Land Use Efficiency in Shrinking Cities

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Abstract. This paper primarily focuses on the land use efficiency in shrinking cities, exploring the changing patterns and influencing factors of land use efficiency in cities experiencing continuous population and economic decline. I explore these questions by summarizing the defining criteria and causes of shrinking cities, as well as their mechanisms of impact on land use efficiency. Furthermore, the study selects Leipzig, Germany, as a typical case to analyze the evolution and characteristics of land use efficiency during urban shrinkage. I find that urban shrinkage, characterized by population decline, leads to aging infrastructure, vacant housing, and a weakened government capacity to provide public services, thereby reducing land use efficiency. However, by optimizing land resource allocation, improving living conditions for residents, and promoting industrial transformation, government can potentially reverse the trend of urban shrinkage, achieving the enhancement of land use efficiency. The conclusions of this study offer important insights for the governance of small and medium-sized cities in China, which currently face challenges such as negative population growth and regional development imbalances.

Keywords: Shrinking Cities, Land Use Efficiency, Leipzig

1 Introduction

Against the backdrop of China's negative population growth and imbalanced regional development, a large number of shrinking cities with declining populations have emerged, particularly in northeastern China and even some cities in central China. This phenomenon is not unique to China—across East Asia, Europe, and the United States, shrinking cities have proliferated due to factors such as population decline and industrial restructuring. On one hand, urban shrinkage is a consequence of social development, and on the other, it severely impacts urban economic vitality. Against this backdrop, this paper explores the social and economic impacts of urban shrinkage from the perspective of land use efficiency.

To investigate the above issues, this paper first reviews relevant theories. Regarding the definition of shrinking cities, the literature primarily adopts two approaches, that is population decline and economic activity decline. This study focuses on cities shrinking due to population loss. Land use efficiency encompasses not only economic output per unit of land area but also indicators related to the environment, industrial structure,

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and social development. The causes of urban shrinkage vary across cities and regions. In East Asian countries like China, urban shrinkage is primarily driven by the overall population decline and the concentration of economic activities. In contrast, in Europe and the United States, urban shrinkage mainly results from industrial restructuring and the impacts of globalization. Urban shrinkage and land use efficiency are closely interconnected and mutually influential. Urban shrinkage disperses economic activities and diminishes the efficiency of infrastructure, both of which contribute to declining land use efficiency. The decline in land use efficiency, in turn, hampers efforts to attract external populations, further exacerbating urban shrinkage.

Building upon the aforementioned theories, this paper uses Leipzig as a case study to analyze the causes of urban shrinkage and its impact on land use efficiency. From the 1930s to the end of the 20th century, Leipzig, an important industrial city in central Germany, experienced a persistent population decline. The reasons for this include the Nazi persecution of Jews, World War II, deteriorating living conditions for workers under the rule of German Democratic Republic, adjustments to traditional industrial structures, environmental degradation, and other factors, making it a typical example of a shrinking city. Amid persistent population decline, Leipzig faced issues such as underutilized infrastructure, vacant housing, declining municipal revenues, deteriorating public services, and difficulties in land development—all of which contributed to a decline in land use efficiency.

Based on theoretical analysis of declining land use efficiency in shrinking cities and the case study of Leipzig, this paper proposes three targeted policy recommendations. First, improve land resource allocation efficiency. Local governments should assess current land use conditions, consolidate inefficiently used land, and promote urban development that is compact and efficient, thereby preventing disorderly urban sprawl. Second, improve the living environment by enhancing basic public services. Increased investment in education, healthcare, elderly care, and other essential services should be prioritized. Additionally, upgrading housing conditions and urban environments will enhance residents' satisfaction and sense of belonging, helping to stabilize the existing population and attract new residents. Finally, promote industrial transformation. Cities should follow their comparative advantages to develop emerging industries, particularly in sustainable sectors such as the digital economy and green industries. Encouraging technological innovation and local entrepreneurship will strengthen urban economic vitality, increase the economic value of land per unit output, and foster endogenous drivers of high-quality development. This, in turn, will create jobs and attract new residents.

The rest of this paper is structured as follows. Section II summarizes the relevant theories and literature. Section III provides case study of Leipzig. Section IV concludes.

2 Literature Review

2.1 What Is a Shrinking City

The concept of urban shrinkage first emerged in the 1970s, when the German government began to notice a series of problems such as population loss and industrial decline. In 1988, German scholar HăuBermann introduced the idea of a "shrinking city" in his case study of the Ruhr region. He used the term to describe the phenomenon of urban hollowing caused by large-scale population outflow[1].

Today, scholars mainly define shrinking cities from two perspectives. The first is the population dimension, which focuses on population loss and the aging of population structures. For example, Zhang and Yang identified shrinking cities by looking at population decline and at the same time, studied shrinking cities' land use efficiency and influencing factors[2]. The second is the economic perspective, which includes signs such as industrial decline, job loss, decreased local revenues, and even municipal bankruptcy. Some studies also explore how shrinking cities can transform and recover. For instance, Chen created a city development index based on three aspects—population, economic growth, and urban construction—to measure the level of urban shrinkage [3].

2.2 How to Measure Land Use Efficiency

In current academic research, land use efficiency in cities is generally divided into two types. The narrow definition focuses on the economic efficiency of urban land use, while the broad definition includes overall benefits—this means not only economic benefits but also social and environmental ones. Bao et al. defined urban land use efficiency as the material output achieved from the inputs and consumption per unit area of land [4]. This includes contributions to society, the economy, and the environment. Guan and Chen described land use efficiency as the process of using production factors like labor and capital on urban land to achieve the best possible outcomes in economy, society, and environment, while also reducing environmental pollution [5].

Zhou et al. measured land use efficiency in the Yangtze River Delta urban area by looking at six factors: land input, capital input, labor input, economic output, industrial upgrading level, and environmental side effects [6]. They used the super-efficiency SBM model and the Malmquist index for the analysis.

2.3 Causes of Shrinking Cities

In developed countries such as those in Europe and North America, globalization, suburbanization, and industrial decline are key reasons for the formation of shrinking cities. Economic globalization has supported the growth of newly industrialized countries, but at the same time, it has hit the manufacturing industries of developed countries hard. These countries lost their competitive edge in the global market, which led to urban decline and shrinkage. Suburbanization has been one of the main causes of

urban population loss after World War II. Many middle-class families and factories moved to the suburbs in search of cheaper land and better living environments. This worsened the decline of inner cities and led to a unique "doughnut-shaped" shrinking pattern in the United States [7].

In China, Zhuang and Chen identified three main reasons for the formation of shrinking cities, which include negative population growth, differences in urban location advantages, and local government development strategies [8]. According to the seventh national population census, China's total fertility rate dropped to 1.3 in 2020, and starting in 2022, the population began to decline. As a result, many cities are now facing population loss. Labor tends to move from low-wage cities to high-wage ones in search of better income. This population movement leads to prosperity in some cities and decline in others. Southeastern China still has advantages in wages, business environment, and other factors, attracting continuous flows of investment, talent, and technology. In contrast, the northeast has experienced ongoing population outflow.

Due to intense competition among local governments in China, provinces often give more support to regional centers and provincial capitals, while ignoring smaller or less developed cities within their borders. This strategy helps already developed cities grow even faster and attract more support, forming a positive cycle. Meanwhile, less developed cities struggle due to lack of support, resulting in slow development or even stagnation.

2.4 The Impact of Shrinking Cities on Land Use Efficiency

Sun et al. explored how labor force shrinkage affects urban land use efficiency and the mechanisms behind it [9]. First, when the number of workers decreases, the size of industries or occupations in the city may shrink as well, leading to lower demand for land. This reduces the density of economic activities in the city and decreases land use efficiency [10]. Second, a shrinking labor force also lowers population density, making the population more spread out than before. This raises the cost of building and maintaining urban infrastructure, leading cities to adopt low-density development models, which further reduces the efficiency and economic value of land use. Third, labor force shrinkage can also affect the city's social and economic structure. For example, the demand for public services such as education, healthcare, and transportation may decrease, which can reduce the efficiency of urban planning and resource allocation[11].

2.5 The Link Between Land Use Efficiency and Urban Expansion or Shrinkage

Xie discussed land use theory, urban scale theory, and economic growth theory, and suggested that land use efficiency can be seen as a form of technological progress that supports economic growth[12]. The study also used methods like Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA) to measure land use efficiency. By analyzing data from 2003 to 2019 on cities of different sizes in China, the study found that higher land use efficiency clearly supports economic growth. Eco-

nomic growth naturally attracts more people, which encourages industrial development and urban construction, helping cities expand.

3 Leipzig Case Study

3.1 Overview of Leipzig City

Leipzig is located in the heart of the Leipzig Basin in eastern Germany, and is a key intersection of Europe's east-west and north-south trade routes. The city boasts a strong industrial base, with major sectors including lignite mining and processing, chemicals, heavy machinery manufacturing, textiles, food processing, printing, and tobacco. By the 1930s, the chemical, mining, and energy industries had closely linked Leipzig with Halle, forming a regional industrial metropolis and the economic hub of central Germany. From its origins as a medieval commercial center to its rise as an industrial powerhouse in the 19th century and its prominence as an internationally renowned trade fair city in the early 20th century, Leipzig has long been a vital industrial and commercial hub in Germany and central Europe [13].

Figure 1 presents historical population data for Leipzig. The city's population peaked at 701,155 in 1939 but declined to 584,593 after World War II, primarily due to war-related destruction and population displacement. In the postwar period, further population loss occurred as a result of industrial restructuring and political factors, reducing Leipzig's population to under 500,000 by 2000. This rapid demographic decline transformed Leipzig into a shrinking city.

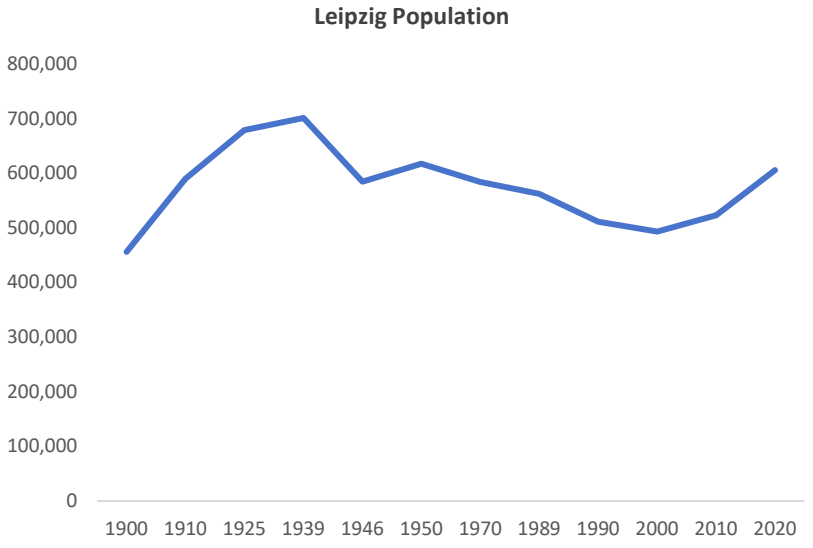

Fig. 1. Population of Leipzig

3.2 Reasons for Leipzig's Population Changes

In the early 20th century, Leipzig experienced rapid population growth due to its favorable transportation conditions andabundant natural resources in the surrounding region. The booming coal and chemical industries drove local employment and economic development, attracting a large influx of migrants.

For example, the coal liquefaction industry, a technology originating in Germany, played a key role in the population growth of Leipzig. In 1913, German chemists developed direct coal hydrogenation, a process that converts coal into liquid fuel under high temperature and pressure. By 1927, the German company Farbenestablished the world's first large-scale coal liquefaction plant in Leuna, near Leipzig, with an annual capacity of 100,000 tons. From the 1920s to the 1930s, Leipzig became the headquarters for major industrial conglomerates such asMitteldeutsche Stahlwerke (Central German Steelworks), Credit Bank Group, andRiebeck-Konzern, solidifying its status as the administrative and commercial hub of the region. Additionally, infrastructure projects like the Leipzig-Halle International Airport (1920s), theHalle-Dresden Autobahn (1930s), and the Elster-Saale Canal further enhanced Leipzig's connectivity as a transportation and logistics center. Driven by heavy coal-chemical industries and advanced transportation networks, Leipzig's population surged, reaching its peak in 1933.

After reaching its peak population in the 1930s, Leipzig's demographic boom came to an abrupt end with the 1938 Kristallnacht ("Night of Broken Glass")—a defining event that marked the collapse of its thriving community. The Nazi regime destroyed nearly all synagogues in the city, and 17,000 German Jews were forcibly deported at midnight by the government, leading to a massive exodus of Leipzig's intellectuals and cultural elites. From then until the end of World War II, the city's population continued to decline under the impact of war. By the war's conclusion, Leipzig had lost nearly one-third of its peak population.

From the post-World War II period to the early 21st century, Leipzig's population continued to decline, driven by both economic and political factors. Economically, in the East German, the government relied on the Soviet model, emphasizing heavy industry and agricultural collectivization, which turned Leipzig and its surrounding areas into an industrial hub. However, due to outdated technology and a lack of modern investment, industries like coking coal and lignite mining were constrained. At the same time, lignite mining caused severe pollution, leading to excessive levels of carbon dioxide, dust, and heavy metals in the region. The deteriorating living environment earned Leipzig the nickname "the dirtiest place in Europe." Poor living conditions and severe environmental pollution accelerated the city's population loss. After German reunification, the shift from a planned economy to a market economy led to the collapse of numerous industrial enterprises in the former East Germany. Leipzig's industrial backbone crumbled, resulting in massive unemployment and population outflow. Nearly 90,000 jobs were lost in Leipzig alone, and the regional labor market saw over 30% of its employment opportunities vanish. This forced many residents to migrate to more economically developed cities in western Germany in search of livelihoods and better prospects. During this deindustrialization process, traditional industries declined.

The government attempted to mitigate the impact by developing the tertiary sector but underestimated the far-reaching effects of deindustrialization. Young people and laborers increasingly moved to Berlin and western cities, exacerbating population loss and urban shrinkage. Additionally, global industrial restructuring made it difficult for Leipzig's traditional industries—such as machinery manufacturing and heavy industry—to adapt to market changes and remain competitive. The economic integration of Western and Eastern Europe further intensified the flow of capital and talent, making it challenging for Leipzig to attract and retain highly skilled workers.

Politically, the dissatisfaction among East German residents stemmed from their rejection of the political system and the unique issues brought about by the Sovietization of the economic system. From early 1953, the number of refugees fleeing to West Germany surged to tens of thousands per month. On May 28, the East German government announced a 10% increase in work quotas for state-owned industrial enterprises without raising wages. This policy sparked widespread public anger, which the authorities dismissed as an inevitable manifestation of intensified class struggle. On June 16, workers in East Berlin went on strike, and by the 17th, the movement had rapidly spread to Leipzig and other cities and regions. However, what began as an economic protest by workers escalated into a bloody political confrontation. The East German government, with Soviet support, responded with tanks and military force—a heavy-handed approach that failed to address the root causes of the conflict. Throughout the 1950s, Leipzig experienced continuous population loss, with many migrating to West German cities and regions. The emigrants were predominantly young, highly educated, and skilled individuals. In 1961, to stem the flow of East Germans to the West, the East German government, under Soviet direction, constructed the Berlin Wall on the East Berlin side, turning it into an iconic symbol of the Cold War. Although the wall temporarily slowed the exodus, Leipzig still saw a large net population outflow from 1951 to 1989. After German reunification in 1990, migration to West German cities and regions intensified. In short, due to the profound impact of Germany's division, Leipzig's population in 1990 had shrunk by a quarter compared to the 1930s.

3.3 How does Urban Shrinkage affect land use Efficiency in Leipzig?

The impact of urban shrinkage on Leipzig's land use efficiency includes idle infrastructure, housing vacancies, declining municipal revenue, reduced public service levels, and difficulties in land development.

The decline in Leipzig's total population and the shift in its age structure have significantly impacted the provision of urban infrastructure and public services. The reduction in population has decreased the demand for transportation infrastructure, such as roads, while a smaller population also means lower returns on infrastructure investments. This further reduces the supply of infrastructure, leading to underutilization and aging of Leipzig's existing facilities. At the same time, the decrease in the young population and the increase in the elderly population have lowered the demand for education while placing greater pressure on social pension and healthcare systems.

This demographic shift has altered the structure of public service demands, posing challenges for urban governance.

Housing vacancy caused by urban shrinkage is a key factor in the decline of land use efficiency. Since the early 1990s, Leipzig's vacant housing has exhibited a notably uneven distribution pattern. In the inner city, the main characteristics of vacant homes include a severe shortage of habitable housing and poor living conditions. By 2000, the number of vacant homes in Leipzig had reached 63,000, accounting for 20% of the city's total housing stock. Among these, 70% were significantly aged due to their long-standing construction period, with widespread deterioration caused by lack of maintenance, leading to substandard living conditions. The aging of housing and high vacancy rates undoubtedly reduce urban land use efficiency and hinder urban renewal efforts.

4 Conclusion

Against the backdrop of negative population growth and regional development imbalances, the number of shrinking cities is increasing. These cities face significant declines in land use efficiency. First, population decline reduces the utilization efficiency of urban infrastructure. As the number of residents and working-age populations decreases, existing public facilities—such as transportation, education, and healthcare—are left underutilized. The high fixed costs associated with these facilities lead to diminished returns on infrastructure investments. Second, widespread housing vacancies and idle land have become commonplace, particularly in inner-city areas. Aging buildings, suffering from a lack of maintenance, deteriorate the urban landscape and diminish the city's appeal, further reducing land value and economic output. Lastly, the weakening of public service capacity lowers the quality of urban life, prompting further population outflow and creating a vicious cycle.

To address this phenomenon, the government needs to implement systematic interventions. First, it should optimize land resource allocation, adjust land-use structures, promote land redevelopment, and enhance the composite utilization rate of land. Second, efforts should be made to improve the living environment for urban residents, with a focus on enhancing the quality and accessibility of social services such as education, healthcare, and housing. This will strengthen the city's appeal and population-carrying capacity. At the same time, industrial restructuring should be advanced by guiding the establishment of emerging industries, thereby revitalizing economic dynamism and restoring economic efficiency.

However, for regions experiencing persistent population outflow, governments need to formulate long-term transformation and development strategies. Measures such as tax reductions, housing subsidies, and entrepreneurship support can be implemented to attract young people and skilled professionals back. Additionally, inter-city regional coordination and cooperation should be strengthened to promote resource sharing and industrial complementarity. By building a quality-centered development model, cities can achieve efficient and sustainable revitalization through regional collaboration.

References

1. Xu Tingting. (2024). Research on Land Use Efficiency and Influencing Factors of Shrinking Cities in Northeast China (Master's thesis, Northeast Normal University).
2. Zhang Haozhe & Yang Qingyuan. (2021). Research on Land Use Efficiency and Influencing Factors of Shrinking Cities in China. Human Geography (03), 108-116.
3. Chen Rui. (2021). Comprehensive Measurement and Influencing Factors Analysis of Shrinking Cities in China. Statistics and Decision (23), 68-71.
4. Bao Xinzhong, Liu Cheng & Zhang Jianbin. (2009). Comprehensive Evaluation of Urban Land Use Efficiency. Urban Problems (04), 46-50.
5. Guan Yujie & Chen Xiaojian. (2013). Investigation on Urban Land Use Efficiency in Weinan City. Urban Problems (10), 72-77.
6. Zhou De, Jin Fengzhi, Li Siyuan, Li Huan & Li Pu. (2025). Spatiotemporal Evolution and Characteristic Decomposition of Urban Agglomeration Land Use Efficiency: A Case Study of the Yangtze River Delta Urban Agglomeration. Journal of Guizhou Normal University (Natural Science Edition), 1-11.
7. Gao Shuqi. (2015). A Review of Shrinking City Research. Urban Planning Forum (03), 44-49.
8. Zhuang Jia & Chen Youhua. (2023). Negative Population Growth, Urban Shrinkage, and National Choices. Population and Development (06), 31-42+58.
9. Sun Yan, Liang Hongtao, Jin Xiaobin, Fu Haiyue, Fan Yeting & Zhang Yunpeng. (2024). The Impact of Labor Force Shrinkage on Urban Land Use Efficiency. Resources Science (06), 1074-1085.
10. Liu Z., Liu S. H. & Song Y. (2020). Understanding Urban Shrinkage in China: Developing a Multi-Dimensional Conceptual Model and Conducting Empirical Examination from 2000 to 2010. Habitat International.
11. Zhang X., Zhang Q. Y., Zhang X. Y., et al. (2023). Spatial-Temporal Evolution Pattern of Multidimensional Urban Shrinkage in China and Its Impact on Urban Form. Applied Geography.
12. Xie Yanqin. (2022). The Impact of China's Land Use Efficiency on Economic Growth (Master's thesis, Zhejiang University of Finance and Economics).
13. Grimm F. D. (1995). Return to Normal - Leipzig in Search of Its Future Position in Central Europe. GeoJournal (36), 319-335.