase of 33.6%, and the range increased from 0.541 to 0.924, which is an increase of 70.8%. This indicates that the disparity in economic resilience between regions gradually widened, highlighting increasingly uneven and imbalanced development. From the data of the two periods, 29 counties and districts, such as Yunyan, Renhuai, and Kaili, showed a significant upward trend, increasing by 0.572, 0.127, and 0.094, respectively. Xixiu, Guanling, Huichuan, Xiuwen, and Qingzhen showed obvious downward trends of 0.116, 0.224, 0.225, 0.134, and 0.055, respectively. Only Guanshanhu and Nanming of Guiyang showed no change in the high-value area. The above situation is attributed mainly to the “13th Five-Year Plan of Guizhou Province”, which focused on supporting emerging industries, such as equipment manufacturing, the digital industry, and biomedicine. The GDP growth rate in 2017 was 10.7%, and the economic growth rate was among the best in the country. Taking the digital industry as an example, the economic growth rate of the industry exceeded 20% in 2017. In 2017, Guizhou Province added more than 500 km of new expressways and opened numerous new high-speed rail lines, such as the Guiyang–Guangzhou high-speed rail and Chongqing–Guizhou high-speed rail lines. The adjustment of the trunk lines of roads and railways promoted economic development and exchanges in some regions. In 2022, Guizhou Province experienced the most severe impact from the COVID-19 pandemic. As a major province for tourism, Guizhou experienced continuous setbacks in its tourism industry due to production halts and business closures. By the end of 2022, the GDP growth rate was 1.2%, with declines of 0.1%, 0.5%, 0.9%, and 5.7% in the construction, wholesale and retail trade, transportation, and accommodation and catering industries, respectively. Therefore, some cities showed a declining trend in economic resilience level in 2022. Owing to the poor resource endowment conditions in the Wuling Mountain area in eastern Guizhou Province and the Miaoling area in southern Guizhou Province, the level of industrial development is low, and the degree of economic resilience is low.

## 5. Study on the Impact of Population Shrinkage on Economic Resilience in Mountain Cities of Guizhou Province

### 5.1. Regression Results of the Mediating Effect of Population Shrinkage in Mountain Cities on Economic Resilience in Guizhou Province

In this study, Stata 17 was used to construct a chain mediation effect model based on the bootstrap method to test the impact of population shrinkage on economic resilience in mountain cities in Guizhou Province. Taking 2017 and 2022 as time nodes, 88 counties in Guizhou Province were used as experimental samples, and the population shrinkage rate was used as the independent variable ( $X$ ), the economic resilience index was used as the dependent variable ( $Y$ ), and the general public budget expenditure ( $M_1$ ), foreign trade investment ( $M_2$ ), urban newly employed population ( $M_3$ ), and GDP ( $M_4$ ) were used as intermediary variables. First, it is assumed that population shrinkage has a direct effect on economic resilience. If the direct effect passes the significance test, it is assumed that population shrinkage has a mediating effect on economic resilience, as shown in the estimates of the baseline regression model of mediation effects (Table 2). To prevent multicollinearity issues among the selected indicators, we first standardized the variables. Next, we conducted a variance inflation factor (VIF) test. The results indicate that all selected variables passed the significance test, and their VIF values were less than 3. Therefore, it can be concluded that there is no multicollinearity issue among the selected variables.

**Table 2.** Baseline regression estimates of the intermediate effect model.

Variable	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>4</sub>	Y
X	24.622 * (2.027)	49.926 *** (4.468)	−1.219 (−0.143)	7.630 (1.617)	1.375 *** (2.705)
M <sub>1</sub>		1.50 * (1.548)	0.458 *** (6.790)	0.478 *** (3.923)	1.376 ** (2.704)
M <sub>2</sub>			0.563 *** (7.558)	0.352 ** (2.514)	0.123 *** (22.505)
M <sub>3</sub>				−0.254 (−0.1604)	0.243 *** (36.813)
M <sub>4</sub>					0.170 *** (37.639)
F-number	4.111 ***	13.261 ***	50.811 ***	7.386 ***	30,781.9 ***
R <sup>2</sup>	0.214	0.488	0.803	0.513	0.998
Sample size	88	88	88	88	88
Individual fixed effects	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes

Note: \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

According to Table 2, the regression coefficient of population shrinkage (X) on economic resilience (Y) is 1.375 and passes the 1% significance test, indicating that population shrinkage has a significant direct effect on economic resilience. After adding a series of intermediary variables, most of the regression coefficients of the intermediary effect are positive and pass the significance tests of 10%, 5% and 1%. Only the impact paths of population shrinkage (X) on GDP (M<sub>4</sub>) and the urban newly employed population (M<sub>3</sub>) on GDP (M<sub>4</sub>) fail the significance test. This means that the hypothesis that population shrinkage has a mediating effect on economic resilience is valid and that the general public budget expenditure (M<sub>1</sub>), foreign trade investment (M<sub>2</sub>), urban newly employed population (M<sub>3</sub>), and GDP (M<sub>4</sub>) mediate the relationship between population shrinkage and economic resilience.

The four selected mediating variables in this study can construct 15 mediating effect paths. However, on the basis of the results of the bootstrap method (Table 3), only five paths pass the significance test (the significance criterion is as follows: if the confidence interval of the estimated upper and lower bounds does not include 0, then the mediating effect is considered significant) [41] (Table 3).

**Table 3.** Chain mediation effects and confidence (bootstrap method).

Intermediate Path	Effect Size	Proportion of Mediating Effect	95% Confidence Interval
			[Lower Limit, Upper Limit]
X → M <sub>1</sub> → Y	3.016	3.6%	[0.368, 7.264]
X → M <sub>1</sub> → M <sub>3</sub> → Y	2.738	3.3%	[0.336, 6.979]
X → M <sub>2</sub> → Y	61.158	73.5%	[24.899, 120.809]
X → M <sub>2</sub> → M <sub>3</sub> → Y	6.821	8.2%	[0.174, 15.768]
X → M <sub>2</sub> → M <sub>4</sub> → Y	2.979	3.6%	[0.131, 6.977]
Total mediating effect	83.224	–	[31.968, 161.942]

### 5.2. Analysis of the Mechanism of the Mediating Effect of Population Shrinkage in Mountain Cities on Economic Resilience in Guizhou Province

According to Table 3, in the first intermediate path, population shrinkage affects economic resilience through general public budget spending. First, according to the law of population flow, the young and middle-aged population dominate the outflow of the regional population, and population contraction within a period indirectly leads to an auto-

matic increase in the degree of regional aging. In terms of government fiscal expenditure, the increase in aging increases the demand for expenditure on old-age infrastructure and social welfare. Moreover, a decrease in the population leads to a gradual decline in the utilization rates of urban transportation, education, and public facilities, resulting in the waste of some resources. Second, the loss of population directly affects regional tax revenue by reducing individual income taxes and consumption taxes. Taking the individual income tax as an example, with the gradual decline in the working-age population, the regional tax base will narrow, the number and amount of taxpayers will decrease, and the amount of tax collected will decrease, especially in mountain cities in Guizhou Province. The population is shrinking relative to that in developed regions, and the loss of population became even more severe during the COVID-19 pandemic from 2019 to 2022. Finally, population contraction weakens the regional economic growth rate. Except for Guiyang and Zunyi, most regions in Guizhou Province still present economic growth dominated by the “demographic dividend”. The contribution of the “talent dividend” to social and economic development is not prominent, and the population size promotes regional economic development to a large extent. From 2018 to 2022, 52 counties in Guizhou Province experienced population contraction. Shrinking populations limit the development of economic resilience.

In the second intermediate path, population shrinkage affects economic resilience through general public budget spending and the newly employed urban population. The impact of general public budget expenditures on the newly employed urban population has been clarified. First, a reduction in general public budget expenditures leads to a reduction in regional infrastructure construction projects, resulting in a reduction in employment opportunities in the construction and engineering industries. According to the data of the seventh population census of Guizhou Province, the population engaged in the construction industry accounts for 16.4% of the total population of the province, and the reduction in infrastructure projects limits the growth of new urban employment. Simultaneously, reductions in general public budget expenditures can hinder technological innovation and the development of emerging industries, thereby partially weakening market vitality. This situation limits the possibility for businesses to expand their production scale and increase employment opportunities, diminishing the local population’s entry into the job market and thereby suppressing the enhancement of regional economic resilience.

In the third intermediate path, population contraction affects economic resilience through foreign trade investment. This influences the direction and sustainability of regional economic development through the number of laborers, market size, industry, and technological innovation. In terms of labor force size, population contraction directly alters the age structure by reducing the working-age population supply and increasing the proportion of elderly individuals. This population decrease results in inadequate regional labor supply, notably in the scientific and technological innovation sectors, which increases enterprise labor costs. Investors may scale back regional investments and expansion plans due to these labor market conditions. In terms of market size, investors usually conduct comprehensive market analysis before investing in a target market to ensure that the expected returns and benefits can be obtained. The population size, consumer demand, and market growth rate play crucial roles in decision making. From 2018 to 2022, the county population of Guizhou Province shrank significantly, with a notable decrease in the number of young people, which means that the market size has shrank, consumption power was weakened, and large-scale investment could not bring real benefits, reducing the possibility of foreign investment. In terms of industrial and technological innovation, investors can bring not only capital but also advanced technologies, which play a transformational role in regional industrial development. Population contraction leads to a decrease in foreign investment, weakening market competitiveness, affecting the stability of regional and industrial supply chains, and slowing the pace of industrial technological innovation.

In the fourth intermediary path, population contraction affects economic resilience through foreign trade investment and the newly employed urban population. An increase or decrease in foreign trade investment means that the market and industry expand, slow,

or shrink, which leads to the growth or reduction of/in employment opportunities. When regional foreign trade investment increases along with the expansion of the market scale and the improvement in enterprise production capacity, a larger labor force is needed to participate in market operations and enterprise production activities, thus promoting the gradual increase in the newly employed urban population. In contrast, when regional foreign trade investment continuously shrinks, it is accompanied by a reduction in market size, a decrease in the production capacity of enterprises, and a decrease in the social labor participation rate, which affects the growth of the newly employed urban population. As a driving force for growth within the economic system, the scale of the newly employed labor force has a declining role in promoting the sustainable development of the regional economy, thus affecting the improvement in regional economic resilience.

In the fifth intermediary path, population contraction affects economic resilience through foreign trade investment and GDP. The expanding market scale, increasing export volume, industrial upgrades, and advanced management practices introduced through increased regional foreign trade investment enhance social production efficiency, create more jobs, and stimulate regional economic development, contributing to GDP growth. Conversely, population decline results in reduced regional foreign trade investment and results in the opposite effects. Economic resilience reflects a region's ability to recover from external risk, with the GDP growth rate accurately indicating the region's adjustment and recovery capabilities.

## 6. Conclusions and Discussion

### 6.1. Conclusions

This paper first measured the economic resilience level of mountain cities in Guizhou Province by building an economic resilience index system based on the entropy value method. It then identified the population contraction of mountain cities by using the average annual population change rate and finally analyzed the impact and mechanism of action between the two by using the chain mediation effect model. The findings can promote the simultaneous development of population and economic resilience in Guizhou Province. The following conclusions are drawn:

1. In terms of population contraction, from 2018–2022, compared to the period from 2013 to 2017, Guizhou Province experienced increasingly severe population contraction in its counties, indicating an uneven spatial development trend. From 2013–2017, only five counties, distributed mainly in southwestern Guizhou Province, had a shrinking population, accounting for 5.7% of the total counties in the province. From 2018 to 2022, the number of counties with shrinking populations in Guizhou Province increased to 52 counties, accounting for 59.1% of the total number of counties in Guizhou Province and indicating a symmetrical distribution pattern on both the east and west sides of the province.
2. In terms of economic resilience, there was a significant spatial difference between 2013–2017 and 2018–2022, with an obvious spatial locking phenomena in the high-value area and the low-value area. The standard deviation and range of the index of economic resilience increased by 33.6% and 70.8%, respectively, in 2018–2022 compared to 2013–2017, and the interregional development imbalance was more prominent.
3. Regarding the impact of population contraction on economic resilience, according to the results of the mediation effect model, first, population contraction has a direct significant effect on economic resilience. Second, after adding the general public budget expenditure, foreign trade investment, urban newly employed population, and GDP as intermediary variables, most of the baseline regression estimates of the intermediary effect pass the significance test of 10%. The total mediation effect value of the 15 output mediation paths is 83.224, and five chain mediation paths are significant.

## 6.2. Discussion

Guizhou Province, which includes cities that are representative of mountain cities in China, shoulders the important tasks of western development and poverty alleviation. However, owing to the long-term influence of geographical location, although the population and economic resilience level increased during the 12th Five-Year Plan and 13th Five-Year Plan, both factors showed a downward trend under the impact of the 2019–2022 COVID-19 pandemic, which reflects the mobility of the mountain city population and the vulnerability of the economy. In this paper, the link between population contraction and brokerage resilience in mountain cities has been established via a chain mediation effect model. The influence path of the conduction effect between different factors on economic resilience has also been clarified. A correct understanding of the relationships between these factors is highly important for promoting the coordinated development of both factors. These findings enrich the theoretical system on the relationship between population contraction and economic resilience, provide theoretical support and empirical guidance for the sustainable development of mountain cities in coping with population contraction and economic challenges at the practical level, and help local governments and planners better understand and cope with the economic pressure caused by population contraction to promote the coordinated development and long-term prosperity of the region. On the basis of these insights, targeted policy recommendations are needed to address the identified challenges and opportunities for enhancing the degree of urban resilience amidst population changes. First, we should address the social phenomenon of population shrinkage and formulate relevant policies to attract and retain the population, such as entrepreneurship training, talent training, and housing subsidies. In addition, we can improve the quality and attractiveness of urban life by improving the urban environment and education level, increasing residents' level of life satisfaction and slowing population loss. Second, regional cooperation and regional network construction should be strengthened; regional economic cooperation zones, joint project development and personnel exchange, and the regional sharing of resources and information should be promoted; economic resilience should be improved; and the competitiveness of cities in larger economies should be enhanced. Finally, economic diversity and innovation should be promoted, and mountain cities should be encouraged to develop diversified economic structures to reduce their degree of dependence on a single industry. In particular, investment in emerging industries and innovation should be promoted, more jobs should be created, and the resilience of the urban economy should be strengthened by guiding enterprises to invest in high-tech, ecotourism, green energy, and other fields.

Although this paper discusses the mechanism by which population shrinkage affects urban resilience in mountain cities, it has several limitations. First, in terms of the selection of indicators of economic resilience, due to the limited data availability, the index system is not very comprehensive. In future research, a more complete and scientific index system can be established according to the population and economic development plan of Guizhou Province by interpreting relevant policies to compensate for the shortcomings of this paper. Second, in terms of the study time span, although the impacts of the COVID-19 epidemic on the regional population and economic development are covered, the change trend over a longer period was not considered; thus, the impacts of long-term dynamic changes and the external economic environment may not be fully explored. In future studies, the years comprising the post-2022 period can be included in similar studies to explore the recovery of Guizhou's population and economic development after the end of the COVID-19 pandemic, and practical recommendations for the development of economic resilience in mountain cities can be provided. Finally, in terms of the impact of population contraction on economic resilience, only four mediating factors were selected for use in this paper, and only five of the mediating paths pass the test of statistical significance. In future studies, mediating variables can be adjusted and optimized (e.g., logarithm or standardization) to explore the impact of population contraction on economic resilience through more comprehensive intermediaries. In summary, the findings of this paper provide valuable insights into the

relationship between population shrinkage and economic resilience in mountain cities. However, when applying these findings, it is necessary to consider their limitations and conduct comprehensive analysis in the context of specific regions and contexts.

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