Understanding Urban Shrinkage from a Regional Perspective: Case Study of Northeast China

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Abstract: Urban shrinkage has become a worldwide phenomenon, and poses challenges to urban planning and regional development strategies. Although numerous researchers have identified the characteristics and causes of urban shrinkage, the understanding of urban shrinkage from a regional perspective has not yet been explored. To fill this gap, in this paper, we analyzed the nature of urban shrinkage in northeast China, the typical Chinese region affected by urban shrinkage, from a regional perspective. The results show urban shrinkage occurs in 64 county-level cities. A total of 34.62% of shrinking cities were classified as smartly growing cities, characterized by economic growth and population loss, while 65.38% of shrinking cities were identified as absolutely shrinking cities, suffering simultaneously from economic and demographic decline. The connection between central cities and shrinking cities allowed identification of three types of phenomena, namely central agglomeration leading to peripheral shrinkage, shrinkage of prefecture-level city proper, and central diffusion leading to peripheral shrinkage. The causes of urban shrinkage include agglomeration effects of central cities, aging of demographic structure, supply-demand mismatch between industries and market, weak connection between industries and services, and underdeveloped public services. Furthermore, the agglomeration effects of central cities play a critical role in urban shrinkage in northeast China. Therefore, from a regional perspective, shrinkage was an inevitable experience in the process of socioeconomic development in northeast China. The “best” development path for northeast China may be to comply with the tendency toward urban shrinkage, and restructuring of the spatial distribution of socioeconomic activities. DOI: 10.1061/(ASCE)UP.1943-5444.0000621. © 2020 American Society of Civil Engineers.

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Introduction

Urban shrinkage, defined as population loss and economic transformation with symptoms of a structural crisis, is becoming a common phenomenon throughout the world (Richardson and Nam 2014). With the emergency of urban shrinkage in Europe and the United States in the 1960s, this phenomenon attracted an extensive debate in the planning and geographical realms (Popper and Popper 2002; Bontje 2004; Bearegard 2009). More recent evidence suggests that the phenomenon of urban shrinkage is also occurring in emerging economies (Yang and Dunford 2018). As the world’s largest emerging economy, China has witnessed substantial urbanization over the last decade. However, very recent studies indicated that urban shrinkage has emerged as the other side of urbanization in China, a fact that has attracted wide attention from scholars (Long et al. 2015; Yang et al. 2015; Long and Wu 2016; Lin et al. 2017).

In the Western context, scholars have conducted numerous studies on the identification of shrinking cities and of the determinants leading to urban shrinkage. In these studies, population loss is widely acknowledged as the core indicator of urban shrinkage. For example, according to demographic trajectories, shrinking cities are divided into five categories: persistent early shrinkage; metropolitan shrinkage; recent shrinkage; cyclic shrinkage; and mild shrinkage (Alves et al. 2016). Nevertheless, urban shrinkage is a multidimensional complex involving demographic and socioeconomic processes and effects (Martinez-Fernandez et al. 2012a; Morrill 2014). Economic transformation is a symptom of urban shrinkage, as important as population outflow. From the perspective of the parallelism of economic and demographic changes, Bartholomae et al. (2017) identified four categories of urban development: shrinking cities (characterized by economic and demographic decline), smartly growing cities (characterized by economic growth and demographic decline), population magnets (characterized by economic stagnation and demographic growth), and growing cities (characterized by economic and demographic growth).

The causes of urban shrinkage vary across countries, due to the heterogeneity of the institutional and economic context. Deindustrialization and resource depletion are major reasons for urban shrinkage in England (Mallach et al. 2017; Döringer et al. 2020). Post-socialist transformation caused a flow of population from East German cities to West German cities (Großmann et al. 2013; Haase et al. 2013; Nelle et al. 2017). Counter-urbanization caused by overcrowded urban cores and radical discrimination resulted in out-migration from American cities (Martinez-Fernandez et al. 2016). Fertility decline and aging played key roles in urban shrinkage in Japan (Hattori et al. 2017). Moreover, under the influence of globalization, all the cities are included in an international network, and cities with comparative disadvantages are facing the challenges of peripheralization (Elzerman and Bontje 2015).

Unlike Western countries, China is experiencing rapid industrialization and urbanization. China’s population as a whole is still growing. Urban shrinkage is embedded within a background of population growth at the national level. In this context, some cities
had a net population inflow, while other cities have inevitably lost their populations. There is a close “competition” relationship between growing and shrinking cities. Therefore, it is necessary to understand urban shrinkage in China from the perspective of regional scale. In particular, as China’s economy enters the “New Economic Normal” phase, high-tech industries have become the new driving forces of economic growth, and the competitive advantages and market demands of traditional industries, such as steel, oil, and coal industries, are shrinking. The cities that quickly adapted to changes in the external market through industrial upgrading have become new population and economic growth poles, while those with stagnant industrial transformation have undergone population outflow. Hence, China’s urban shrinkage is also regarded as the result of the spatial restructuring of economic and population factors on a city–region scale.

Studies on Chinese urban shrinkage have mainly concentrated on the identification, spatial distribution, and influencing factors of shrinking cities at the national level. In light of these studies, population loss is widely regarded as the only indicator of urban shrinkage (Yang and Dunford 2018; Zhang et al. 2019). The determinants leading to urban shrinkage include the shock of economic crises, disappearing demographic bonuses, aging population, resource depletion, insufficient investment in fixed assets, industrial transformation, and the siphoning effect of high-speed rail (Du and Li 2017; Sheel 2018; Deng et al. 2019; Zhang et al. 2019). Simply put, current research mainly focuses on population loss in single shrinking cities and on its causes, neglecting the interconnections that exist between cities. In fact, urban shrinkage is not an isolated phenomenon occurring in a single city, but is a widely associated spatial manifestation in the urban system. The purpose of this paper is to understand urban shrinkage from a regional perspective, that is, spatial association, and to develop cross-national knowledge on shrinkage by bringing together researches performed on Europe, America, and China.

Urban shrinkage in China is affected by resource depletion and macroeconomic transformation, where traditional industrial cities dominated by coal, chemical, and steel industries have experienced both an economic transformation and population outflow, due to the loss of competitive advantage of their leading industries. Chinese urban shrinkage most typically occurs in northeast China (Ma et al. 2016; He et al. 2017; Zhang et al. 2017). As early as in the 1990s, with the emergence of the “Northeast Phenomenon,” a large number of resource-dependent cities have undergone shrinking problems, characterized by the collapse of enterprises and socioeconomic waning. Since 2014, under the influence of the New Economic Normal, a “New Northeast Phenomenon” has appeared, and urban socioeconomic development in northeast China has once again encountered a “cold flow.” The interweaving of the old and new Northeast Phenomenon has increased the complexity of shrinking problems in northeast China, such that this can be considered as a typical region to study the phenomenon of urban shrinkage in China.

This paper is structured as follows. The second section, “Literature Review,” constructs the theoretical analysis framework of the causes leading to urban shrinkage, and analyzes the factors resulting in urban shrinkage in China. The third section, “Study Area, Data, and Methods,” describes the study area, data, and methods. The fourth section, “Characteristics of Urban Shrinkage in Northeast China,” presents the characteristics of urban shrinkage in northeast China. The fifth section, “Causes of Urban Shrinkage in Northeast China,” analyzes the reasons for urban shrinkage. Finally, the sixth section, “Discussion and Conclusions,” discusses the results and draws the main conclusions.

Literature Review

Theoretical Cause Analysis

To date, various reasons for urban shrinkage have been investigated; however, there is currently no comprehensive framework to understand the causes of urban shrinkage (Haase et al. 2014; Jaroszewski 2019). Extant studies have identified three possible reasons for urban shrinkage: external environmental changes, urban development effects, and governance.

Changes in the external environment include globalization and natural or human-made disasters. Globalization has impacted cities and countries unevenly (Martinez-Fernandez et al. 2012a; Cunningham-Sabot and Fol 2007). Cities that are isolated from global knowledge and economic networks must face development bottlenecks in maintaining economic growth and their inhabitants. War or climate changes destroy the economic power and the living function of cities and force urban inhabitants to migrate quickly (Beauregard 1993). For example, the flooding resulting from hurricane Katrina in 2005 caused an abrupt population outflow from the New Orleans metropolitan area (Zaninetti and Colten 2012) into surrounding major cities.

Urban development effects include resource depletion, suburbanization, poor quality of life, deindustrialization, and aging. As resource exploitation entered a depletion stage, some resource-based cities, such as those in the “Rust Belt,” a particular area of the United States characterized by industrial decline after the 1980s, suffered from economic downturn and population loss (Martinez-Fernandez et al. 2012b). After World War II, highway construction greatly contributed to suburbanization of economic activities and the wealth of citizens in the United States. As firms and the wealth moved out to the suburbs, the centers of cities suffered from the continuous deterioration of living quality, such as public insecurity, low-quality public schools, and infrastructural obsolescence due to the loss of tax sources. The poor quality of life further accelerated the outflow of wealth from the central city and exacerbated its urban shrinkage (Clark 1989; Couch et al. 2005; Oswalt 2005). Business-oriented services may fail to fill the occupational gaps caused by deindustrialization, resulting in unemployment and out-migration problems (Cheshire 1995). Demographic changes resulting from reductions in fertility rate contribute to a decrease in the number of inhabitants living in cities (Klingholtz 2009).

Governance mainly refers to changes in political regime and industrial policies (Vale and Campanella 2005; Cheshire and Magrini 2006). After the 1990 unification of East and West Germany, German governments implemented an institutional and industrial transformation characterized by “shock therapy,” which damaged abruptly the economic structure of East German cities and motivated the migration of young and skilled workforces to West Germany (Bartholomae et al. 2017).

Actually, in many cases, urban shrinkage was mainly caused by the interactions of these three aspects (Cortese et al. 2014). As shown in Fig. 1, due to extensive development, a city forms a single industry structure, lacking the adaptability to adapt to external environmental changes. When the external environment changes, the city fails to achieve a timely and smooth industrial transformation, causing serious employment supply–demand mismatches. In this process, if governments implement a “shock-style” industrial shift policy and reduce fixed-asset investments, the urban carrying capacity will be rapidly weakened and outmigration will be accentuated.

Reasons for Urban Shrinkage in China

The reasons for urban shrinkage in China are argued to be largely different from their counterparts in Europe and the United States, as in the 1990s, with the emergence of the "Northeast Phenomenon" and the "New Northeast Phenomenon." urban shrinkage was mainly caused by the interactions of these three aspects (Cortese et al. 2014). As shown in Fig. 1, due to extensive development, a city forms a single industry structure, lacking the adaptability to adapt to external environmental changes. When the external environment changes, the city fails to achieve a timely and smooth industrial transformation, causing serious employment supply–demand mismatches. In this process, if governments implement a "shock-style" industrial shift policy and reduce fixed-asset investments, the urban carrying capacity will be rapidly weakened and outmigration will be accentuated.
given its socioeconomic stage and urbanization background (Long et al. 2015). In light of the theoretical framework just presented, the causes leading to urban shrinkage in China may include the New Economic Normal, the agglomeration effect stemming from central cities, resource depletion, the single-industry structure, poor quality of life, demographic aging, and supply-side structural reform.

The New Economic Normal triggers urban shrinkage. Since 2014, China entered a stage of socioeconomic transformation, characterized by a disappearing demographic dividend and rising environmental awareness. Against this background, the traditional manufacturing industries in China’s developed areas were forced to shift to other developing regions, causing serious unemployment and outmigration. For example, the city of Dongguan, the so-called world’s factory, lost a large number of its inhabitants during the period of socioeconomic transformation (Du and Li 2018).

The agglomeration effects stemming from central cities result in urban shrinkage. Currently, many large cities in China are still in the stage of agglomeration development. Through the “polarization effect,” these large cities continue to absorb production factors, such as population, capital, and industries, from the surrounding small- and medium-sized cities, thereby inhibiting their development to a certain extent. This rapid transportation has accelerated the flow of production factors between cities, thereby further strengthening the “polarization effect” of China’s large cities. For example, Deng et al. (2019) found that the construction of high-speed rail exacerbates urban shrinkage in China.

Resource depletion, the single-industry structure, and poor quality of life cause the shrinkage of resource-based cities. Natural resources exploitation for mass production is unsustainable, and the natural resources are ultimately exhausted. In addition, resource-based cities are highly reliant on the mining industry, and usually do not build a strong connection between this sector and other businesses (He 2014). Once resources are exhausted, these cities face the challenges of economic decline, reduction of fixed asset investment, and deteriorating quality of life, which in turn triggers outmigration of urban population.

Demographic aging aggravates urban shrinkage (Yang and Yang 2019; Zhang et al. 2019). In 2018, about one-sixth of the total population in China was aged 60 and older. According to the standards of the United Nations, China has entered the phase of aging society. The impact of aging on urban shrinkage includes two aspects. On the one hand, aging causes a natural decrease of the number of people living in cities; on the other hand, aging impairs the vitality of cities and weakens the cities’ attractiveness to their inhabitants, especially young adults.

Supply-side structural reforms facilitate urban shrinkage. In previous decades, China achieved a remarkable economic success through the large-scale development of traditional industries, which resulted also in the surplus of industrial capacity, such as in the coal and steel sectors. In 2015, the state initiated a supply-side structural reform in order to reduce excessive industrial capacity. The implementation of this policy undoubtedly deteriorates both the unemployment situation and outmigration problems in shrinking cities (He et al. 2017).

Study Area and Methods

Study Area

Northeast China includes 34 prefecture-level cities and 147 county-level cities, covering an area of 787,300 km² (Fig. 2). Given the availability of statistical data, we regarded the county-level cities as the unit of analysis. As China’s economy entered the New Economic Normal phase in 2014, the competitive advantage of the industries in northeast China was gradually lost, contributing to increasingly prominent regional economic stagnation and population loss. As shown in Fig. 3, the total population of northeast China decreased from 108,081,000 in 2013 to 105,854,000 in 2017, with an annual average decrease of 556,750. In contrast, in 2013–2017, the national population increased from 1,360,720,000 to 1,390,080,000, with an annual average increase of 7,340,000, which indicates that outmigration is the main reason for population loss in northeast China.

Northeast China is adjacent to Beijing, the capital of China. The rapid development of Beijing has exacerbated the problem of economic stagnation and population outflow in northeast China. Since 2014, thanks to its political and talent advantage, Beijing has rapidly transformed its industrial structure. In 2017, the output value of the high-tech industry, modern services, and information sector accounted for 20.01%, 61.35%, and 16.30% of the GDP of Beijing, respectively (Beijing Statistics Yearbook 2018). As a result, Beijing’s income level, employment opportunities, and residential satisfaction are significantly higher than those in northeast China, prompting the continuous flow of young talent from northeast China into Beijing. To date, the population with a university degree or above in northeast China decreased by 184,600 (China Statistical Yearbook for Regional Economy 2019), resulting in the lack of talent support for the development of emerging industries. Consequently, northeast China experienced a continuous stagnation of industrial structure upgrading and population outflow.

The raw data used for this study include the administrative division map and socioeconomic statistical data. The administrative division map was derived from 1.25 million basic geographic data provided by the Resource and Environmental Science Data Center of the Chinese Academy of Sciences. The statistical data were obtained from the statistical yearbooks of Liaoning, Jilin, and Heilongjiang, the China County Economic Statistical Yearbook, and the statistics bulletin issued by county statistics bureaus in 2001 and 2018. The reasons for selecting the statistical data of two time nodes, that is, 2001 and 2018, are to measure urban shrinkage of both resource-based and non-resource-based cities in northeast China.

Methods

Identification of Shrinking Cities

In this paper, we employed changes in GDP and urban population size as indicators to assess urban development in northeast China. Through a comparison of these two indicators, northeast China...
Cities can be classified into four different types, as presented in Table 1. Broadly speaking, type 1 and type 2 cities should be classified as shrinking cities:

- **Type 1:** Absolutely shrinking cities, simultaneously experiencing GDP decrease and population loss.
- **Type 2:** Smartly growing cities, suffering population loss, but achieving favorable GDP growth.
- **Type 3:** Population magnets, undergoing population growth combined with slow or stagnant GDP growth.
- **Type 4:** Growing cities, achieving simultaneously population and GDP growth.

Furthermore, we used the method of “average + standard deviation” of the proportion of industry output value to classify the shrinking cities in northeast China. First, the average and standard deviation of the proportion of the output value of all industries in the corresponding county-level cities in northeast China were calculated (Table 2). Second, if the proportion of the output value of an industry in a shrinking city was higher than the average + standard deviation of the proportion of the output value of the corresponding industry in northeast China, that industry was recognized as the leading industry of the city. Last, depending on the leading industry, the shrinking cities in northeast China were classified as mining, manufacturing, tourism, and port cities.

### Measuring the Degree of Urban Shrinkage

We constructed a difference index of urban shrinkage to explore the spatial pattern of the shrinking degree in northeast China. The formula used is

$$D_i = \frac{X_i - \sum_{i=1}^{n} X_i}{n}$$

(1)
Table 1. Types of cities according to changes in GDP and population size

<table>
<thead>
<tr>
<th>Status</th>
<th>Population growth</th>
<th>Population loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP decrease/stagnation</td>
<td>Population magnets</td>
<td>Absolutely shrinking cities</td>
</tr>
<tr>
<td>GDP growth</td>
<td>Growing cities</td>
<td>Smartly growing cities</td>
</tr>
</tbody>
</table>

Table 2. Average and standard deviation of the indicators of various industries in northeast China in 2017

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Mining</th>
<th>Manufacturing</th>
<th>Trade and transportation</th>
<th>Culture and entertainment</th>
<th>Other services</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>9.41</td>
<td>47.08</td>
<td>8.63</td>
<td>7.84</td>
<td>27.04</td>
</tr>
<tr>
<td>SD</td>
<td>14.71</td>
<td>5.37</td>
<td>16.42</td>
<td>19.31</td>
<td>13.72</td>
</tr>
</tbody>
</table>

Note: M and SD indicate average and standard deviation, respectively.

where \( D_i \) = difference index of urban shrinkage; \( X_i \) = rate of change in population in a shrinking city; and \( n \) = number of shrinking cities in northeast China. This index is negative, when the shrinking degree is higher than the average of counterparts in the northeast, and vice versa.

We employed Getis-Ord \( G_i^* \) to evaluate the status of the shrinking degree on a global scope and to distinguish the hot spots and the cold spots of the difference index of urban shrinkage, namely urban agglomerations of severe and mild shrinkage. The formula of the Getis-Ord \( G_i^* \) is

\[
G_i^* = \frac{\sum_{j=1}^{n} w_{ij} X_j - \bar{X} \sum_{j=1}^{n} w_{ij}}{S \sqrt{\left( \sum_{j=1}^{n} w_{ij}^2 - \left( \sum_{j=1}^{n} w_{ij} \right)^2 / n \right) / (n-1)}}
\]

\[
\bar{X} = \frac{\sum_{j=1}^{n} X_j}{n}
\]

\[
S = \sqrt{\frac{\sum_{j=1}^{n} X_j^2}{n} - (\bar{X})^2}
\]

where \( x_i \) = attribute value for feature \( j \); \( w_{ij} \) = spatial weight between feature \( i \) and \( j \); and \( n \) = total number of features.

Examination of the Reasons for Urban Shrinkage

In the light of this theoretical framework, we introduced the OSL model to examine the correlation between the difference index of urban shrinkage and quality of life, industrial structure, demographic characteristics, and agglomeration effects, in terms of 10 indicators (Table 3). Table 4 presents the descriptive statistics of variables in the OLS model.

Finally, we applied geographic detectors to examine the intensity of the impact of the determinants of urban shrinkage (Wang et al. 2010). The calculation formula used is

\[
P_{D,H} = 1 - \frac{m}{\sum_{i=1}^{m} n_{D,H}^2} \sum_{i=1}^{m} n_{D,i} \delta_{H,i}
\]

where \( n \) = sample size; \( m \) = number of indicators; \( \delta_{H,i}^2 \) = variance of the difference index of urban shrinkage; and \( n_{D,i} \) = sample size of indicator \( D \) on category \( i \). The value of \( P_{D,H} \) ranges from 0 to 1. A higher value indicates a greater impact of this factor on urban shrinkage.

Characteristics of Urban Shrinkage in Northeast China

In 2000–2017, a total of 64 county-level cities in northeast China suffered from urban shrinkage. In shrinking cities, mining, manufacturing, tourism, and port cities took up 45.31%, 31.25%, 18.75%, and 4.69%, respectively. The output value of the mining industry accounted for more than 52.45% of the GDP of shrinking mining cities. The output value of the manufacturing industry accounted for more than 24.12% of the GDP of shrinking manufacturing cities. The output value of the culture and entertainment industry accounted for more than 27.15% of the GDP of shrinking tourism cities. Finally, the output value of trade and transportation accounted for more than 25.05% of the GDP of shrinking port cities.

Categories of Urban Shrinkage: Economic versus Demographic Perspective

In the period 2000–2017, growing cities, population magnets, smartly growing cities, and absolutely shrinking cities accounted for 13.81%, 45.86%, 10.50%, and 29.83% of the total number of county-level cities in northeast China, respectively. As shown in
Compared with absolutely shrinking cities (Fig. 5), population magnets showed higher output value shares for public administration, social insurance, education and health, trade, transportation, and hotels and restaurants sectors. This suggests that some absolutely shrinking cities with comparative disadvantages may need to prioritize the improvement of the quality of life rather than short-term economic growth. Growing cities showed a higher output-value share for real estate and housing than smartly growing cities; this indicates that smartly growing cities should focus on the development of real estate and housing sector to support the development of the manufacturing sector.

**Spatial Relations of Urban Shrinkage: Core versus Edge Perspective**

The spatial relations of urban shrinkage encompass several features (Fig. 4). First, the agglomeration effects of central cities have caused population loss in county-level cities under their jurisdiction, forming a pattern characterized by central growth and peripheral shrinkage. This type of prefecture-level cities includes Baicheng, Jilin, Mudanjiang, Yanbian, Jinzhou, Tonghua, Tiegel, Dandong, Yingkou, Liaoyang, Daqing, Changchun, and Qiqihar. In these cities, economic activities were significantly concentrated in central cities, resulting in the economic slowdown or stagnation of peripheral cities. During the period from 2001 to 2017, the population growth rate of the central cities of these prefecture-level cities reached around 8.00%, a value that was higher than the average rate in the northeast (5.13%). From the perspective of the city proper, urban population showed a tendency toward growth, with an increase of 1.04%.

Second, central cities affected by resource depletion were remote locations that had an economic slowdown, causing the proper of the prefecture-level cities to suffer from a net outflow of...
population. These prefecture-level cities include Yichun, Qitaihe, Jixi, Hegang, Fushun, Benxi, Anshan, Fuxin, Chaoyang, and Liao- yuan. These cities are either resource-exhausted cities, or isolated from urban agglomerations, such as the Ha-Da-Qi Industrial Corridor, the Liaoning Coastal Economic Belt, and the Changji Metropolitan Area. In 2001–2017, the population growth rate of these central cities (3.82%) was significantly low, while the corresponding rate in northeast China reached 5.13%. In terms of the city proper, urban population showed a negative growth, with a decrease of 4.54%.

Third, urban shrinkage may be caused by the spatial mismatch between the functional diffusion of a central city and its administrative areas. The cities of Shenyang, Dalian, and Harbin are classified into this category of prefecture-level cities. The county-level cities on the functional diffusion axis of central cities developed rapidly, while the cities in the opposite direction were faced with urban shrinkage. More specifically, Shenyang city transferred its industries from the central city to the cities of Tieling and Liaooyang connected with convenient transportation means, which slowed down the economic development of the county-level cities under its jurisdiction. Dalian city mainly diffused its industries to Dandong city along the coastline, resulting in the failure of Wafangdian city to undertake sufficient economic activities from the central city. Harbin city focused on industries integration with the cities of Daqing and Qiqihar, triggering population loss and economic decline in Bayan and Hulan cities in the north.

**Spatial Differentiation of Urban Shrinkage Degree**

Urban shrinkage in the northeast was significantly serious. The cities with a shrinking degree above the average level of northeast China accounted for 42.63% of the total number of shrinking cities. From the perspective of urban functions, the shrinking degree gradually intensifies on a scale from port cities, to tourist cities, mining cities, and manufacturing cities. More specifically, 50.32% of shrinking manufacturing cities had a shrinking difference index within the range from $-0.5990$ to $-0.4475$. The majority of shrinking mining cities (70.14%) had a shrinking difference index falling into the range $-0.1558$ to $0.1119$. Almost half (44.11%) of shrinking tourist cities had a shrinking difference index included in the range from $0.0048$ to $0.1119$. The shrinking difference index of all shrinking port cities changed from $0.1119$ to $0.1174$.

The urban shrinkage degree in northeast China demonstrated a high-low alternating trend from north to south. As shown in Fig. 6,
shrinking cities along the Sino–Russian border, including Xunke, Jiayin, and Suibin, had negative shrinking difference index values, revealing that their shrinkage was more serious than the average of northeast China. Shrinking cities along the Binzhou–Binsui railway showed positive shrinking difference index values, indicating that their shrinking degree was lower than the average of northeast China. The shrinking difference index of shrinking cities along the Hun–Wu Expressway was negative values; the index shifted from negative to positive values southward along the Liaoning Coastal Economic Belt, suggesting a gradual moderation of urban shrinkage along this geographical direction.

Urban shrinkage in northeast China showed a trend of “first strengthening and then weakening” from east to west (Fig. 6). In the eastern region, apart from Jidong, Hulin, Mishan, and Dongning, the shrinking degree of the cities was generally lower than the average of northeast China. In the central region, the difference index values of shrinking cities along the Ha–Da Railway varied from −0.5990 to −0.4475, suggesting that urban shrinkage was more serious than the average of northeast China. The difference index of shrinking cities at the junction of Jilin, Liaoning, Heilongjiang, and Inner Mongolia changed from 0.0049 to −0.1559, revealing that the degree of urban shrinkage of the western region was slightly higher than that of eastern region, and significantly lower than that of the central region.

The urban shrinkage degree showed a tendency toward spatial agglomeration in northeast China. The z-score and p-value on Getis-Ord Gi* of the difference index of urban shrinkage degree were −0.0694 and 0.0032, respectively, indicating that the low values for difference index of urban shrinkage degree were significantly clustered in northeast China. As shown in Fig. 7, five severely shrinking urban agglomerations and four mildly shrinking urban agglomerations were identified. Severely shrinking urban agglomerations included the Heihe–Jiayin port and tourist-type urban agglomeration, the Boli–Jidong–Mishan mining-type urban agglomeration, the Daan–Zhenlai manufacturing-type urban agglomeration, the Nongan–Dehui–Jiutai–Yongji manufacturing-type urban agglomeration, and the Kaiyuan–Fushan–Qingyuan–Xinbin manufacturing-type urban agglomeration. The mildly shrinking urban agglomerations included the Yian–Baiquan mining-type urban agglomeration, the Bayan–Hulan mining-type urban agglomeration, the Dunhua–Antu tourist-type urban agglomeration, and the Fengcheng–Kuandian–Xiuyan tourist-type urban agglomeration.

Causes of Urban Shrinkage in Northeast China

Agglomeration Effects of Central Cities

Currently, the economic growth of northeast China is at a stage of agglomeration development, generating several “core-periphery” patterns. The agglomeration development of the central cities
forms Matthew effects and substantially captures the production factors of peripheral cities. As a result, peripheral cities are affected by economic slowdown and population loss problems. As presented in Table 5, the coefficient of traffic advantages in Model 2 was positive and significant at 0.001 level. This result confirms that the closer a manufacturing city (affected by agglomeration effects of central cities) to a central city, the more serious its urban shrinkage. The spatial outcome of agglomeration effects is a circle-like spatial distribution of shrinking manufacturing cities around central cities.

More specifically, the central city of Baicheng concentrated on the development of labor-intensive industries, such as food, textile, and auto parts, which pushed large-scale labor forces in Daan, Zhenlai, and Taonan to migrate into the central city. Changchun and Jilin had not yet achieved industrial integration, and were still at an independent stage of agglomeration development. As a result, the surrounding cities were deprived of development opportunities. In particular, Jiutai and Yongji were under the dual influence of the agglomeration effects of these two cities. Shenyang’s industrial diffusion to the central cities of Liaoyang and Tieling strengthened their agglomeration effects, stimulating the population in peripheral cities to flow into the two central cities. Simultaneously, the spatial mismatch between industrial transfer and administrative jurisdiction of Shenyang caused economic stagnation and population outflow in Xinmin and Liaozhong. Finally, an urban agglomeration was formed composed of shrinking cities around the triangle area of Shenyang–Liaoyang–Tieling (Fig. 4).
Aging of Demographic Structure

Generally speaking, there is a cumulative causation mechanism between aging and urban shrinkage, which constantly exacerbates urban shrinkage. On the one hand, a prominent effect of urban shrinkage is the large-scale exodus of young labor forces, resulting in the aging of the demographic structure. On the other hand, the habits and customs of the old people, including a slow-paced life, a small range of activities, and an early rest schedule, are not conducive to the development and prosperity of the services industry, causing the lack of youthful vitality in shrinking cities. This, in turn, weakens the attractiveness of shrinking cities to the young, and aggravates the loss of young population.

The coefficient of aging was negative and significant in Models 1, 2, and 3 ($p < 0.1$ in Models 1 and 2; $p < 0.05$ in Model 3) (Table 5). This result indicated that the larger the size of the elderly population, the more serious the urban shrinkage. During the period from 2000 to 2017, the rate of elderly population in shrinking cities in northeast China increased from 10.21% to 21.93%, with an annual average increase of 0.69%. The demographic structure of shrinking cities showed a tendency toward rapid aging. A typical example was Yichun city: young labor forces escaped from this recessionary city in order to seek better job opportunities, leaving behind a large population of old people. As a result, the phenomenon of “young labor shortage” was increasingly aggravated. The average age of business service practitioners was around 54 years, and...
During the period from 2000 to 2017, the number of annual average of enterprises, abandonment of factories, and layoffs of employees. The utilization efficiency of these industries was less than 65%, respectively lower than the average of 1.09 km/km² and 219/10,000 of northeast China. Besides, due to the small number of samples in port cities, all indicators failed to pass the significance test in Model 5. However, the highway density of port cities was only 0.41 km², a value that was lower than the corresponding value for northeast China. Therefore, the inconvenient transportation hinders the interconnection between ports and the hinterland, and is also the reason for urban shrinkage of port cities.

Finally, we employed geographical detectors to examine the magnitude of the impact of the aforementioned factors on urban shrinkage in northeast China. We selected traffic advantages, aging rate, industrial greening, services sector size, and investment in fixed assets per capita as indicators representing agglomeration effects, aging, supply-demand relations between industries and markets, industrial structure, and public services, respectively. The results were as follows: agglomeration effects of central cities (0.28) > aging of demographic structure (0.20) > weak connection between industries and services (0.17) > supply-demand mismatch between industries and market (0.09) > underdeveloped public services (0.02). As presented in Table 5, the coefficient of traffic advantage was the largest in Model 2, which suggests that the agglomeration effect of central cities is the most influential factor on urban shrinkage of manufacturing cities. The coefficient of service size was the largest in Model 3, indicating that the weak connection between industries and services has played a critical role in the shrinkage of mining cities. Hospital bed per 10,000 people and traffic advantages were extremely dependent on resource exploitation, formed a significant amount of scattered small/medium enterprises. In order to save costs, these cities have adopted the development pattern of “mining-urban combination and enterprise-run society.” whereby the residential areas are placed near the mining areas, and residents’ employment and life are highly reliant on mining industries. Nevertheless, these enterprises, with a scattered layout and a small size, failed to agglomerate people at a large scale and further triggered the development of the services industry. As the area entered the resource depletion stage, the jobs provided by mining industries were increasingly reduced, and the underdeveloped tertiary sector was unable to grow in a timely manner into a substitute sector to absorb the surplus labor released from the mining industries. As a result, the mining areas degraded gradually into urban decaying areas with various socioeconomic issues, which further stimulated population exodus.

Underdeveloped Public Services

The coefficient of investment in fixed assets per capita was positive and significant at 0.1 level in Model 1; this indicates that insufficient investment in fixed assets may aggravate the outflow of population in shrinking cities. As presented in Table 5, the coefficient of the student–teacher ratio was positive and passed the significance test in Model 3. The result indicates that the teaching quality cannot satisfy the demand of the inhabitants in the mining cities, resulting in household outmigration stemming from children’s education. The number of hospital beds per 10,000 people and traffic advantages were significant explanation factors of the urban shrinkage of tourist cities in Model 4. Shrinking tourist cities in northeast China are far away from tourist sources, that is, the central cities. Underdeveloped transportation isolates the shrinking tourist cities from travel markets, while inadequate medical services further weaken the travel motivation of foreign tourists, which seriously constrain local socioeconomic development. Specifically, in 2017, the highway density and the number of hospital beds of shrinking tourist cities were 0.73 km/km² and 121/10,000, respectively, lower than the average of 1.09 km/km² and 219/10,000 of northeast China. Besides, due to the small number of samples in port cities, all indicators failed to pass the significance test in Model 5. However, the highway density of port cities was only 0.41 km², a value that was lower than the corresponding value for northeast China. Therefore, the inconvenient transportation hinders the interconnection between ports and the hinterland, and is also the reason for urban shrinkage of port cities.
significantly and negatively correlated to the dependent variable in Model 4, indicating shrinkage of tourism cities mainly results from underdeveloped public services. The traffic advantage was negatively correlated to the dependent variable in Model 5, reflecting that the shrinkage of port cities may be attributed to underdeveloped public services. Hence, in the light of the differences in the intensity of the dominant influential factors in various shrinking cities at the regional scale, urban shrinkage was more serious in manufacturing cities, followed by mining cities, tourist cities, and port cities.

Discussion and Conclusions

From a global perspective, urban shrinkage does not follow a homogeneous pattern, and every shrinking situation has its unique characteristics and reasons. Accordingly, in this paper, we analyzed features from the perspective of categories, spatial relations, and degree of urban shrinkage in a non-Western context, that is, northeast China. By using the OLS model and geographical detectors, the determinants leading to urban shrinkage in northeast China were identified, and the magnitude of determinants was assessed.

The phenomenon of urban shrinkage has been affecting 64 county-level cities in northeast China – 34.62% of these shrinking cities were classified as smartly growing cities, undergoing economic growth and population loss; the corresponding share of 65.38% was assigned to absolutely shrinking cities suffering simultaneously from economic and demographic decline. The smartly growing cities were mainly mining cities, while the absolutely shrinking cities were almost manufacturing cities. Compared with smartly growing cities, absolutely shrinking cities demonstrated a relatively low output-value share for trade, transportation, hotels and restaurants, information and communication, and scientific and technical services sectors. Three main types of connection between central cities and shrinking cities were identified, that is, central agglomeration leading to peripheral shrinkage, shrinkage of prefecture-level city proper, and central diffusion leading to peripheral shrinkage. Urban shrinkage was more serious in manufacturing cities, followed by mining cities, tourist cities, and port cities. The determinants leading to urban shrinkage in northeast China include agglomeration effects of central cities, aging of the demographic structure, supply–demand mismatch between industries and market, weak connection between industries and services, and underdeveloped public services. Specifically, the agglomeration effects of central cities played a key role in urban shrinkage in northeast China. Therefore, from the perspective of regional scale, urban shrinkage is the result of the restructuring of regional socioeconomic factors. Northeast China should adapt actively to the phenomenon of urban shrinkage, adopting differentiated development strategies for different types of cities in order to optimize and reorganize the social and economic factors in the region.

The concept of a smartly growing city means that, after changes in the external development environment, a city has alleviated the external shocks through industrial transformation and upgrading, and recultivated its own market competitive advantage to achieve economic growth. However, the newly formed industrial system in the city does not completely match the original employment structure, leading to a certain level of unemployment and outflow of population. In the future, the development of this type of city should follow the trend of population loss, and gradually realize the matching and interactive development between industrial and employment structure. At the same time, the smartly growing city should establish a land bank to store the land taken from bankrupt enterprises. The urban planning community should consider the land use of abandoned land as a whole, according to the principle of urban spatial structure optimization. The abandoned land that is temporarily unavailable can be preserved in the form of green space.

Absolutely shrinking cities show a trend of sustained population shrinkage and economic decline, due to the loss of the competitive advantages of the city’s leading industries and to the stagnation in upgrading of the city’s industrial structure. The primary guiding principle of the absolutely shrinking city is to transform into population magnets. The development of population magnets focuses mainly on the improvement of urban spatial quality and residents’ quality of life, rather than on GDP growth and expansion of built-up areas. Hence, absolutely shrinking cities should reduce urban built-up areas, concentrate on the redevelopment of urban central areas, and strengthen the construction of hospitals, schools, and nursing homes to improve the carrying capacity of the city’s population.

Growing cities are expected to experience a continuous growth in population and economic size in the long run. From the perspective of regional scale, growing cities will be the main carrying space of economic and demographic growth in the future. Therefore, it is necessary to transfer the excess construction land quota in absolutely shrinking cities and population magnets to growing cities, in order to moderately expand the urban space of growing cities and improve their carrying capacity to support population and industries.

Historical trajectories of urban development in Western countries confirm that urban shrinkage is an inevitable phenomenon in the process of transformation of urban-region spatial structure from single center to multicenter. In the 1920s, industrialization dominated by mass production model caused a flow of population and economic factors from urban hinterland into city centers, and shaped monocentric urban forms (Cheshire 1995). In the 1970s, with the advent of post-industrialization characterized by flexible production, the mobility of production factors was strengthened. Emerging industries, represented by electronics sector, tended to be localized by selectively relying on the relatively competitive advantage that each place offered, which promoted transformation of urban development from monocentric models of city and suburban to polycentric models of metropolitan region (Audirac et al. 2012). As a result, within the metropolitan region, there has been a division between urban centers dominated by mass production and those dominated by flexible production models. Along with the loss of competitive advantage in the mass production model, the original city center will continue to decline and become a “shrinking city.” In addition to following these laws, the relationship between polycentric development and urban shrinkage in China has its own particularity. Impacted by performance evaluation and land finance, local governments reject urban shrinkage and tend to motivate economic growth by building blindly new cities. However, the investment density and output level of the new cities have often grown slowly. Many new cities in China show a tendency toward “temporary shrinkage” or even evolve into “ghost cities” (Zhang et al. 2017). Hence, in order to deal effectively with urban shrinkage, Chinese government must also change its growth-oriented development concept, actively accept urban shrinkage, and guide the multicenter development of metropolitan regions based on the spatial evolution trend of regional socioeconomic factors.

Data Availability Statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.


