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# County-Level City Shrinkage in China: Representation, Cause, and Response

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**Abstract:** Shrinkage in China's cities has gradually received increasing attention. Specifically, county-level shrinking cities are numerous and widely distributed. City shrinkage even appears throughout Zhejiang Province, which is highly developed and has stable economic growth. County-level shrinking cities resulting from regional competition can still maintain long-term and stable economic growth, but their economic growth lags behind the whole competitive region. We identified five county-level shrinking cities in Zhejiang Province, and characterized the shrinkage phenomenon in Changshan County using census, nighttime lighting (NTL), and Tencent Location Big Data. City shrinkage resulted from the comprehensive effects of declining traditional industries, backward per capita income, highly skilled labor force shortages, and population age structure changes. Given the shrinkage status of Changshan, we proposed countermeasures and suggestions including aspects of industrial development, urban planning, social governance, and care for the elderly.

**Keywords:** city shrinkage; representation; cause; response; nighttime lighting data; China; Changshan

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## 1. Introduction

City shrinkage has become an international phenomenon [1] and a new challenge for global population development [2]. Shrinkage started in the 1950s, with stagnating population growth in some European cities and regions [3]. Up to the 1980s, numerous cities in developed European and American countries underwent shrinkage, accompanied by sustained population losses, declining economic vitality, decaying buildings, and increasing social contradictions [4,5]. Recently, the shrinkage phenomenon has been observed in cities of some developing countries, especially in emerging economies [6]. China, a developing country and the world's second-largest economy [7], is faced with an increasingly aggravated challenge of city shrinkage. Over 260 cities sustained population shrinkage from 2010 to 2020 as Beijing, Shanghai, Shenzhen, Chongqing, Guangzhou, Chengdu, and Tianjin grew into megacities with urban populations exceeding 10 million [8]. Presently, several cities face various problems such as economic recession, industrial shortage, imperfect infrastructures, deteriorated living environment, and housing vacancy [9–11].

Such shrinkage phenomena have attracted close attention from the Chinese government. At the Central Urban Work Conference in 2015, General Secretary Xi Jinping pointed out the requirements for enhancing shrinking city sustainable development. Seventh census data show that the population urbanization rate in Mainland China grew rapidly from 49.7% (2010) to 63.9% (2020). Now China remains in the rapid urbanization phase, in which large-scale and high-speed population aggregation from rural areas towards cities will not slow, not to mention be reversed [12]. To meet the challenge, China is implementing a new type of people-oriented urbanization strategy and has vowed to devise a new development path for county seats suffering from population outflows [13]. In recent years, continuously deepening research has been conducted on city shrinkage in China. The connotations of

city shrinkage have been discussed, international experience has been generalized and summarized [14–16], and the uniqueness and complexity of city shrinkage in China has been recognized [10,17]. More data are required to profoundly explore the impacts, development mechanisms, and response measures of county-level city shrinkage in more dimensions [17] in combination with more actual local context [18]. Moreover, Chinese shrinking cities have been empirically analyzed [19–21]. Most of these studies were conducted before 2015, although the city shrinkage phenomenon in China has been reflected, to some extent, by existing research results [22]. In most previous studies, the causes of shrinkage were analyzed mainly at the macro-level or with a focus on declining and resource-exhausted cities in relatively economically backward regions; however, county-level city shrinkage in developed regions has been largely ignored [23].

To address this research gap, our study aims to identify county-level shrinking cities in Zhejiang Province from population and industrial structure changes and investigate the shrinkage characteristics of a county-level city (Changshan County, Zhejiang Province) from population age structure and short-term population changes based on census, nighttime lighting (NTL), and Tencent Location Big Data perspectives. Furthermore, shrinkage causes were explored from industrial structure, income gap, highly skilled labor force, and population age structure angles. This study contributes a practical observation and a case study of county-level city shrinkage in a relatively economically advanced region in China to broaden the understanding of city shrinkage.

## 2. Literature Review

In the 1970s, the term "shrinking city" was initially used by German scholars to describe some urban areas subjected to reduction in employment opportunities and population size. Later, this term became popular because of a famous paper published by German scholars Häussermann and Siebel in 1988 [24,25]. City shrinkage also appeared in America [26,27], the UK, France [28], and Portugal [18], arousing increasing attention. In a Western city shrinkage context, the shrinkage connotative definition, representation characteristics, driving factors, and development tracks have been extensively explored by scholars [3,5,28,29], and a "smart decline" strategy to cope with challenges has been proposed [30,31]. Oswalt and Rieniets [32] proposed that population losses in shrinking cities accounted for 10% of the total population, or the annual average population loss rate was >1%. Schilling and Logan [27] believed that shrinking cities are a subset of industrial cities, in which population loss rate has been 25% or more over the past 40 years and is accompanied by a continuous increase in urban vacant land and abandoned properties. Shrinking cities are defined by the Shrinking Cities International Research Network as densely populated (population size >10,000) urban areas facing population losses for over two years and experiencing structural economic crises [29,31]. It is quite difficult to give a globally universal and accurate city shrinkage definition considering enormous urban context differences. Presently, city shrinkage has been defined from a singular population perspective [33] or by other factors such as economy [31], land, and public services [21,22].

As generally believed by scholars, shrinkage is a complex and pluralistic process with no universally applicable evolution model [29]. Many causes for city shrinkage have been summarized by scholars through unremitting efforts in relevant studies. Such causes are divided into economic (e.g., globalization, deindustrialization, regional economic recession, industrial transformation failure, and resource exhaustion) [17,34–36], population (e.g., population aging, declining birth rate, ethno-racial transition, and out-migration) [5,37–39], social (e.g., urban decay, congestion diseconomies, excessive suburbanization, infrastructure aging, aggravated regional unfairness, and deteriorated climatic conditions) [18,31,39–41], and political (e.g., socialist transformation, administrative division adjustment, and reform and development) [5,18,42,43].

Western society has responded to city shrinkage challenges in various ways. Smart growth, a representative planning concept in North America in 1990, proposed to implement measures such as urban growth boundary delineation and advocated for mixed land

use and recovery of vitality of old communities. The smart growth concept helps, to some extent, relieve problems of suburban sprawl and declining population density, yet fails to cast off traditional growth-oriented constraints. Wiechmann and Pallagst [31] pointed out that more inclusive attitudes and a broader field of view are required to cope with the city shrinkage problem. In 2002, the smart decline concept was proposed in America, which was defined as "planning for less—fewer people, fewer buildings, fewer land uses". The smart decline concept worked very well, as evidenced in the Youngstown 2010 Citywide Plan, in which the vision of "accepting Youngstown will be a smaller city" was proposed, with residential lands and commercial lands reduced by 30% and 16%, respectively. In Germany, which pioneered the changing values of shrinkage, good results have been achieved through revitalization of shrinking cities [44]. When formulating a new plan in 2001, the Dresden government abandoned growth orientation, reduced land consumption, and highlighted the creation of an attractive city center and a stably populated "compact" city. In Plagwitz, Leipzig, the regional population has once again grown through projects such as dismantling vacant properties and transforming vacant land plots into open space [45]. Such changes conforming to the concept of "Less Is More" have injected new vitality into powerless and helpless shrinking cities.

Less attention has been paid to population losses in Chinese cities compared with Western shrinking cities [46]. Long, Wu, and Wang [17] pointed out that many Chinese cities have shrinking populations according to the fifth (2000) and sixth (2010) census data in China. The Northeast China region has the most serious net population outflows and the most significant city shrinkage throughout the country [11]. Here, over half of the resource-based cities have been caught in severe recession and showed a shortage of alternative industries and industrial structural imbalance due to resource exhaustion, making it difficult to resuscitate their populations and economies [20]. Other shrinking cities occur in relatively economically underdeveloped western and central regions of China, although they are in a smaller proportion and have a lower shrinkage degree than those in the northeast [47]. Due to the weak economic base and slow development rate, the shrinking cities in western and central regions are prone to low per capita income, imperfect urban infrastructures, and deteriorated living environments, along with an ever-declining attraction to the population [47]. In the eastern region, which enjoys the highest economic development level in China, city populations continue to decline in Yancheng and Huai'an in Jiangsu Province and Shanwei and Chaozhou in Guangdong Province [48]. Zhang et al. [49] thought that Chinese city shrinkage generally was due to a mismatch between market-driven resource flow and allocation with the vigorous promotion of the government's growth supremacism. Xu [15] pointed out that inter-regional utility differences are strengthened by factors such as government control, and small- and medium-sized city populations are relocated to maximize utilities such as incomes and urban public services. Li [50] believed that household registration constitutes the greatest institutional barrier obstructing the migration of rural workers, and internal migration in China does not follow the normal law of push and pull. Chen et al. [51] summarized system restrictions, economic and environmental transition, and development model defects as the causes of small town shrinkage in China, and thought that their large-scale shrinkage will be unavoidably triggered by the sustained promotion of China's urbanization, strong megacity momentum, and decline in the function and position of small towns. Gao, Wang, and Gu [21] believed that an external factor, anti-globalization, generates enormous impacts on the population and economy of Chinese cities, thus leading to regional city shrinkage.

City shrinkage characteristics are inseparable from local contexts [29], which vary substantially between Chinese and Western cities [49]. As reported by Long, Wu, and Wang [17], the degree of population shrinkage in Chinese shrinking cities is lower than those in the West, with the coexistence of population shrinkage and economic growth. Liu and Yang [10] pointed out that the shrinkage degree of foreign shrinking cities is generally 2–5% with a duration of several decades, while that of Chinese cities is <2% with a duration of <10 years. Additionally, suburbanization, deindustrialization, industrial recession,

and population structure changes are embodied in a minority of Chinese cities, without representativeness or universality [19]. Different from the American Rust Belt Region, the Greater London Region in the UK has witnessed a so-called "doughnut effect" spatial shrinkage pattern due to deindustrialization and suburbanization. The Chinese shrinkage pattern is the opposite (i.e., "central fullness and marginal hollowness"), where shrinkage mainly prevails in villages, towns, and counties at the periphery of megacities [10,21]. Most Chinese shrinking cities are county-level cities [17], where the population shrinkage phenomenon is quite prominent [22]. The county-level city is a hybrid institutional system between city and county, which combines urban management with rural management, not only emphasizing city construction and management but also taking villages into account at the same time [52]. Due to the Chinese administrative division system, there are generalized and narrow senses of cities. The generalized cities refer to the region corresponding to the jurisdiction of cities, and narrowly defined cities refer to the physical regions of cities [53]. Based on this, scholars have proposed the generalized and narrow sense of urban shrinkage in China, referring to the continuous decline in the population within the counties or cities and urban district, respectively [53,54]. Sun [55] believes that the narrow urban shrinkage can fully reflect the strength of urban population agglomeration and is more in line with international practice. Liu and Zhou [54] argue that the generalized city is more suitable as a spatial scale to explore Chinese shrinking cities, because administrative division is the basic unit for urban management and urban planning. Guan et al. [56] and Zhang et al. [57] believe that the government administrative ability has significant impacts on the urbanization and it is inseparable from the policy system to explain urban shrinkage in China. Liu, Qi, Qi, and Liu [22] discovered that nearly 70% of county-level cities in Northeast China have shrinking populations, and the proportion of severely shrinking cities is growing. Wu, Long, and Yang [19] found that the period 2000–2010 witnessed gradually aggravated local shrinkage in 1/2 and nearly 1/5 of county-level cities, respectively, in two extremely dynamic urban agglomerations—the Yangtze River Delta and Beijing–Tianjin–Hebei Region. For the current shrinkage status of Chinese county-level cities, more typical cities should be included to deeply explore the context and causes of local city shrinkage and to provide countermeasures [17,58].

## 3. Data Methodology and Case Study

### *3.1. Data*

The following data were included in our research:

(1) Version 4 DMSP/OLS Nighttime Lights Time Series dataset (non-radiometrically calibrated) (a total of 34 images shot by six satellites F10, F12, F14, F15, F16, and F18 during 1992–2013) released by the National Oceanic and Atmospheric Administration (NOAA) of America, global radiometrically calibrated NTL products (6 images in total), and VIIRS/DNA synthesized monthly average light radiation dataset (96 images in total during 2013–2020).
(2) Vector data of the administrative division (1:1,000,000) released by the National Geomatics Center of China.
(3) Global location data released by the Tencent Location Big Data platform on 30 August, 13 September, and 27 September 2019.
(4) Data of the fourth (1990), fifth (2000), sixth (2010), and seventh (2020) Zhejiang Province censuses.
(5) Data of the fifth (2000) and sixth (2010) Changshan County censuses.

### *3.2. Methodology*

The city shrinkage explored in this research refers to shrinkage in a generalized sense, and the whole region within the boundary of the urban administrative district served as the research object, covering built-up and non-built-up areas. Moreover, the population included urban and nonurban populations. As aforementioned, the generalized cities research scope likely better reflects the actual situation in China and helps explore greater

county-level city shrinkage details [54,56]. Given that population losses and structural economic crises are common in shrinking cities [31,59], the city shrinkage phenomenon was depicted in this research in two aspects: population and economy.

Firstly, the long-term variation trends of the city population and economy were represented by the population change within a time period and the change in NTL intensity. Based on Oswalt and Rieniets [32] and Liu, Qi, Qi, and Liu [22], the annual average population change rate was adopted for analysis:

$$P = \sqrt[30]{\frac{P_{2020}}{P_{1990}}} - 1 \quad (1)$$

where $P$ indicates the annual average population change rate during 1990–2020. $P_{2020}$ and $P_{1990}$ refer to the total population in 2020 and 1990, respectively. According to the population shrinkage concept, a city is subjected to population shrinkage when $P < 0$, and a greater absolute value of $P$ indicates a higher shrinkage degree, or otherwise, a city is free from population shrinkage. We divided cities into types I, II, III, IV, and V based on the annual average population change rate of [1%, +∞), [0.3%, 1%), [−0.3%, 0.3%), [−1%, −0.3%), and (−∞, −1%), respectively.

According to Kuznets [60], a certain industrial structure is formed in an economy through professionalization and social division of labor, which, in some sense, decides the economic growth mode. Specifically, a reasonable industrial structure contributes to highly stable economic growth [61]. A reasonable or optimal industrial structure is determined by the composition of different factor endowments (including land, labor, human capital, physical capital, etc.) or endowment structure [62]. Moreover, when the endowment structure evolves over time, the optimal composition of industries also changes accordingly and optimal growth is achieved only when the industrial development follows the comparative of the endowment structures of the economy [62]. Chen and Deng [63] discovered that China's structural change presents a quantitative relationship with the economic growth rate. As pointed out by Liu and Li [64], the economic scale growth in China is positively influenced by primary and secondary industries but negatively affected by tertiary industry. Based on the above studies and economic growth rate comparisons between cities, the ratio of urban to economic growth rate of the whole province was used to represent urban industrial structure change. Given shortcomings such as inconsistent statistical standards, inaccurate price indices, and political pressure to maintain strong local economic growth [65], economic changes were investigated using NTL data in our research. NTL data, which can reflect population and urban changes, is applicable to socioeconomic research with the advantages of higher accuracy and comprehensiveness over traditional data [66]. The regional NTL intensity is significantly linearly correlated with the regional gross domestic product (GDP), as evidenced in some present studies [67,68]. In our research, NTL data were processed using the method proposed by Cao et al. [69] and Liang et al. [70] to overcome low NTL data comparability due to time and sensor differences.

$$NTLR = \frac{CNTL_{2020}/CNTL_{1992}}{PNTL_{2020}/PNTL_{1992}} \quad (2)$$

where $NTLR$ denotes the ratio of the growth amplitude of urban NTL intensity to that of the whole province during 1992–2020. $CNTL_{2020}$ and $CNTL_{1992}$ stand for the urban NTL intensity in 2020 and 1992, respectively. $PNTL_{2020}$ and $PNTL_{1992}$ represent the provincial NTL intensity in 2020 and 1992, respectively. If $NTLR < 1$, then the NTL intensity in this city grew more slowly than that in the whole province, or otherwise, the growth rate of urban NTL intensity was higher than that of the provincial NTL intensity. We divided cities into types A, B, C, D, and E according to the urban NTL values of [1.1, +∞), [1.03, 1.1), [0.97, 1.03), [0.9, 0.97), and (−∞, 0.9), respectively.

In our research, cities with a $P$ value belonging to types IV or V and $NTLR$ value belonging to types D or E were classified as shrinking cities, i.e., cities of types IVD, IVE,

VD, and VE. The other cities were excluded from the scope of shrinking cities. Notably, NTL data during 1990–1991 were not accessible, so we only used NTL data during 1992–2020, thus leading to certain differences in the time horizon between population changes and NTL intensity changes. Nonetheless, the influences caused by such differences were acceptable.

Additionally, more details of city shrinkage were presented from population age structure, as well as population changes during holidays and festivals on the basis of age-specific population data and Tencent Location Big Data. Urban population age structure has enormous influences on cities, especially shrinking cities [3], and measures coping with shrinkage can be formulated by acquiring these data. Hence, we depicted the age composition characteristics of populations as well as those of outflowing populations using the age-specific Changshan County population data. Long and Wu [71] believed that shrinking cities would be better understood, analyzed, and responded to by strengthening monitoring and evaluation of the intensity of human activities. In the past, due to the restriction of the low spatial–temporal resolution of traditional data, short-term population changes could hardly be displayed. However, short-term population change could also be used to describe the characteristics of shrinking counties (e.g., residents' behavior, mobility communication, etc.) [72]. The rapid development of information technology has taken us into the "Big Data Era", causing transformation of the methods in urban temporal and spatial research [73]. Big data have been applied to urban temporal and spatial behavior research from the perspectives of residents' behavior, urban space, and development [74–77]. Compared with traditional statistical data, Tencent Location Big Data have higher temporal and spatial resolution [78], thus meeting display requirements. During holidays and festivals, people choose to enjoy leisure by leaving their regular workplace or even leaving their workplace city. In China, most people who work and study away from home traditionally return during the Spring Festival or Mid-Autumn Festival, and cities experience short-term population change. During the period before the festivals, the main population flow goes from central or developed cities to non-central or undeveloped cities, and opposite occurs after the festivals [79]. Therefore, we revealed the population change characteristics in Changshan County using Tencent Location Big Data on the Mid-Autumn Festival (an important Chinese festival) two weeks before and after the 2019 festivals. The standardized data provided by Tencent have spatial resolution of 5 km and temporal resolution of 30 min. Through comparison, it is found that the user activity between 14:30–15:00 is relatively high, largely because most people use Tencent applications for communication, entertainment, purchasing, etc., during this time period. Therefore, we chose the data between 14:30 to 15:00 over these three days and used the ordinary kriging method to map the user activity in Changshan County by ArcGIS 10.5.

### *3.3. Research Area*

Changshan is a county under the jurisdiction of the prefecture-level city of Quzhou in the west of Zhejiang Province, People's Republic of China, which covers 1099 $km^2$ and has a permanent population of 260,000, of which 127,700 (49.12%) is urban (Table 1 and Figure 1). As a relatively economically underdeveloped county-level city in Zhejiang Province, Changshan County's GDP ranks 78th among county-level units in Zhejiang Province, and its per capita GDP is only about 60% of that of Zhejiang Province. In 1949, namely the initial post-liberation period, Changshan County remained an agriculture-dominated city, with a population of about 140,000. The proportion of industrial output value was <15%, and there were only several lime kilns, brick and tile kilns, and manual workshops. After liberation, modern industry gradually developed, and industries such as bearings, construction materials, and calcium developed and grew stronger by virtue of locally abundant non-mineral resources. In the 1980s, the industrial output value in Changshan exceeded the agricultural output value, with the total population rapidly growing to 286,000 because of the high birth rate. Since the reform and until now, regional GDP in Changshan County grew at a high annual average rate of over 10%, stabilizing at 6.5% in the most recent decade. Despite sustained overall growth, the population has not

kept up with the growth trend. According to census data, the population started declining after peaking in 1990, and in 2010 was only about 80% of that in 1990, indicating significant population shrinkage. In 2020, the population rose again slightly, but did not recover to the 2000 level.

**Table 1.** Permanent Changshan County population.

| Year | 1953 | 1964 | 1982 | 1990 | 2000 | 2010 | 2020 |
|---|---|---|---|---|---|---|---|
| Population size (ten thousand people) | 13.92 | 18.87 | 28.60 | 30.00 | 26.55 | 24.14 | 26.00 |

Source: Changshan County censuses.

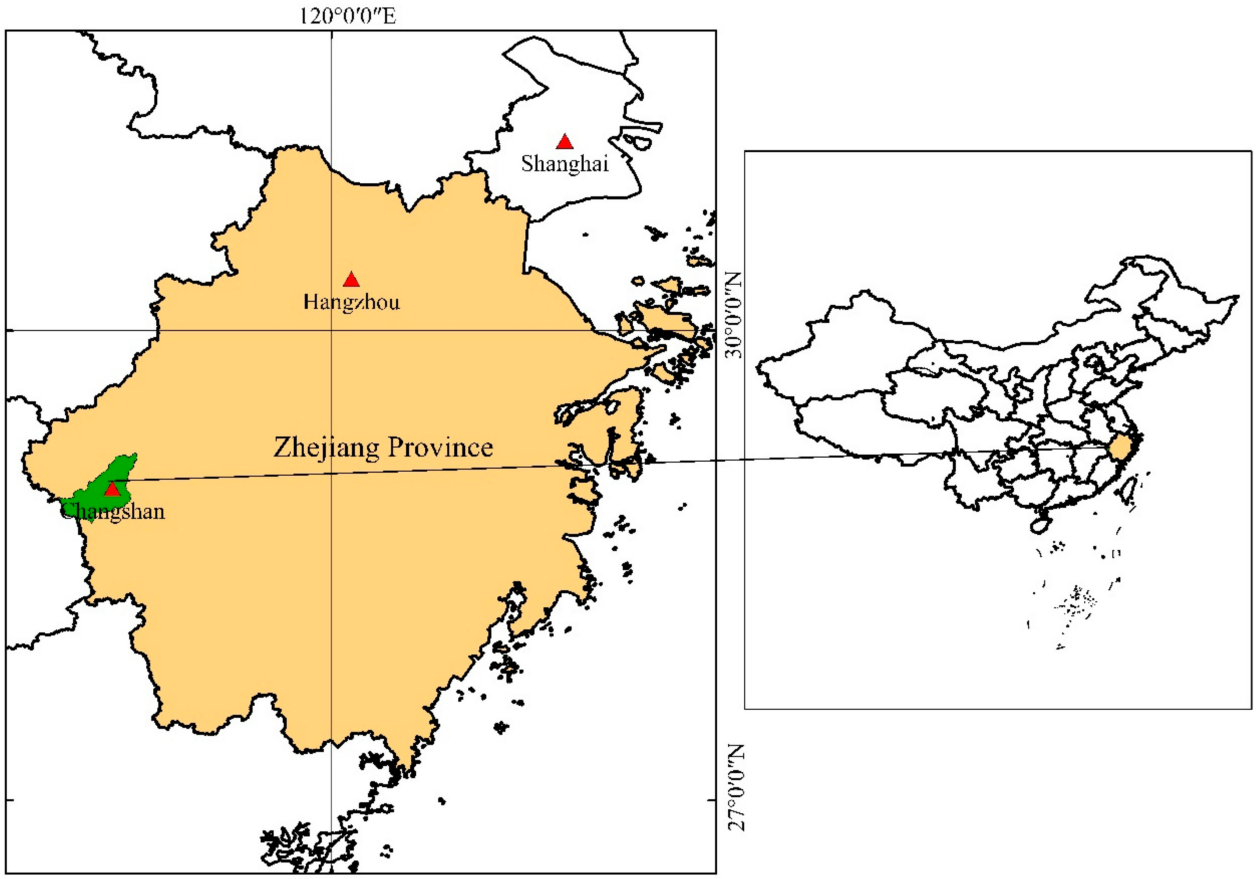


**Figure 1.** Location map of Changshan County.

We selected Changshan County for our research for the following main reasons: Firstly, previous shrinking city research has focused on northeastern, central, and western cities, but shrinking cities such as Changshan County located in the economically developed eastern region have been scarcely studied. Secondly, city shrinkage in the eastern region does not completely equal the "absolute shrinkage" brought to resource-based cities when they are stuck in an economic downturn and even a negative economic growth cycle, but instead, it is equivalent to "relative shrinkage", resulting from regional competition in competitive regions such as Zhejiang Province. Finally, both population size and economic development in Changshan County are low among Zhejiang Province county-level cities, so it is representative.

## 4. County-Level City Shrinkage Representation

Changshan County city shrinkage was represented by population size, NTL intensity, population age structure, and population size change during holidays and festivals.

### *4.1. Population Size and NTL Intensity*

From the *P* value perspective, a total of 64 county-level units in Zhejiang Province belonged to types I and II (annual average population growth exceeded 0.3%), which were collectively distributed in the northern and eastern coastal areas and some central areas (Figure 2). Such areas possessed a relatively favorable economic base with a high economic growth rate, thus attracting a large population from other areas in the province and other provinces. Additionally, a total of 10 county-level units belonged to types IV and V (Table 2), which were mainly concentrated in relatively economically underdeveloped western and southern areas, with the annual population rate exceeding 0.3%. For *NTLR* value, the NTL intensity growth rate in 45 county-level units was higher than the average overall province level, and they were collectively distributed in the southern and central areas. Moreover, the NTL intensity of 40 county-level units grew at a lower rate than the average overall province level, and they were mainly distributed in the northern and western areas.

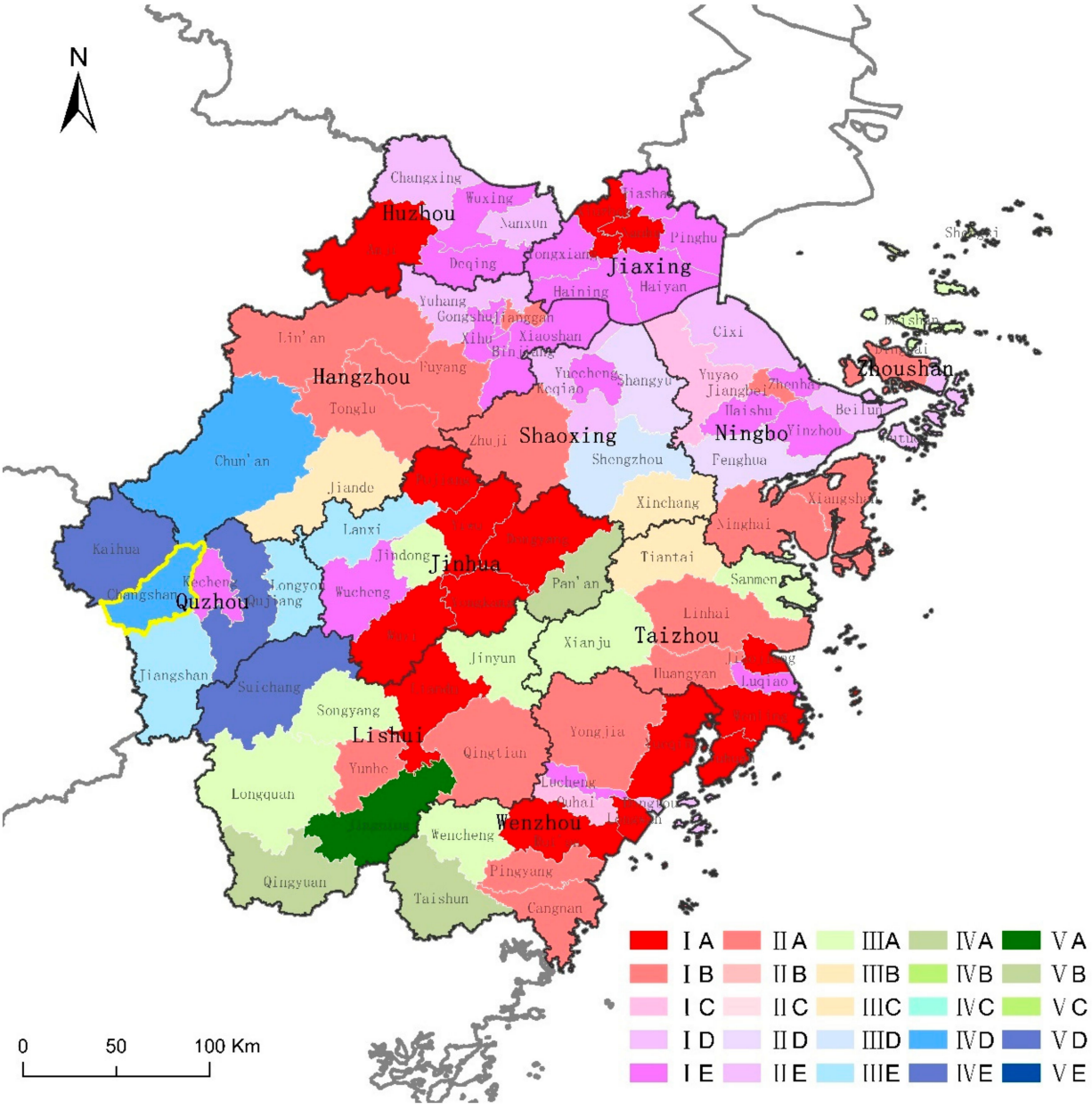


**Figure 2.** Changes in population and NTL intensity in Zhejiang Province county-level cities during 1990–2020.

**Table 2.** Quantity of Zhejiang Province county-level cities belonging to each change type of population and NTL intensity.

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| A | 14 | 12 | 8 | 4 | 1 |
| B | 5 | 0 | 1 | 0 | 0 |
| C | 2 | 0 | 2 | 0 | 0 |
| D | 3 | 2 | 1 | 2 | 0 |
| E | 20 | 6 | 3 | 3 | 0 |

For the *P* and *NTLR* values combined, population and NTL intensity grew fast in the peripheral parts of central urban areas in Hangzhou, Ningbo, Wenzhou, Taizhou, and Jinhua, as well as the Lishui urban central area (IA, IB, IIA, and IIB). This is mainly because urbanization and economic development levels were low in the peripheral parts of Hangzhou, Ningbo, Wenzhou, Taizhou, and Jinhua in the early stage, which, however, enjoyed rapid economic growth owing to radiation from the city centers, along with fast NTL intensity growth. In peripheral areas, an increasing population flowed from rural areas to towns, and rapid secondary industry development contributed a lot to NTL growth intensity, which reflects these changes. In central urban areas, however, the industrial structure was gradually transited into a model centering on the tertiary industry, which boosted NTL intensity growth at a relatively low level, and the past high-energy-consumption and high-pollution industrial sectors were phased out. Hence, the population continued to grow in the central urban areas of Hangzhou, Ningbo, and Wenzhou, although their NTL intensity was not as high as that in surrounding areas and even lower than the average overall province level. In Lishui and Quzhou, the NTL intensity growth rate developed slowly with a poor overall economic base, although their central urban areas did not obviously fall behind peripheral areas due to the lack of powerful outward radiation capacity.

A total of five shrinking county-level cities (types IVD, IVE, IVD, and IVE) were subjected to declining populations and NTL intensity slow growth in Zhejiang Province (Changshan, Qujiang, and Kaihua Counties in Quzhou City as well as Chun'an and Suichang Counties in adjacent Hangzhou and Lishui, respectively) (Table 3). Changshan County NTL intensity grew more slowly than in the whole province, which reflected its primitive industrial structure and low economic growth rate as well as its competitive disadvantages in the whole province. Wuyi County (type IA) near Jinhua serves as a very good area for comparison with Changshan County (type IVD). In 1990, the GDP and population sizes were RMB 377,000,000 and RMB 440,000,000, and 300,000 and 318,000 in Changshan County and Wuyi County, respectively, indicating the approximate economic development and population size of the two cities. Up to 2020, however, the GDP in Changshan County was RMB 16,015,000,000 with the population declining to 260,000, while the GDP in Wuyi County was RMB 27,133,000,000 (1.69 times that in Changshan County) with the population growing to 462,500 (1.78 times that in Changshan County). Moreover, the NTL intensity growth rate in Wuyi County was 1.67 times that in Changshan County. All of the above data highlight significant economic and population differences between the two cities. In industrial structure, tertiary industry accounted for the highest proportion (52.53%) in Changshan County, while secondary industry accounted for the highest proportion (48.04%) in Wuyi County. The industrial structure in Changshan County seemed to be better than in Wuyi, which contradicts their relationship in GDP growth rate. In fact, secondary industry developed slowly in Changshan County with a lag in industrial upgrading and transformation, which slowed increase in the output value of secondary industry and resulted in failure to improve local employment, thus causing backward local economic growth. In short, Changshan County industrial structure was inadequate, as the proportion of secondary industry was not high enough. Comparing Changshan and Jiangshan Counties, both of which are county-level cities in Quzhou City, further highlights the comparative disadvantages in their industrial structures. The Changshan

County (type D) NTL intensity growth rate was higher than in Jiangshan County (type E), but the annual average population loss rate (−0.8%) in the former was four times that (−0.17%) in the latter.

**Table 3.** Zhejiang Province and the shrinking county-level cities.

| | Population Change (% P.A.) | NTL Intensity Growth Ratio |
|---|---|---|
| Chun'an (IVD) | −0.93 | 8.80 |
| Qujiang (IVE) | −0.95 | 8.06 |
| Changshan (IVD) | −0.48 | 8.82 |
| Kaihua (IVE) | −0.80 | 7.66 |
| Suichang (IVE) | −0.47 | 8.11 |
| Zhejiang | 1.48 | 9.57 |

### *4.2. Population Age Structure*

When the Changshan County population was further subdivided, it transpired that the population age structure had already shrunk in 2000, and the population at age 10–49 created a "sandglass" shape (Figure 3). In 2010, the total permanent population declined from 265,000 to 241,400, indicating a more prominent shrinkage-type population age structure. A large young population, especially from age 20 to 39 flowed out, which led to a rapid decline in this age group and its proportion, accompanied by the thinner "grip" part of the "sandglass". Moreover, the average population age rose from 34.69 to 39.92 years, and the median age increased from 30 to 40 years. Compared to in 2000, in 2010, the population of 0–14 years old declined by 13,600 in this county (3.49%), while the 15–59 cohort dropped by 20312 (1.90%), and those 60 years and above increased by 9800 (18.70%). Notably, the proportion of the population aged 65 or above reached 12.58%, which was closer to the standard (14%) for a deeply aging society given by the United Nations (UN).

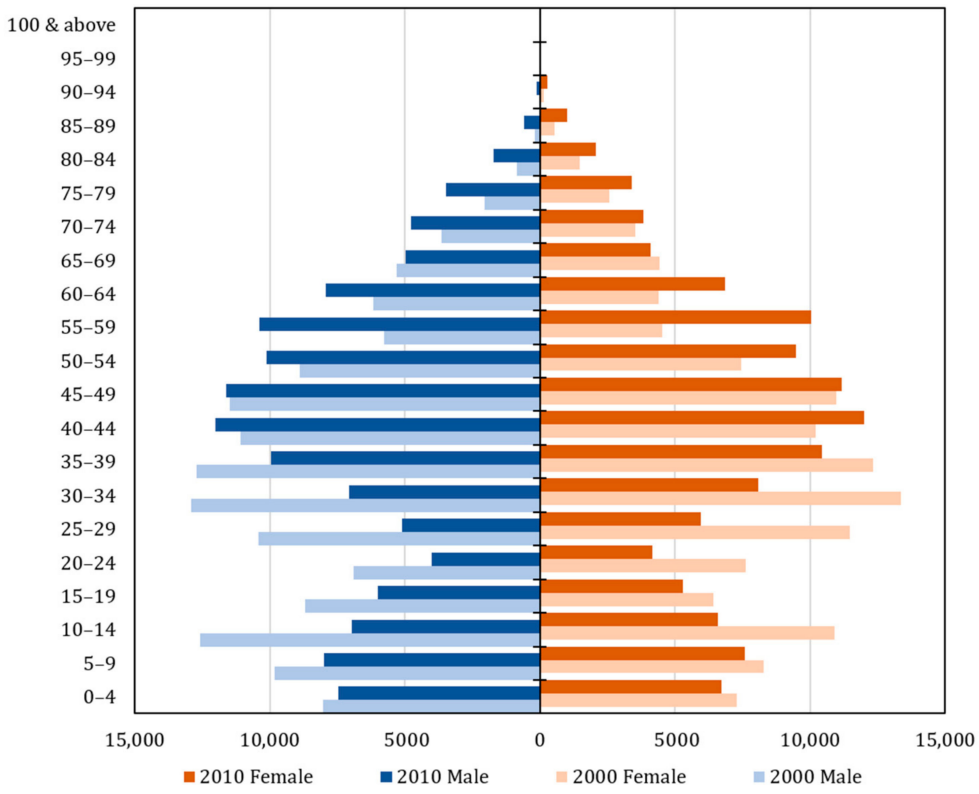


**Figure 3.** Variation diagram of population age structure in Changshan County during 2000–2010.

According to the latest seventh census, the total population in Changshan County was 260,000 in 2020, a slight increase compared to 2010. The latest changes in the population age structure in Changshan County could only be interpreted through some already released data considering the confidentiality of detailed data. By comparing the situation in 2020 and 2010, we found that the 0–14 age group declined by 1800, the 15–59 age cohort declined by 3800, and the 60+ age group grew by 24,200. The proportion of the population 65 years and above reached 19.27%, which approximates the standard (20%) for a super-aging society proposed by the UN and is much higher than the average level (13.27%) in Zhejiang Province. Generally, Changshan County total population experienced a 20-year shrinkage since 1990. The population has risen again in the most recent decade yet has not recovered to the 2000 level. Moreover, the population age structure has been transformed from an early-stage rapid growth type into a shrinkage type, and the sustained reduction in the young population and the population aging trend will continue. Even worse, a society already on the verge of super-aging is estimated to experience accelerated aging in the next 10 years, which will impose considerable elderly care pressure on the whole society.

### *4.3. Population Changes during Holidays and Festivals*

On 13 September 2019 (Mid-Autumn Festival in the Chinese lunar calendar) when people were enjoying short-term leisure leaving their workplace, the world was not yet severely impacted by COVID-19, and population flow and economic development were still normal. According to traditional customs, families come together to admire the full moon and eat moon cakes at night. Most people who work and study away from home will return on this festival and soak themselves in the sweet and warm atmosphere with their family members.

In our research, the intensity of population activities in Changshan County on 30 August, 13 September, and 27 September 2019 was largely determined using Tencent Location Big Data (Figure 4). Overall, the intensity of population activities was the highest in the central urban area of Changshan County owing to the large number of residential and business districts, containing over half of the total county population. Within the county territory, population activity intensity continuously declined with increasing distance from the central urban area. Population activity intensity in the central urban area on the day of the festival was higher than on the other two days, but in the peripheral areas was basically similar over the three days. This suggests that a large outflowing population returned to Changshan County and gathered in the central urban area with developed business and entertainment industries, while there was almost no population change in peripheral villages and small towns without large shopping malls. Two weeks after the festival, however, the intensity of population activities recovered to the level two weeks before the festival. Population fluctuations triggered by the short-term festival were evidence of large population losses in Changshan County. Meanwhile, the evidence also revealed that a secure emotional bond was kept between the outflowing population and their families in their hometown.

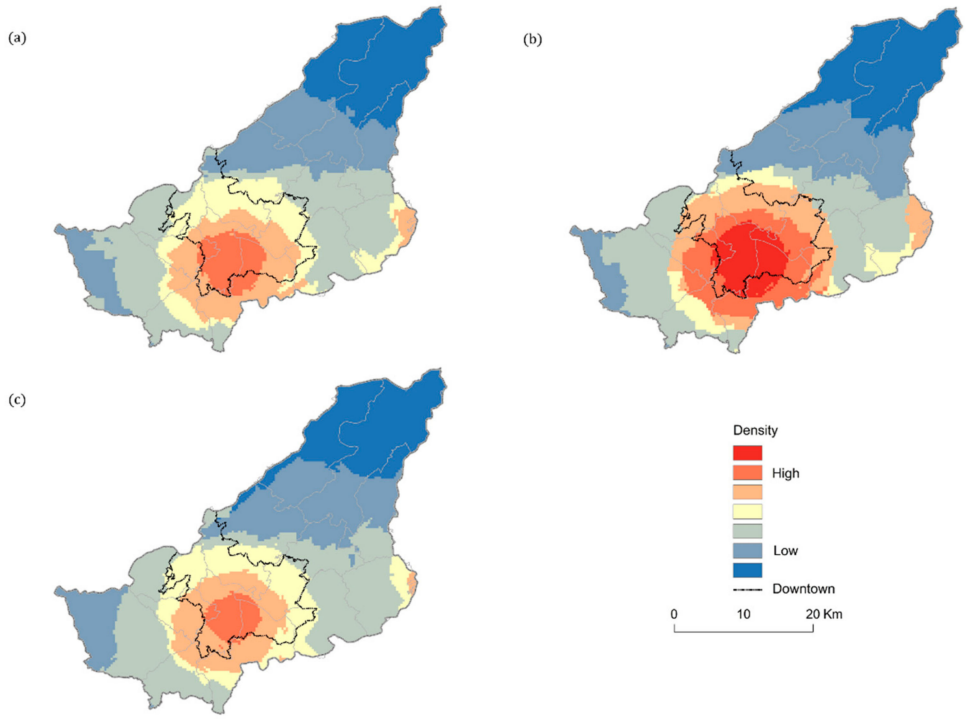


**Figure 4.** User density map of Tencent Location Big Data in Changshan County: (**a**) 30 August, (**b**) 13 September, (**c**) 27 September (the density value, which was standardized, does not represent the actual number of people).

## 5. Analysis on the Causes of County-Level City Shrinking

### *5.1. Decay of Traditional Industry*

Changshan County has suffered shrinkage mainly due to the decline in traditional industrial sectors. Traditional enterprise productivity is restricted due to an outdated management system. After the reform and opening-up policy in 1978, the Changshan County economic base was poor, but industry then began vigorous development. Based on rich nonmetallic mineral resources and the local first-mover advantages of the bearing industry, a batch of state-owned industries such as cement, bearings, and chemical engineering developed and rapidly grew strong, boosting local economic development. As China's economy shifted to a socialist market economy system, the drawbacks of state-owned enterprises under the background of a traditional planned economy were gradually exposed, and enterprise enthusiasm, proactivity, and creativity (and their employees) were repressed [80]. In 1997, many state-owned industrial enterprises in Changshan County were affected by competition from other enterprises, product sales declined, a large number of products piled up in warehouses, and enterprises suffered severe financial arrears [81]. Employee incomes fluctuated due to such problems. Without a basic living guarantee, some employees were not paid, and they lost confidence in enterprise prospects. The industrial employment population decreased by 14,000 during 1996–2003.

Traditional enterprises were subjected to a continuous decline in product competitiveness owing to the gradual loss of their competitive edges. Previously, Changshan traditional enterprises had won the market by virtue of advanced technologies and locally abundant non-mineral resource advantages. Most enterprises were small and had low product technology content, accompanied by very limited economic profits due to fierce competition for similar products with low added values. Additionally, there was little innovation in product input and output from enterprises in Changshan County due to the comprehensive influence of small capital scale, high financing difficulties, and the general lack of entrepreneurship among enterprise operators. Moreover, the competitive edges of traditional enterprises in Changshan County disappeared with the continuous emergence

of high-quality new products developed by enterprises in other regions and the declining transportation cost of raw materials. In 2014, traditional leading industries declined across the board, including the output values of 50% of bearing manufacturers, 80% of organic chemical manufacturing enterprises, and 100% of cement enterprises decreased. Over 70% of enterprises above the designated size in the county subject to output value declines were old enterprises. Among such enterprises, 80% never conducted technological innovation, and 65% still focused on old products [82]. Unprofitable industrial enterprises above the designated size in Changshan County increased from 18% in 2003 to 41% in 2015.

### *5.2. Widening Gaps in Per Capita Income*

Census data show that over 70% of the outflowing population in Changshan County emigrates because of economic factors. In Zhejiang Province, one of the most economically vigorous provinces throughout China, most outflowing Changshan County residents stay in the province and mainly flow towards Hangzhou (the most economically developed city in Zhejiang) and Kecheng (central urban area of Quzhou). Urban and rural per capita disposable incomes in Changshan County have been steadily growing, although they have been lower than the overall level in Quzhou City, and the income gap with Hangzhou has widened every year (Figure 5). In 2011, the urban and rural per capita disposable incomes in Changshan County were RMB 18,600 and RMB 9300, respectively, declining by RMB 15,500 and RMB 5900, respectively, in comparison with those in Hangzhou. In 2020, the two figures reached RMB 42,000 and RMB 24,000, respectively, but the gaps with Hangzhou expanded to RMB 26,800 and 14,700, respectively. Urban per capita disposable income in Changshan County was basically equivalent to the rural per capita disposable income in Hangzhou (Figure 5). In per capita disposable income, income from wages, which accounted for the highest proportion, better reflected the income status of most bottom-layer labor forces. In 2020, urban and rural per capita incomes from wages in Changshan County were RMB 25,800 and RMB 12,500, respectively, equaling 87% and 80% of the overall level in Quzhou, respectively, and 65% and 53% of the overall level in Hangzhou. Such enormous and ever-broadening income gaps directly led to the long-term outflow of labor forces in Changshan County.

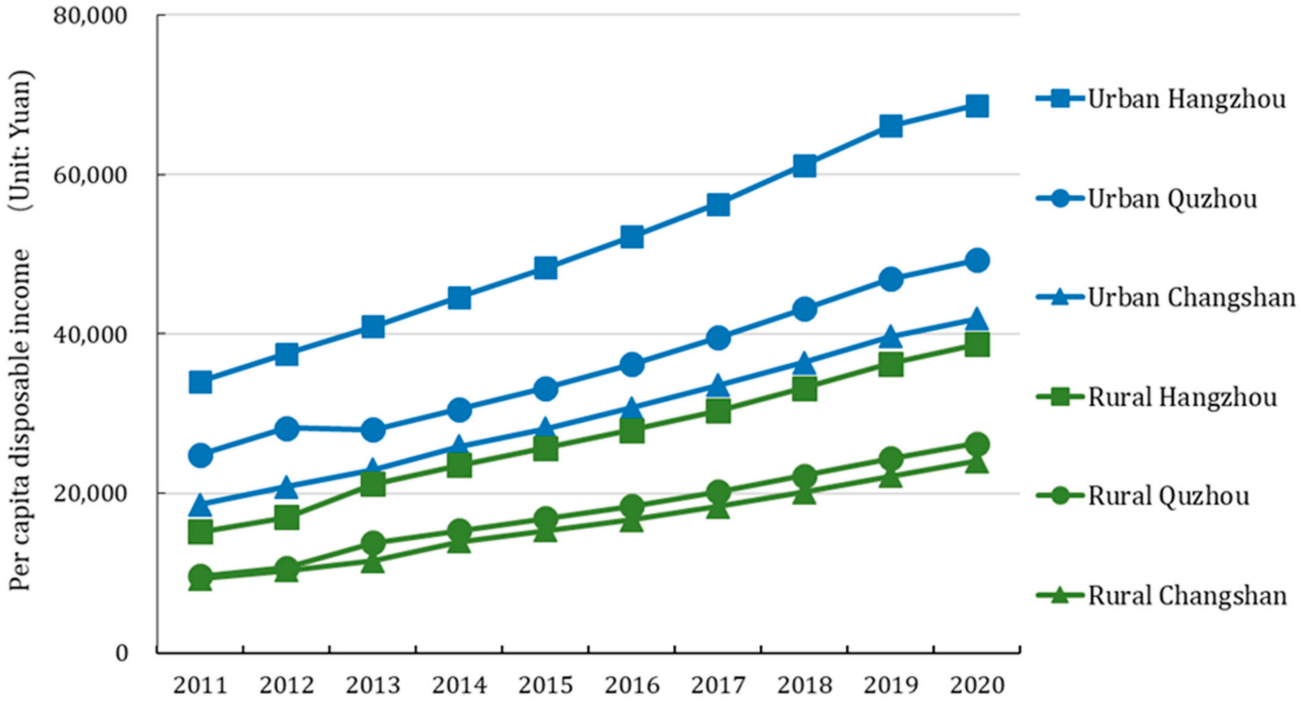


**Figure 5.** Urban and rural per capita disposable incomes in Hangzhou, Quzhou, and Changshan during 2011–2020.

Notably, the Changshan government has exerted some effects on outflow of the labor force population. Firstly, the government has carried out labor skill training, established solid cooperative relationships in labor services with enterprises in other places, and facilitated the employment of originally less-skilled labor forces. Secondly, the government has established a tracking management and visit system for output labor populations, helping them to solve practical difficulties. All of the above measures have effectively reduced employment difficulties faced by local labor forces. Meanwhile, the originally spontaneous and disorderly labor output became increasingly well-organized. From January to September 2003, a total of 6728 labor forces in the whole county were well-organized through government organizations, labor intermediaries, and vocational schools, accounting for 68.2% of the newly added labor output in that year.

### *5.3. Shortage of Highly Skilled Labor Forces*

In the 1980s, traditional industrial enterprises remained in the rough processing stage of resources such as minerals, with simple product craftsmanship and low requirements for labor skills and quality. A lot of surplus labor forces outflowing from rural areas were competent for jobs in most plants just through short-term training. However, traditional industrial enterprises not only consume a large quantity of energy resources with declining operating benefits but can also cause serious environmental harm. For instance, Fangcun Town in Changshan County has become a fire-coal-pollution-type local fluorosis area. With greater importance attached by the local government to the ecological environment, the development of traditional high-energy-consumption and high-pollution industries has been strictly restricted [83]. The government has tried to cultivate an environment-friendly and high-value-added industrial economy through advanced manufacturing and modern service industries, although these develop slowly due to difficulty in recruiting labor forces that meet their skill requirements.

Recently, the shortage of highly skilled labor forces has severely restricted Changshan County development. The demand–supply relation in the whole-county labor market is strained despite the transfer of numerous surplus rural labor forces to cities and towns. Nevertheless, most county labor forces are relatively old, poorly educated, and unskilled. In 2010, those with a college degree and >age 5 population in Changshan County was only 4.89%, which was much lower than the overall level (9.53%) in Zhejiang Province and the level in Kecheng, Quzhou (15.06%). This is because Changshan has a relative shortage of education and training resources, which considerably limits the number of locally cultured highly skilled labor forces. Moreover, highly skilled labor forces in the county usually prefer to work in economically developed regions such as Hangzhou, Ningbo, Wenzhou, and Kecheng of Quzhou after graduation, while few of them are willing to develop in Changshan County. A vicious circle of backward economic growth, highly skilled labor force shortages, and insufficient regional development vigor has developed in Changzhou.

### *5.4. Population Age Structure Changes*

In the last 30 years, the population age structure in Changshan County has changed dramatically and become a primary cause of city shrinkage. The number of births has declined rapidly due to a substantial drop in the proportion of 20–34-year-olds in the population. In 2010, the female population at the age of 20–34 was only 56% of that in 2000, and the male population accounted for an even lower proportion (53%). This age group was the main cohort breeding the next generation, and 80% of mothers of newborns in the county fell into this group. In 2000, the number of births was 5670, while in 2010 it was 3773, a decline of 33.46%. In this period, the population loss rate was not low (9.08%), but less than 1/3 of the decrement in the number of births. The Changshan County population rose again slightly from 2010 to 2020, but the 0–9 years cohort decreased by 2300.

Aging is another characteristic of the population age structure in Changshan County which has importantly influenced regional development. In 2020, 19.27% of the Changshan County population was >65 years old, quite close to the standard for super-aging. The aging

population has brought ever-increasing financial endowment pressure to the government. In 2022, local expenditure (RMB 5,831,000,000) in the general public budget outlay in Changshan County declined by 5.27% compared with the amount allocated in the previous year (RMB 6,155,000,000). The total expenditure on endowment-related aspects grew from RMB 463,000,000 to RMB 535,000,000, a growth rate of 15.58%. Additionally, the growing number and proportion of old people mean that they need increased care and more pension services. However, most pension services need to be provided by families due to "aging before getting rich" of the population and the incomplete development of the county pension service market, which, to some extent, results in a decline in labor force size and quality. Notably, the increased number of old people does not necessarily slow economic development, as the region is already at a high development level and economic development is driven by conducting scientific and technological innovation and enhancing productivity. Nevertheless, Changshan County has not yet achieved such a high development level, and so sustained aging has imposed an ever-increasing burden on regional development.

## 6. Policy Response to County-Level City Shrinking

The impacts generated by county-level city shrinkage in China have been gradually aggravated, so local governments should guide transformation and development of counties subjected to population losses [13]. Shrinkage can bring about multi-aspect influences, including population, economic, and social aspects; accordingly, the policy response to city shrinkage should cover multiple fields [84,85]. Based on our analysis of shrinkage characteristics in Changshan County, we suggest that the local government could relieve the shrinkage-induced negative impacts by boosting the upgrading and transformation of industrial structure, shaping compact and green urban space, perfecting social governance, and caring for the elderly.

### *6.1. Boost the Upgrading and Transformation of Industrial Structure*

The first measure suggested is to promote the scale expansion and deep processing of the health food industry. The health food industry is the "sunrise industry" developed in the context of the globalization of social consumption [86]. With the improvement of living standards, Chinese people are paying increasing attention to their health, and the pursuit of health food has reached unprecedent heights [87]. Depending on locally abundant agricultural product resources, the health food industry centered on "two grapefruit and one tea" (grapefruit, sesame oil, and tea-oil camellia) is one of the leading industries in Changshan. However, local health food enterprises are mostly small or medium enterprises with deficient financial strength and very limited R&D capabilities [87,88]. The local government should offer tax incentives for R&D or the introduction of innovation and more guaranteed loans to strengthen its financial support for healthy food deep processing enterprises, actively forging a base featured with the integrated development of the primary, secondary, and tertiary industries to extend and strengthen the industrial chain. Moreover, the local government should enhance publicity through various channels to create geographically symbolic and highly popular agricultural product brands.

The second is to boost the digital transformation of traditional manufacturing enterprises. Advances in enterprise technology can streamline processes and deepen insights, giving companies the support to weather an unpredictable marketplace and capitalize on opportunities for growth. Digital transformation has been an irresistible trend for high-quality economic development, because it can effectively simplify enterprise production processes, thereby improving production economic efficiency [89]. Hengjia, for example, a local bearing company, has increased productivity by more than 20% and reduced production costs by more than 10% through digital transformation [90]. In addition, another local company, Zhejiang Advanced Precision Machinery, has improved product quality and increased sales by more than 100% through digital transformation. However, skill shortages and lack of funds are holding most local manufacturing enterprises back from

pursing their transformation goals. Therefore, it is suggested that the local government should reduce enterprise digital transformation costs by building digital infrastructures and introducing incentive measures, and create multiple data sharing platforms and perfect data governance systems to facilitate the steady operation of industry standards.

### *6.2. Shaping Compact and Green Urban Space*

Reasonably enhancing the compactness of built-up urban space is suggested. Presently, the planned population for built-up areas in Changshan County is much higher than the actual population, and existing population density is only 50% of expected density, along with low utilization efficiency of infrastructures. Excessive urban construction is mainly attributed to the growth-oriented development strategies [91], which will probably strengthen the negative impacts of city shrinkage [5]. Some cities provide good references for taking measures, such as planning for a smaller city (Youngstown, USA) [31], transit-oriented development and mixed land use (Fuji, Japan) [92], and industrial area rehabilitation (Magdeburg, Germany) [93]. During urban planning, the past development strategy should be transformed to create more compact and simplified urban space. The government should strictly control urban land use expansion, improve urban development quality within the existing built-up scale boundary, attract new transportation-oriented concepts to promote the layout of infrastructures with diversified functions, and intensify the reasonable mixing of land use and land functions to prevent the degradation of land utilization efficiency due to overly pure urban functional zoning.

Another suggested measure is to increase the proportion of urban green space to create a more beautiful living environment. In shrinking cities, greening transformation of vacant and inefficient land plots can increase the values of surrounding areas, boost benign community development, and reshape social capitals [27]. A green and livable environment is, to a great extent, the yearning for and pursuit of high-quality urban development. The local government needs to support more funds to transform abandoned inefficient brownfields into green space, construct park systems of distributive equilibrium, and provide residents with more comprehensive functions such as leisure and recreation, physical fitness, and emergency and disaster prevention.

### *6.3. Improve Social Governance*

It is necessary to improve social security and welfare to achieve common prosperity. A perfect social security system is conducive to securing people's lives and social development in a harmonious way. However, the present social security still features low insurance quality of social health care, in which pensions are inadequate for maintaining basic life, and imprecise welfare policies that lead to detached supply–demand. For example, less than 1/4 of jobless workers can benefit from unemployment insurance, and the average benefit is less than 1/10 of the average salary of urban workers [94]. What is more, there is a huge disparity between the benefits received by urban and rural unemployed individuals [95]. Especially impacted by COVID-19, residents' living standards cannot be guaranteed in the face of such a great challenge. The local government should enlarge public investments to enhance social security, implement more precise social security policies to improve treatment for groups with greater social security needs, and fill legal gaps in important fields such as social assistance, medical security, and pension services as soon as possible.

Strengthening social security administration and enhancing residential life security are also essential. The rising crime rate is a possible serious negative impact of city shrinkage [42]. Social security services in small county-level cities are not as complete as those in large cities. Rural communities especially are prone to crimes due to population unemployment, poverty, and weak public security. The local government needs to be vigilant about such risks, strengthen the social security prevention and control system, reduce illegal criminal activities, perfect education and propaganda, and enhance resident legal and self-protection awareness.

### *6.4. Care for the Elderly*

Accelerating the development of a health pension industry and meeting the ever-increasing pension service needs are suggested. As the county is on the verge of super-aging, it will continue to grow rapidly in the future, so there is an urgent need for more high-quality services such as life care, medical rehabilitation, cultural learning, physical fitness and leisure, and entertainment. The local government should enhance related policy support through financial support and tax reduction and exemption, encourage pension industry development, loosen social capital access conditions, attract more enterprise and social capital by purchasing services and providing fiscal subsidies, and establish supporting institutional systems such as supervision, evaluation, and guarantees to boost sustainable and healthy development of the pension industry.

The next step is to attach importance to the needs of the elderly and provide them with more company. The needs of old people for spiritual consolation, which are as important as their needs for economic support and daily care, should also be satisfied [96]. Because the large young population has outflowed and will only return to their hometown during holidays and festivals, old people are short of company and spiritual consolation, accompanied by the substantial degradation of their living quality. Faced with such a situation, the local government needs to formulate and perfect related legal policies, provide active policy support and reliable legal protection policies for socialized spiritual endowment, allocate special funds to help communities build more harmonious and intimate neighborhoods and provide more care for the elderly, and promote the formation of the socio-cultural atmosphere of "respecting the elderly and valuing their spiritual needs".

## 7. Conclusions

The city shrinkage phenomenon in China has been reflected by existing research results [22], while county-level city shrinkage in developed regions has been largely ignored [23]. Based on dimensions of population and economy, our study identified five county-level shrinking cities (Chun'an, Qujiang, Changshan, Kaihua, Suichang) in Zhejiang, and characterized the population age structure change between 2000-2020 and population changes during short-term holidays in Changshan County by using census, NTL, and Tencent Location Big Data. In Zhejiang Province, an economically powerful province in China, the five shrinking cities at the periphery of the metropolitan area concentrate in the western area and have undergone long-term population losses due to regional competitive disadvantages. County-level shrinking cities resulting from regional competition can still maintain long-term and stable economic growth, but their economic growth lags behind the whole competitive region. City shrinkage can result from comprehensive effects [36], and we found the causes of shrinkage in Changshan including declining traditional industries, backward per capita income, highly skilled labor force shortages, and population age structure changes. Negative impacts brought by city shrinkage involve various fields such as population, economy, and society; accordingly, the policy response to shrinkage should cover multiple fields combined with the actual local context [18]. Therefore, we proposed countermeasures and suggestions for the local government, such as boosting the upgrading and transformation of industrial structure, shaping compact and green urban space, improving social governance, and caring for the elderly.

Our study makes three key contributions. First, we expand the research paradigm of city shrinkage from the Western context and economically declining regions [5,18,20] to a relatively economically advanced region in China. Second, our study employs a novel methodology to identify and characterize shrinking cities by utilizing census, NTL, and Tencent Location Big Data, and provides more reliable identification and characteristics of shrinking cities than those that use population as the only indicator of city shrinkage [2,27]. Third, based on actual local context, our study proposed constructive suggestions which can be useful to the government of Changshan and other shrinking cities with similar conditions.

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