Chapter 3
Urban Shrinkage in the Beijing-Tianjin-Hebei Region and Yangtze River Delta: Pattern, Trajectory and Factors

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Abstract This paper investigates the shrinkage patterns and related influencing factors in the Beijing-Tianjin-Hebei Region (BTH) and the Yangtze River Delta (YRD) using data from the 5th and 6th national censuses. The permanent resident population, registered population and working population are used to measure the urban shrinkage. The results show the following: (1) nearly twenty percent of cities/countries/districts of BTH and half of YRD present a local shrinkage phenomenon, which is still growing. (2) The shrinkage areas in BTH are primarily mainly located north of Hebei in Zhangjiakou and Chengde, and it has spread to the south central plain of Hebei, while the shrinkage in the YRD presents a spatial agglomeration pattern distributed in Northern Jiangsu, southwestern Zhejiang and most of Anhui province, except Hefei and Wuhu. (3) The shrinkage trajectories in the megacity regions can be classified into five forms: less-developed peripheral shrinking, large city downtown shrinking, industrial and mineral city shrinking, adjustment of administrative division and county/rural/town shrinking. (4) Outflow of population caused by unequal development of the regional economy, urbanization level and urban administrative system contributed to the shrinkage; some western shrinkage included suburbanization, deindustrialization or industrial transformation, whereas demographic shifts only emerged in a small number of large cities' downtowns and some old industrial and mining cities (towns). (5) Urban shrinkage in China is more complex and should be considered a cumulative and self-reinforcing process, which warrants further investigation.

Keywords Shrinking cities · City-regional differences · Beijing-Tianjin-Hebei · Yangtze River Delta

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3.1 Introduction

Urban development is often fluctuating in regional, national and global urban systems. Such fluctuations can be observed through many aspects such as population size, employment scale, transportation networks and enterprise organization (Hall and Hay 1980; Cheshire et al. 1986; Liu et al. 2014; Wang et al. 2014). It is difficult for individual cities to maintain long-term prosperity and economic growth during their long-term evolution. Although the traditional urban and regional development theory recognizes the (transient) decline of cities, it is generally regarded as a stage of development in the urban life cycle and the preparation for the next growth cycle (Leo and Brown 2000; Savitch and Kantor 2003; Wu and Wang 2003). Especially in the past 200 years, human civilization has ushered in the industrial revolution and the wave of urbanization. The rapid growth of the urban population and steady prosperity of the economy in the industrialized countries have prompted theoretical models and practical policies in urban research to be based on broad and even permanent growth. Growth has become the premise of nearly all urban and regional economic development research (Xu and Pang 2014). At the end of the twentieth century, however, under the influence of globalization, suburbanization, deindustrialization, local financial crises and social transformation, 'shrinkage' is becoming an increasingly common phenomenon worldwide. Many people move to cities every year, as urbanization is still increasing (especially in developing countries). Urban shrinkage is becoming the 'new normal' and expansion and growth are no longer a city's only standard succession path (Turok and Mykhnenko 2007; Kabisch et al. 2010). Related research shows that, between 1990 and 2000, more than a quarter of the world's urban population was shrinking, and approximately 40% of Europe's urban population was declining (Turo and Mykhnenko 2007), especially in the post-Socialist countries of eastern Europe (Großmann et al. 2008; Kabisch 2007). Approximately a tenth of the American cities in the rust belt and surrounding areas are experiencing 'shrinkage' (Beauregard 2009, 2013; Blanco et al. 2009). Although the megacities of Japan are prosperous, population loss in small- and medium-sized cities is also very common, and similar situations occurred in South Africa and South Korea (Oswalt and Rieniets 2006).

In urban studies and planning, urban shrinkage refers to the process of population reduction or loss experienced by a densely populated urban area with a minimum population of 10,000 residents that has faced population losses in large parts for more than 2 years and is undergoing economic transformations with some symptoms of a structural crisis (Wiechmann 2008; Pallagst 2008; Hollander and Németh 2011). Urban shrinkage is often accompanied by a series of negative effects such as an ageing population, rising unemployment, vacancy, and public facility idle space, and may trigger further social and economic problems such as investment, finance and land use issues. Urban decline is not a recent phenomenon. As early as the 1950s, urban and regional studies began to focus on the population loss, but wording of decline/decay, demographic depression and disurbanization was used. As a result of the rooted classical urban development model and urban growth theory, although

many cities have encountered similar problems of decline and shrinkage, they have not attracted the attention of urban policy researchers. Because of the rapid urbanization in the world, the small number of cities that have lost their population are considered to be deviating from the conventional 'non-mainstream'. Although urban shrinkage attracted the attention of urban study scholars and policy makers in the United States and Europe after 2000, most focused on how to achieve growth and future prosperity (Haase et al. 2014). Recently, they began to realize that, in the context of the transformation of the world economy and society, the traditional planning concept and management policy focused on 'urban growth' must be transformed into a focus on improving the quality of urban space and the paradigm of smart growth (Martines-Fernandez et al. 2012). This has led some scholars to study the advantages of 'smaller' cities and explore how to achieve sustainable urban development in the context of slow growth or adverse growth (shrinkage) (Schilling and Logan 2008; Haase et al. 2014).

Over the past 40 years of reform and opening up, China's economic development has made a remarkable achievements. Especially in the past 20 years, urbanization is in full swing. Similar to the early urban development of European and American countries, China's urbanization is also based on the top-level design of the growth model (Xu and Pang 2014). Academia and policy circles mainly focus on the growth and expansion of urbanization (Zhao and Zhou 2002; Research Group on China's Economic Growth et al. 2011; Wu and Fang 2009; Gao et al. 2013). Some scholars believe that the excessively high rate of urbanization and widespread spatial expansion make the urbanization in China appear to be in a state of rash advance (Lu 2007, 2010). The pressure on resources and the environment in high-density urbanization areas is prominent (Chen et al. 2010; Wang et al. 2015). Until recently, many cities appeared to be an 'empty city' (Nie and Liu 2013) or 'ghost city' and rural areas appeared to be 'hollowing out' (Xue 2001; Liu and Liu 2010). These 'shrinkage' issues, contrary to the growth and prosperity of traditional urbanization, have attracted further attention. There is no consensus on whether there are shrinking cities in China, although the United Nations Human Settlements Programme identified approximately 50 shrinking cities in its world city report (UN-Habitat 2012). Unlike the west, China's urban economy is still expanding, with no significant population loss, economic decline or high unemployment. However, in a recent report, the Economist noted that China's old industrial cities have begun to decline and, after the level of urbanization stabilizes in the middle of this century, China's cities will experience a period of shrinkage.[2] Domestic scholars believe that China does not have an urban shrinkage problem, but it shows typical shrinkage phenomena in different urban areas. With potential factors such as an ageing population, oversupply and speculation on real estate, the problem of urban shrinkage will inevitably arise (Xu and Pang 2014). In addition to the globalization and informatization, China's urban development has entered an era of 'space of flows' and 'network systems' (Wu et al. 2013, 2015). With the introduction of the national new urbanization plan (2014–2020) and acceleration of the reform of China's household registration system, China's population structure and population movement rebound will undergo major and profound historic changes in the future. Currently, the study of shrinking

cities mainly focuses on Europe and America. Research shows that urban shrinkage has significant global, local, multidimensional and complex characteristics. There is no uniform analytical model for urban shrinkage, and western contexts and structures cannot be applied to eastern Europe or other countries. Comparative analysis, spatio-temporal analysis, regional analysis and prediction simulation analysis are needed (Haase et al. 2012, 2014, 2016; Martines-Fernandez et al. 2012; Wiechmann and Pallagst 2012; Hoekveld 2012). In contrast, shrinkage city research in China is just beginning and is in an introductory stage (Wu et al. 2008; Huang 2011; Yang and Yin 2013; Gao 2015). Last year, the authors conducted an empirical study of shrinking cities based on national population data and found cities and towns with different scales have experienced obvious population loss (Mao et al. 2015; Long and Wu 2016). This study further explores the regional shrinkage of urban agglomeration based on the fifth and sixth nationwide population censuses.

3.2 Research and Data

The largest and only two inter-provincial administrative units of urban agglomeration in eastern China: the Beijing-Tianjin-Hebei Region (BTH) and the Yangtze River Delta (YRD) were selected as the research area. The BTH Region is the largest and the most developed urban agglomeration area in northern China. This region is also the only 'dual-core' mega-region in China that involve two municipalities. For BTH, thirteen prefecture-level cities and 181 prefecture-level administrative units were included in the research. As China's largest and strongest urban agglomeration, the YRD has both broad and narrow scopes. The broad scope covers 25 cities at the prefecture-level and above in Jiangsu, Zhejiang and Shanghai; the narrow scope refers to the 15 cities in the inner circle. Considering the close economic connections[3] between Anhui and the YRD over time, the YRD scale extends to Jiangsu, Zhejiang, Shanghai and Anhui, and 41 prefecture-level cities and 282 prefecture-level administrative units were included in this research.

The main data are the short and long table data from the fifth and sixth nationwide population censuses in 2000 and 2010 and socio-economic indicators in the corresponding years. To facilitate the study, the county administrative units were divided into four attribute types: (1) urban areas; (2) suburban areas; (3) county-level cities; (4) counties. Urban area refers to a city proper established when the city was designated before 2000[4] and suburban area refers to a 'county changed into city proper after 2000. Because such suburban areas were originally located in counties or county-level cities outside the central city and the economic and social development level is relatively lower than urban areas, most of the suburbs remain relatively independent in the fields of administration, finance and taxation.

The proportion of permanent residents in the BTH Region and the YRD increased from 7.1% and 15.4% in 2000, respectively, to 7.8% and 24.4% in 2010, respectively. The GDP of the two regions accounted for 9.2% and 22.4% of the country's GDP in 2000 and for 10.7% and 24.4% in 2010, respectively. The population carrying

Table 3.1 Comparison of basic social and economic indicators between the two urban agglomeration areas

	Beijing-Tianjin-Hebei region			Yangtze River Delta		
	2000	2010	Proportion (%)	2000	2010	Proportion (%)
Permanent resident population/10,000 people	9010	10,441	15.9	19,438	21,561	10.9
Urban population/10,000 people	3517	5871	66.9	8348	12,705	52.2
Urbanization rate (%)	39	56.2	17.2	42.9	58.9	16
GDP/100,000,000 yuan	9144	43,084	371.2	22,190	97,968	341.5

capacity and economic agglomeration of the two mega-regions are increasing (Table 3.1). In the two mega-regions, there is an imbalance development (Fig. 3.1). The imbalance of the BTH is mainly reflected in Beijing, Tianjin and other urban areas. The imbalance of the YRD is mainly existed in the core area (Shanghai, southern Jiangsu and northeast Zhejiang), the peripheral zone (northern Jiangsu, southwest Zhejiang) and the marginal zone (Anhui).

3.3   Measurement and Analysis of Shrinkage Patterns

3.3.1   Indicators

To measure and recognize shrinking, the most common indicators are population indicators. It can also be reflected by employment indicators. In China, population indicators are divided into permanent residents and registered residents. The permanent resident population refers to the population that is living in a place for a certain period of time (more than 6 months). It is a more realistic representation of the actual number of people living and moving in a given area (often called 'the real population'), including both the population with household registrations and actual residents (the 'household resident population') and those without registration but also practically living there (also known as the 'floating population' and 'other administrative region into the local population'). The registered population, also termed *hukou* population refers to the population with a registered permanent residence in the district (including actual residents and the outflow population). Therefore, the 'registered resident population' is a part of the 'permanent resident population' whereas
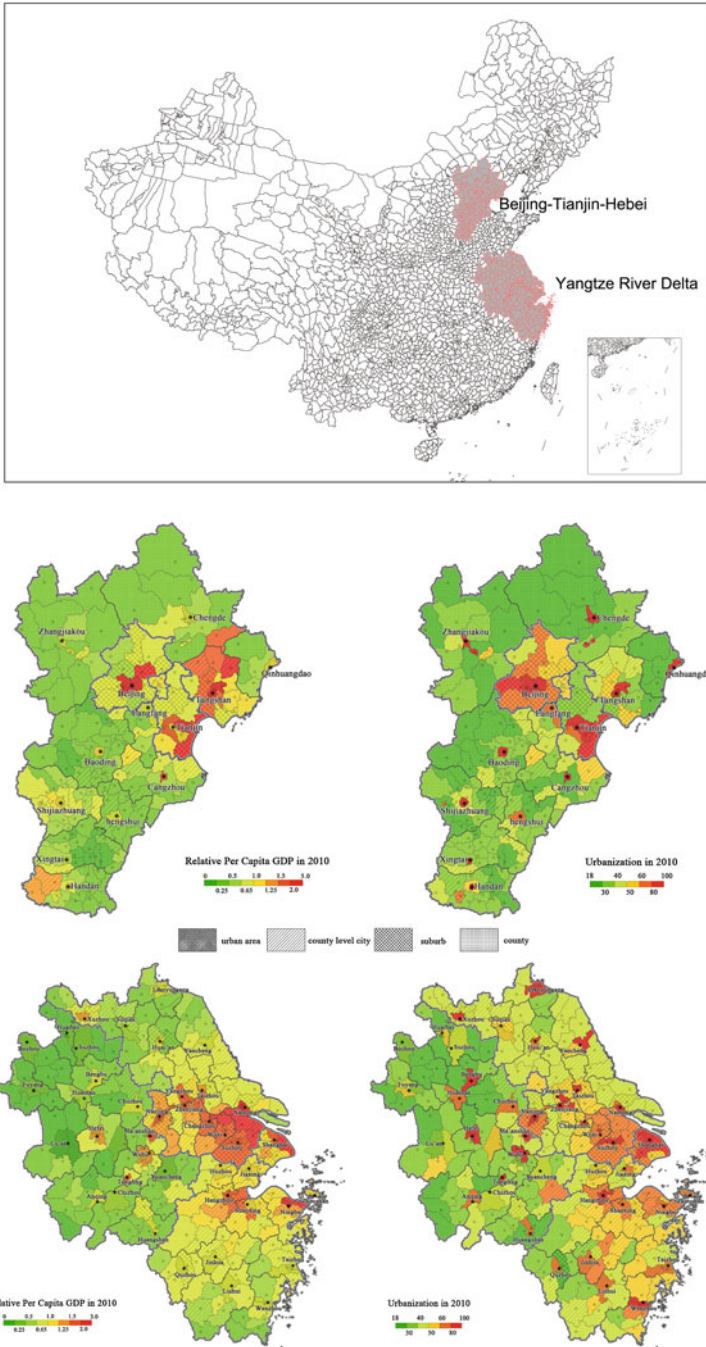
Fig. 3.1 Per capita GDP and urbanization rates in the Beijing-Tianjin-Hebei region and Yangtze River Delta

'resident population' and '*hukou* population' intersect (with each other, each with another part).

Along with the development of China's economy and urbanization, the east coast and several node cities on the frontier of reform and opening up are at the forefront of development. Urban agglomerations represented by the Pearl River Delta, YRD and BTH and several large- and medium-sized cities have become agglomeration areas of various social and economic activities. Due to the relatively developed economy in coastal areas and large and medium-sized cities, more work opportunities and higher incomes caused a large rural surplus population to flow to cities and eastern regions (Du et al. 2005). The trend has been further promoted by the steady progress of household registration reform. Due to the regional development gap (Heilig 2006), first-tier cities such as Beijing, Shanghai and Guangzhou have been preferred development areas for newly employed college students and young people. While many studies focused on population mobilities, they have rarely been associated with urban shrinkage. Many people are streaming into the east coast and some hot cities, creating an 'expansion' effect. For cities and regions where the population is outflowing, shrinking has occurred, especially at a time when the birth rate has decreased.

Therefore, the following indexes are constructed using the three indexes of resident population, *hukou* population and total working population[5], respectively, to comprehensively measure the shrinking pattern of urban agglomeration:

$$C_r = \frac{P_{r2010}}{P_{r2000}} \tag{1}$$

$$C_h = \frac{P_{h2010}}{P_{h2000}} \tag{2}$$

$$C_e = \frac{P_{e2010}}{P_{e2000}} \tag{3}$$

$$C_{rh} = \frac{P_r}{P_h} \tag{4}$$

$$C_{eh} = C_e/C_h = (P_e2010/P_e2000)/(P_h2010/P_h2000) \tag{5}$$

In the formulas, the C_r, C_h and C_e indexes assess the shrinkage by comparing the changes in the three indicators of the permanent resident population, registered population and employed population, respectively, in the study area from 2000 to 2010. The C_{rh} index assesses the shrinkage of the study area by comparing the changes in the permanent resident population and the registered population in 2 years. The C_{rh} index assesses the shrinkage of the study area by comparing the changes in the permanent resident population and the employed population. When the above index value is less than 1, it is assessed as shrinkage; when it is greater than 1, it indicates expansion. For a more intuitive comparison of this shrinkage and expansion, a cartogram transform map is used for visualization (Figs. 3.2 and 3.3).
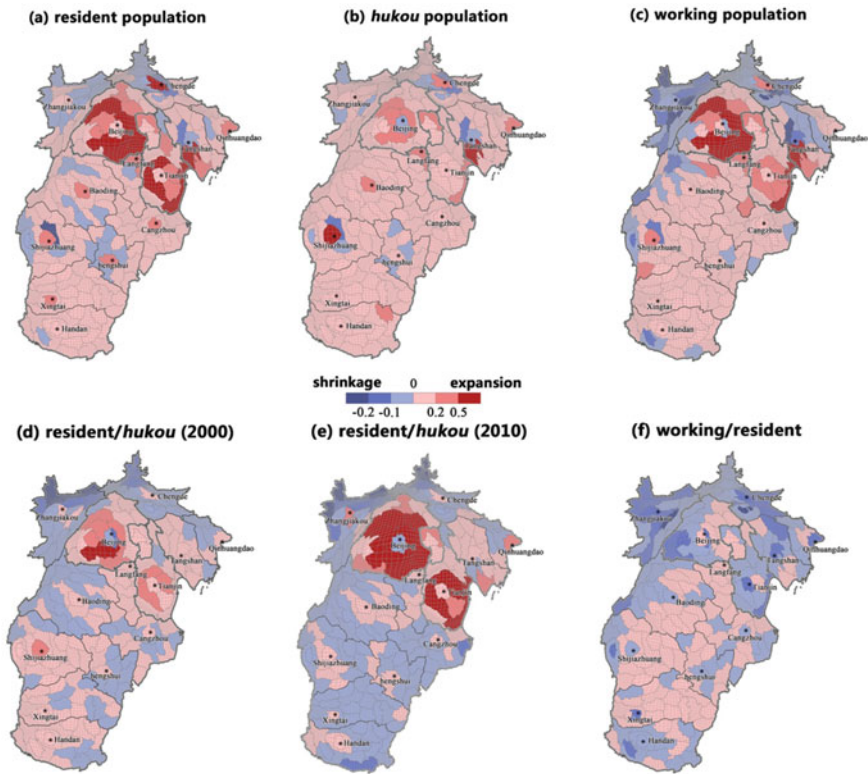
Fig. 3.2 The shrinkage and expansion of the Beijing-Tianjin-Hebei region

3.3.2 The Shrinkage Pattern of BTH

From 2000 to 2010, among 181 research units in the BTH, there were 34 counties
and cities with a shrinking permanent population, accounting for 18.8%. They were
mainly concentrated in the northern Hebei plateau and central and southern Hebei
plain, among which the shrinking degree of the Zhengding and Fengrun districts and
Chengde county was more than 10%. In addition, there was a shrinakge in downtown
Tangshan and most mining areas such as the Jingxing diggings in Shijiazhuang and
the Fengfeng diggings in Handan. If the household registration population index is
applied, the number of shrinking counties and cities in the BTH decreases to 17.
Notably, in addition to the typical diggings and mining cities, the registered popu-
lation of Beijing also shrank in the central downtowns of Dongcheng and Xicheng.
Further comparing the two years of permanent resident population and household
registration population, the number of shrinking counties and cities in the BTH
increased from 73 in 2000 to 107 in 2010. Apart from Zhangjiakou and Chengde
Bashang plateau counties, the shrinking counties in 2000 are mainly distributed in the
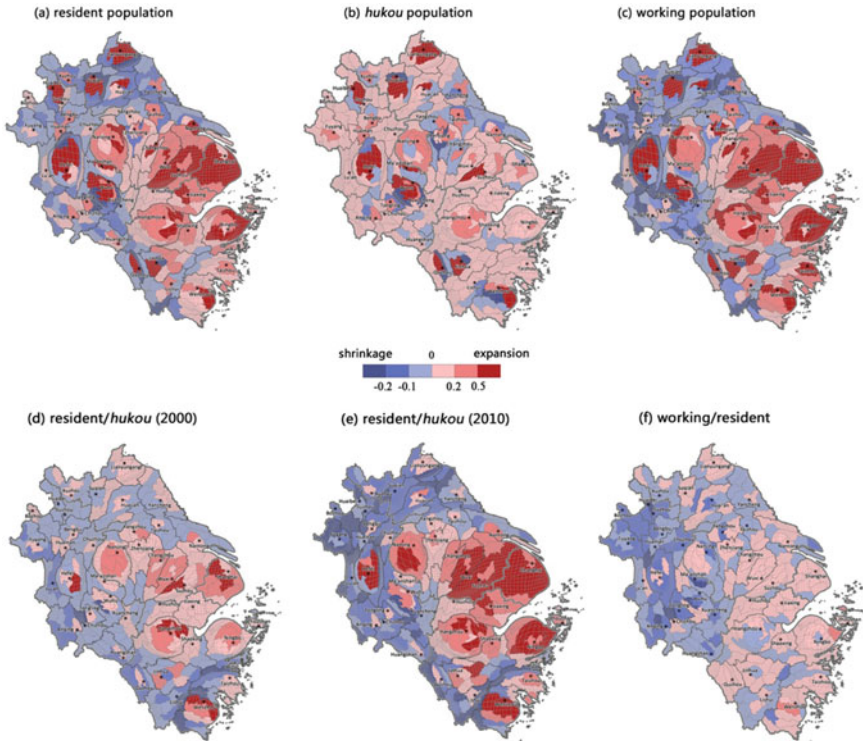
Fig. 3.3 The shrinkage and expansion of the Yangtze River Delta

Taihang mountainous area in the west, Cangzhou, Hengshui, Xingtai in the southeast and central urban areas of Beijing. By 2010, more districts and counties were shrinking than expanding, covering most districts and counties outside the main urban areas of Beijing and Tianjin where an expansion ring had formed around the outskirts of the Beijing and Tianjin megacities.

The shrinking patterns measured by the employment-population are similar to those measured by the permanent resident population, but the degree of the shrinking is strengthened. Especially in the Taihang mountainous area of northern and western Hebei, the employment shrinking in most districts and counties was 5 to 10% higher than that of the permanent residents. Figure 3.2f reflects the shrinkage pattern by comparing the changes in employment in the BTH with the changes in the permanent resident population. According to the calculation results, from 2000 to 2010, in 101 counties in the BTH, the number of employed people increased more than the number of permanent residents decreased. These 'shrinking' units are mainly located in the northern BTH, including some central and suburban areas of Beijing and Tianjin. As the core circle of the BTH urban agglomeration area, the population in the areas around Beijing, Tianjin and Tangshan increased significantly in the past 10 years but

the increase in employment did not match the increase in population, resulting in a 'relative shrinking'.

3.3.3 The Shrinkage Pattern of the YRD

Of the 282 study areas in the YRD, nearly half of the units show a permanent residents shrank, with 11 districts and counties shrinking more than 20%. Due to the adjustment of the administrative division, the population of Wuhu county, Fanchang county, Jindong district and Suyu district shrank by more than 30%. In addition, the regular shrinking areas of the permanent population were mainly located in the north of Jiangsu province (except the urban areas), southwest of Zhejiang and in most of Anhui's cities (except Hefei, Wuhu, Ma'anshan, Tongling and a few other major cities). Under the household registration population scale, the shrinking areas of the YRD decreased to 59, accounting for 21% of the total number of areas. In addition to a number of administrative division adjustments of counties and cities, the shrinkage occurred mainly in the central downtown of Shanghai, Nantong and Yancheng in the northern Yangtze River in Jiangsu province, Zhenjiang and Changzhou in the southern Yangtze River, and Wenzhou in the southern Zhejiang province. Comparison of the permanent resident population and registered population in the 2 years shows the shrinking pattern of the YRD has obvious spatial agglomeration and continuity. In addition to southern Jiangsu and northeast Zhejiang in the core areas of the YRD, Wenzhou in southern Zhejiang and Hefei, the capital of Anhui province, most other counties and cities shrank, and this pattern was further strengthened after 2000. In 2000, more than half of the 150 counties and cities had fewer registered residents than permanent residents. By 2010, although the number of shrinking areas with fewer registered residents than permanent residents had increased to 153, most of the shrinkage had increased (Fig. 3.3e). Among them, the number of districts and counties with a shrinking rate of more than 20% increased from 8 to 42, mainly distributed in western and northern parts of Anhui and southwest Zhejiang. In sharp contrast, the YRD formed seven 'expanding cities' circles in Shanghai, Suzhou, Nanjing, Hangzhou, Ningbo, Wenzhou and Hefei.

Between 2000 and 2010, 140 units in the Yangtze River Delta experienced a shrinkage in employment. Between 2000 and 2010, 140 counties and cities in the Yangtze River Delta experienced a shrinkage in employment. Its shrinkage pattern was basically consistent with that of the permanent resident population, mainly occurring in the cities of northern Jiangsu, the suburbs, county-level cities and counties of southwest of Zhejiang faubourgs and most of Anhui (except Hefei) and the municipal district of Wuhu. Among them, the employed population of Anhui shrank relatively more than its resident population did, which is verified by Fig. 3.2f. Comparison of the changes in the employed population and the permanent resident population shows that the shrinkage pattern of the YRD has been significantly alleviated. In the YRD from 2000 to 2010, nearly half of the regions experienced a less employment increases rate than the increase in permanent residents. However, it was mainly

located in Anhui and covered the central urban areas of many cities including Huaibei, Tongling, Anqing, Chuzhou and Huangshan. In contrast, the shrinkage in northern Jiangsu and southwest Zhejiang provinces decreased and even turned into relative expansion.

3.3.4 Shrinkage Types

Through the above preliminary analysis of the shrinkage pattern of the BTH and YRD, the shrinkages of the two mega-regions can be roughly divided into the following five types:

(1) Shrinking in underdeveloped areas. Underdeveloped areas were often located on the periphery of mega-regions, which was the main area of population outflow and most typical shrinking pattern in China. Shrinking in the northern BTH, central and southern Hebei plain, northern Jiangsu, southwest Zhejiang and much of Anhui fell into this category.

(2) Local shrinking in megacities. With the industrial restructuring of megacities, deindustrialization of the central city and suburbanization driven by the development of rail transit and public transportation, the central cities of Beijing, Shanghai and other megacities were not hot spots for population and employment expansion. In terms of the permanent resident population, household registration population, employment and other indicators, it began to grow slowly and gradually declined.

(3) The decline and shrinkage of industrial and mining cities. This is another important type of shrinking city in China, especially in the BTH. For example, the permanent and employed population of Tangshan, Shijiazhuang, Handan, Zhangjiakou, Chengde and some urban areas and mining areas all declined. The Yangtze River Delta, an old coal mining area in Xuzhou, Jiawang district also experienced a decline in some population indicators.

(4) Statistical shrinkage caused by administrative division adjustment. Such shrinkage occurred mainly in the suburban or suburban areas of central cities. As a result of the expansion of the central city, some towns originally belonging to the suburbs and suburban counties were subdivided into the central city area or municipal district, resulting in the shrinkage of these suburbs and suburban counties statistically, such as in Wuhu county in Anhui and Suyu in Jiangsu.

(5) Shrinkage of counties, villages and small towns. This shrinkage is common and intersects with the above types. Even in regions such as the YRD where the township economy was developed, in addition to the core areas of southern Jiangsu and northeast Zhejiang, most relatively underdeveloped counties, small towns and rural areas were shrinking. Administrative division adjustment could also aggravate this kind of shrinkage. Many rural counties and towns that were assigned to municipal districts had relatively good economic foundations. Most are the key growth towns of the original county and city, and their

delineation negatively impacted the economies of their respective suburbs or suburban counties and caused shrinkage. For example, Yanghe town in northern Jiangsu originally belonged to Siyang. In 2004, it was divided into Suqian city. The shrinkage of Siyang was prominent in northern Jiangsu.

3.4 Identification of Factors Influencing Regional Shrinkage and Expansion

Many factors contribute to urban and regional shrinkage. According to relevant scholars, these factors mainly include five categories, namely, 'demographic changes', 'climate change', 'economic change', 'political change' and 'space variation', and include a number of drivers and functions (Zhou and Qian 2015). The mechanisms are complex; some are linear and more are nonlinear and accumulative (Hoekveld 2012). At present, most cities in China are in the middle and late stages of industrialization, and some developed areas are entering the transition period of a 'new normal' of industrial structure adjustment. Do these factors affect the shrinkage and expansion of urban areas? Combined with relevant research experience in China and abroad as well as the shrinkage patterns and types of the BTH and Yangtze River Delta, this paper identifies and summarizes the influencing factors from five aspects: regional economic difference, urbanization process, industrial structure change, population structure change and administrative level (Table 3.2).

3.4.1 Regional Economic Imbalance

The imbalance of regional economic development is the main cause of the regional and internal population flow in China, which leads to local shrinkage (Wu et al. 2008). The BTH and YRD are no exception. The per capita GDP (yuan) in 2000, which reflects the initial level of economic development, and the GDP growth range in 2000–2010, which reflects the speed of economic development, were selected to analyze the correlation with the Cr index of the permanent resident population.

In general, the initial per capita GDP level has a high correlation with the Cr index. The shrinking areas were distinguished from the expanding areas and correlation tests were conducted. for regions with a Cr index greater than 1, the index and per capita GDP are positively correlated. A shrinking area with a Cr index less than 1 has little correlation with the GDP per capita, that is, the worse the economic foundation, the more significant the shrinkage.

Table 3.2 Pearson coefficient of C_r index and related factors

	C_r		$C_r > 1$		$0 < C_r < 1$	
	Beijing-Tianjin-Hebei region	Yangtze River Delta	Beijing-Tianjin-Hebei region	Yangtze River Delta	Beijing-Tianjin-Hebei region	Yangtze River Delta
Initial per capita GDP	0.541**	0.501**	0.578**	0.216**	−0.096	0.103
Rate of economic growth	0.157*	0.256	0.237**	0.295**	−0.123	−0.174
Initial urbanization level	0.452**	0.672**	0.489**	0.504**	0.009	0.105
Urbanization growth	−0.084	0.345**	−0.077	0.464**	0.001	0.130
Manufacturing employment change	0.009	0.145*	−0.065	0.430**	0.083	0.089
Tertiary sector employment change	0.426**	0.633**	0.164*	0.725**	0.368*	0.117
Ageing change	−0.441**	−0.58**	−0.408**	−0.385**	0.027	−0.159
Birth rate change	−0.197**	−0.098	−0.346**	0.257**	0.097	−0.018
Administrative level	−0.447**	−0.65**	−0.481*	−0.661**	−0.303**	−0.237*

Note **Indicates a significant correlation at the level of 0.01 (bilateral); *Indicates a significant correlation at the 0.05 level (bilateral)

3.4.2   Urbanization Level

Urbanization is also closely related to the shrinkage and expansion of cities. As a complex social and economic process, urbanization has a significant population agglomeration effect that promotes the expansion and development of urban and regional economies. When the agglomeration effect reaches full load, especially with the emergence of adverse phenomena such as urban crowding, environmental degradation and reduced quality of life, enterprises must spontaneously move to the edges of cities, and urban centres face an inevitable loss of population.

A correlation analysis was conducted with the urbanization rate in 2000, which reflects the initial urbanization level, the urbanization rate in 2000–2010, which reflects the urbanization process speed, and the Cr index of the permanent resident population. The results show that the initial urbanization level is significantly correlated with subsequent shrinkage and expansion. The shrinking area was distinguished from the expanding areas and correlation tests were conducted. For expansion areas with a Cr index greater than 1, the index value is positively correlated with the initial urbanization level. However, shrinking areas with a Cr index less than 1 have no

significant relationship between the subsequent shrinkage degree and early urbanization level. Thus, a lower initial urbanization level does not lead to a more obvious subsequent shrinking.

The correlation between the urbanization speed and Cr index value differs in the BTH and YRD. During 2000–2010, the rate of increase of urbanization level of districts, counties and cities in the BTH had no correlation with its shrinkage or expansion. That is, the urbanization speed did not significantly affect whether districts, counties and cities in the BTH shrank or expanded whereas the overall performance of the YRD was positively correlated. For the shrinking areas with a Cr index less than 1, the urbanization speed also influenced the remission of shrinkage but it was not significant.

3.4.3   The Change in Industrial Structure

Relevant studies abroad have confirmed that the shrinkage of many cities is related to deindustrialization, post-Fordism and structural adjustment of the global economy. China is still in the process of mid-industrialization. Evolution of the industrial structure in most areas is still in the decline of primary industry and the rise of manufacturing-based secondary and tertiary industry. Changes in the number of people employed in manufacturing and tertiary industries were selected to reflect the relationship between the change in industrial structure and the shrinkage and expansion of the two urban agglomerations in the past decade.

The linkage between manufacturing and urban shrinkage differs in the BTH and YRD. For the BTH, although the decline in the proportion of manufacturing in a small number of industrial and mining cities coincides with population shrinkage, for more cities, there is no significant correlation between shrinkage and structural changes in manufacturing. The YRD, where manufacturing has boomed over the past decade, showed a weak correlation, especially in the expanding cities (Cr > 1), and the manufacturing industry has obvious synchronous change trend. This shows that China's urban and regional shrinkage has not been significantly affected by the worldwide deindustrialization and economic restructuring.

The changes of the tertiary industry structure in the BTH and YRD are significantly correlated with the Cr index of the permanent resident population, that is, the more obvious the improvement of the tertiary industry in the industrial structure, the more cities tended to expand rather than shrink. For the BTH, the rapid development of the tertiary industry more positively impacted the shrinking area of cities with a Cr index less than 1. In contrast, in the Yangtze River Delta, the expansion areas with a Cr index greater than 1 showed a correlation with the growth contribution of tertiary industry as high as 0.725 whereas the shrinking area is not obvious.

3.4.4 The Change in Population Structure

A correlation analysis was conducted with the change in the proportion of the elderly population, the change in the birth rate and the Cr index of the permanent resident population. The results show that for, the two urban agglomeration areas, the ageing increase or decrease has a significant correlation with the expansion or shrinkage of the permanent population. Especially for regions with a Cr index greater than 1, ageing inhibited the expansion to some extent. However, for the shrinking regions, the increase in ageing did not significantly impact the degree of shrinkage.

The correlation between the change in the birth rate and the Cr index of the permanent population is not obvious. There is a certain negative correlation in the BTH, especially for the low birth rate in expansion areas with a Cr index greater than 1 but there is no such correlation in the shrinking regions. The YRD is not related as a whole, but its expansion area is positively correlated.

The above shows that the problem of urban shrinkage in western countries due to ageing and low birth rate is not typical in China's urban agglomeration areas. Although the correlation statistic shows that an increase in ageing inhibits the expansion and growth of cities, most of the shrinking areas are relatively old and have relatively high birth rates. This also shows that most of the shrinking urban areas in China are caused by population outflow due to relatively backward economic and social development, particularly in the young and middle-aged, rather than ageing demographics.

3.4.5 Administrative Hierarchy

The top-down administrative system in China determines the different levels of towns that use the resources in its development and provide public services, and development opportunities are very different. Cities with high levels often have absolute advantages in transportation infrastructure, public service facilities, investment attraction and financial support, continuously attracting people in the regional logistics information flow capital flow to its agglomeration. Over time, a virtuous circle of development has formed. Small- and medium-sized cities, small towns and villages are facing capital and human resource outflows. Cities that rely on a single industrial sector are more vulnerable to recession (Wu et al. 2008; Marines-Fenandez et al. 2012). Therefore, the correlation between the administrative units and the shrinkage was tested according to the classification of the administrative units (urban, suburban, county-level city, county region) in the two urban agglomerations.

The results show that different types of regions (administrative levels) are negatively correlated with urban shrinkage and expansion. The correlation coefficients between urban type and the Cr index of the permanent population in BTH and YRD are -0.0447 and -0.65, respectively. Thus, the shrinking trend of urban areas and

some suburban areas was significantly smaller than that of more marginalized and lower level county-level cities and counties.

3.5 Conclusions

As two large mega-regions along the east coast of China, the BTH and the YRD have attracted a large number of people, logistics and information flows that have been developing and expanding continuously for more than 10 years. There is also significant local shrinkage within these areas. The shrinking patterns of the BTH and the YRD were measured using household registration, permanent residence and employment data from two censuses. The results show the following:

(1) In approximately one-fifth of cities, counties and districts in the BTH, the permanent resident population has suffered local shrinkage and the shrinkage unit in the YRD is nearly half, slightly less than the shrinkage of the employed population. Although the shrinkage of the household registration population is not obvious, the shrinking of the household registration-permanent residence ratio is the most prominent, and the shrinkage in 2010 was still increasing compared with that in 2000.

(2) Although the degree of shrinkage measured by different data is not completely consistent, the shrinking spatial pattern reflected is generally the same. The main shrinking areas of the BTH are concentrated in Chengde and Zhangjiakou and scattered across the central and southern Hebei plain. The shrinking areas of the YRD are spatially concentrated and continuous, concentrated in northern Jiangsu, southwest Zhejiang and most areas of Anhui except Hefei and Wuhu.

(3) The shrinkage types of the two mega-regions can be roughly divided into six types: shrinking in the less-developed periphery, shrinking of the central urban areas of megacities, represented by Beijing and Shanghai, decline and shrinkage of industrial and mining cities and mining areas, statistical shrinkage caused by administrative division adjustment, and widespread shrinkage of counties, villages and small towns.

(4) The shrinkage in China was mainly caused by the imbalance of regional economic development, differences in the urbanization level and the population outflow caused by differences in urban administrative registration. The typical shrinkage of western cities such as suburbanization, deindustrialization or industrial transformation and demographic changes are only seen in the central urban areas of a few large cities or some old industrial and mining towns in China and are not representative and universal.

(5) The factors and action mechanisms that influence the shrinking pattern in China are very complex. Moreover, it has prominent regional consistency (for example, the correlation between industrial structure and population structure and shrinkage is not consistent in the BTH and the YRD). Although the level and speed of economic development, the level and process of urbanization and the

level of urban administration have some explanatory power, the correlation is clearer in expanding cities and regions, more precisely affecting expansion or shrinking. For shrinking regions, these factors are less illuminating.

Limited by the data and the length of the article, this research did not analyze other important factors such as investment, finance and transportation infrastructure. The influencing factors and path of shrinkage are a nonlinear and complex cyclic accumulation process. The correlation analysis in this paper is not sufficient and should be explored further.

Annotation:

① Shrink city international research network (SCIRN) define shrinking cities as densely populated urban areas with at least 10,000 people with most areas experiencing population loss over a period of more than two years and undergoing an economic transformation characterized by some sort of structural crisis.
② How to shrink a city. https://www.economist.com/leaders/2015/05/30/how-to-shrink-a-city, 2015-05-30.
③ According to the sixth national population census, Anhui nationality ranks first in the non-resident population of Shanghai with a registered residence of 2.6 million, accounting for 30% of Shanghai's migrant population, far more than other provinces.
④ Generally, this kind of municipal district is the centre of the 'purity' high urbanization area, especially in 1995 before the ground level above the city divided into districts, but part of the municipal districts also contains the proportion of rural population.
⑤ The total employed population index is derived from the national population censuses based on the employment length table data of 10% sample.

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