

Spatial Contraction Characteristics and Regeneration Pathways in Industrial Areas: A Comparative Study of Venice and Nanjing

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Abstract

The rapid industrialization of metropolises has facilitated the formation of industrial areas, but urban transformation has challenged these industrial areas, leaving behind brownfield sites that affect urban density, environment and memory. The path of shrinkage and regeneration of these brownfield sites varies from region to region, reflecting the city's response to the transformation. Although there have been studies on brownfield identification and restoration, there is a lack of comparative studies on industrial shrinkage and regeneration paths in different areas. Taking Venice and Nanjing as examples, this study compares and analyzes the shrinkage characteristics and regeneration mechanism of brownfield in their industrial zones. The results show that there are both commonalities and differences in the contraction of industrial land in the two cities, which are closely related to the life cycle and development strategy of enterprises. While the industrial regeneration of Nanjing is government-led, the industrial regeneration of Venice is market-driven, and although it has some flexibility, it needs a stronger voice in the implementation of major projects and the coordination of heritage protection. Although the industrial areas of the two places face different development environments and land system backgrounds, their paths and experiences in spatial shrinkage and regeneration have certain mutual learning value, which can provide a reference for industrial and spatial regeneration in other cities around the world.

Keywords

Spatial Contraction, Industrial Areas, Regeneration Pathways

1. Introduction

After the industrial Revolution, along with the rapid industrialization and urbanization process, a number of industrial clusters have appeared in cities, which have made great contributions to the development of urban industries. However, with the continuous transformation of urban industrial structure, the number of idle land and abandoned brownfields in these industrial areas is rising day by day, and the proportion of brownfields in some industrial areas has reached a certain extent, and the regions have contracted and declined. These brownfield sites have a profound impact on urban density, urban environment, and urban memory, and pose challenges for urban planners. Therefore, the restoration of brownfield is not only to promote the sustainable development of industry, but also to preserve the memory of urban production and lifestyle.

Brownfield is an important issue in every country, which has been paid attention to by scholars from all over the world, and a wealth of research has been conducted (Newman, 2016). The concept of brownfield is broad, and the emphasis is different. The U.S. brownfield concept emphasizes contaminated industrial and commercial abandoned land, Japan expands the concept to include "potential brownfield sites" that

may be abandoned in the future, and Canada's brownfield concept focuses more on market redevelopment value.

The identification, assessment, and remediation of vacant land have also been key areas of focus for scholars. In terms of identification, the formulation of identification standards primarily involves establishing a multi-indicator identification evaluation system or model (Wang,2022; Ahmad,2018), yet significant discrepancies exist in indicator selection and weight determination due to different value orientations and research perspectives among scholars, leading to varied identification and evaluation results. In terms of assessment, existing research primarily revolves around the land use characteristics, spatial distribution features, and spatial morphological characteristics of vacant land (Coffin,2003). Relevant assessments mainly involve evaluations of vacant land types, spatial compactness, hollowing-out, and fragmentation, with evaluation methods evolving from single-indicator measurements to systematic index system evaluations (Sun et al,2023). As measurement indicators gradually expand, measurement domains deepen, and evaluation methods become increasingly quantitative, traditional spatial analysis methods have gradually become inadequate for studying land use patch morphologies (Bacon,2007; Hayek et al,2010). Therefore, in addition to spatial analysis methods, interdisciplinary techniques such as landscape pattern analysis are often employed for auxiliary analysis (Zhong et al,2020).

In terms of vacant land redevelopment, many scholars have proposed a series of development concepts in response to urban shrinkage, including smart growth, compact development, and infill development, all embodying the idea of urban morphological adjustment (Dixon et al,2006; Klusáček et al,2018). These concepts emphasize achieving "dynamic transformation and smooth transition" in urban morphology through planning intervention and landscape management (Gao,2017). Howland (2003) argues that the key to redevelopment lies in addressing financial issues and decentralized ownership; Pagano (2000) believes that land banks have played a crucial role in addressing land vacancy and abandonment issues in the United States, and insurance products such as pollution liability insurance and cost coverage insurance can also help developers reduce pollution cleanup cost; Dewar (2006) and Hackworth (2014) suggest that compared to purely market-driven models, government-intervened redevelopment approaches yield better results. In terms of spatial remediation, substantial practical experience has been accumulated in brownfield pollution treatment and landscape reconstruction (Song et al,2019). However, existing research primarily focuses on large-scale projects, with limited attention given to regional vacant land distribution and holistic renewal.

The characteristics of industrial area contraction and their regeneration pathways vary across regions, reflecting both commonalities and profound differences in urban responses to industrial transitions(Rall et al,2011; Dixon,2007). Jigoria (2017) conducted a comparative analysis of the brownfield regeneration pathways in two single-industry cities in neighboring former socialist countries (Romania and Serbia) but did not delve deeper into their commonalities and characteristics. Therefore, existing research on vacant land is limited to the identification of phenomena or detailed analysis of single cases(Smojakova,2017; Osman et al,2015), lacking comparative studies to examine the different pathways of industrial area contraction and regeneration across different regions.

This study aims to address this gap by exploring the spatial characteristics of industrial area contraction and the mechanisms underpinning their regeneration in two globally renowned tourist destinations with rich historical and cultural heritages: Venice and Nanjing. Venice, known for its canals and rich historical architecture, has a profound industrial legacy exemplified by Porto Marghera, which once housed a vibrant shipbuilding and chemical industry. Nanjing, on the other hand, is famous for its ancient history and culture, and is also an important industrial development center in the middle and lower reaches of the Yangtze River, with 15 provincial-level and national-level development zones. Both cities now grapple with the

proliferation of vacant land and the challenge of transformation. By comparing these two cities, this study aims to provide valuable insights into the shared and distinct paths of industrial district contraction and regeneration. Utilizing Google Earth satellite imagery and diverse open-source data, this study adopts a hybrid approach combining visual interpretation of satellite imagery with multi-source data calibration to identify brownfields. A comprehensive methodology for vacant land recognition and assessment is established, validated, and refined through localized empirical tests. Based on that, This study delved into the spatial characteristics of industrial area shrinkage, analyzed the formation and evolutionary texture of vacant land clusters, and explored and compared the redevelopment paths of different industrial areas.

2. Data and Methods

2.1. Research Objects

This study selects two cities, Nanjing in China and Venice in Italy, as the research subjects, with a comparative analysis focusing on the *Porto Marghera* Industrial area in Italy and the *Nanjing Economic and Technological Development Zone (NETDZ)* in China as specific case studies. Both industrial areas are representative within their respective cities, forming industrial agglomerations of significant economic and land-use scale. They have made substantial contributions to the economic development of their cities during specific historical periods and currently face renewal challenges characterized by business closures and land-use contraction.



Figure 1 Real scene inside Porto Marghera. Source: Author.

Located in the Veneto in northeastern Italy, Porto Marghera is a representative area of Italy's traditional industries and one of Europe's largest coastal industrial zones, with chemicals, steel, shipbuilding, and petroleum processing as its leading industries. Centered around the core Porto Marghera, several major industrial clusters have formed within the current industrial zone, including shipbuilding, oil refining, old petrochemicals, new petrochemicals, and biotechnology, which contribute significantly to the industrial zone's output and employment. In terms of overall production scale and employment, it serves as a crucial economic hub for Venice and the entire northeastern region of Italy. As of 2020, the Porto Marghera and Industrial Zone occupy an area of 2,200 hectares, with 884 enterprises, 11,060 employees, and an annual

turnover of €27 billion. However, due to its proximity to the historic center of Venice and its orientation towards the vast lagoon area, Porto Marghera is bordered by the culturally rich World Heritage Site on one side and the thriving production scene of a giant tanker manufacturing base on the other. Consequently, the industrial zone faces immense pressure in terms of ecological and environmental protection. Over the past few decades, many factories and companies within the industrial zone have temporarily or permanently closed. For instance, the EVC Compounds company ceased operations in 2006 and relocated to the Emilia-Romagna region, where factories offered more advanced technology. Under the influence of EVC, five other factories that used dichloroethane as a raw material also closed, highlighting the low resilience of the company's supply chain.

The Nanjing Economic and Technological Development Zone, situated in Qixia District of Nanjing, is one of the earliest national economic and technological development zones in Nanjing. It ranks among the top ten national development zones in China, is a national eco-industrial demonstration park, a world-class photoelectric display industry base, and a national Yangtze River shipping and logistics hub. In 2020, the Nanjing Economic and Technological Development Zone had a regional GDP of €15.5 billion, a total industrial output value of € 40 billion for above-scale industries, and an area of 200 square kilometers. It focuses on the development of three leading industries: photoelectric display, new materials, and high-end equipment.

2.2. Data Source and Technical Methodology

Based on the review of identification standards for vacant land in Italy and China, this study initially proposes criteria for vacant land identification. Considering the accuracy of vacant land identification in existing research and the average scale of industrial enterprises, and to fully leverage the advantages of visual interpretation of satellite imagery, this study determines an identification accuracy threshold of industrial land areas greater than or equal to 1 hectare and a time criterion of being vacant for at least six months. The key criterion for identifying vacant land lies in whether the land is in a state of disuse, regardless of the presence of buildings or the level of building density.

To minimize errors and biases introduced by satellite imagery identification, the identification should be subjected to multi-source data calibration based on visual interpretation of satellite imagery, with the aim of supplementing and correcting the identification results. The correction process consists of two rounds. The first round involves confirming the property rights and operational status of enterprises using open-source online data to supplement a batch of abandoned land that cannot be identified through visual interpretation of satellite imagery. The second round involves field corrections and multi-party verifications, with specific methods including field inspections and enterprise interviews, aimed at reconfirming the land use status of enterprises and making final judgments on cases that are difficult to assess through satellite imagery. These two rounds of corrections not only correct and supplement the results of manual identification but also allow for in-depth engagement with enterprises through visits to uncover their actual needs and typical experiences, discover new issues, and summarize new characteristics. Specific methods include supplementary online data, field inspections, enterprise interviews, and so forth.

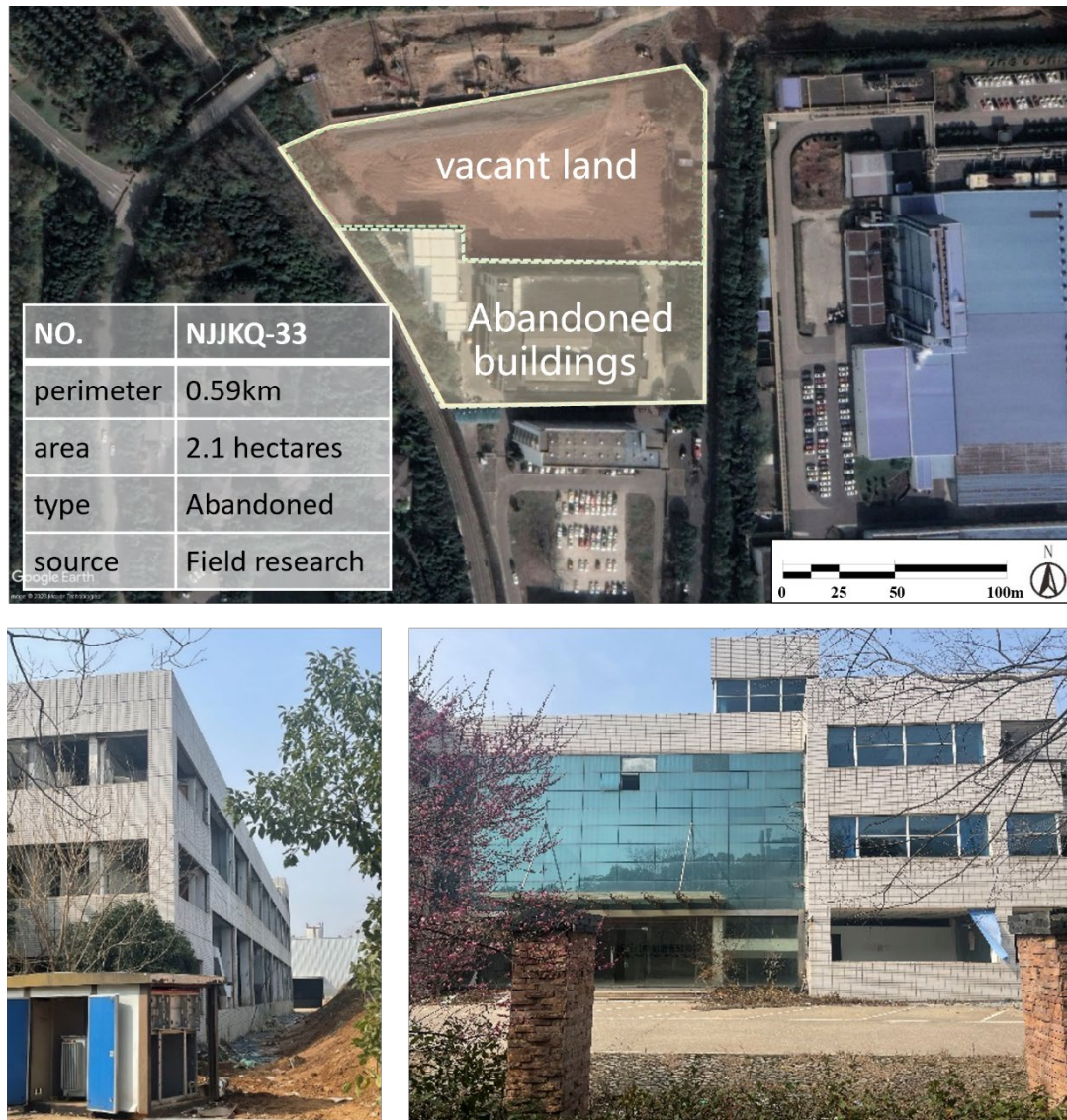


Figure 2 Abandoned buildings in Nanjing Economic and Technological Development Zone. Source: Author.

Following identification, an evaluation of vacant land is conducted to comprehensively assess the level of vacancy and contraction in the industrial areas. Based on existing research methods and considering the actual industrial development situations in Nanjing and Venice, evaluation indicators are selected from three dimensions: quantity, morphology, and distribution, to professionally evaluate the distribution status of vacant brownfields within the study area. Ultimately, the framework for brownfield identification and evaluation is established as illustrated in the figure.

3. Results

3.1. Spatial Characteristics of Industrial District Contraction

Firstly, the contraction of industrial spaces in Nanjing and Venice exhibits both common and unique features. The spatial distribution of vacant land in both cities demonstrates a degree of dispersion and randomness. From the perspective of land use morphology, compared to general construction land, vacant land typically exhibits smaller areas, irregular shapes, and fragmented boundaries. At the micro-level, the

vacant land within industrial areas tends to be located in less accessible areas, often developing away from major roads, resulting in hollowed-out and porous internal plots. Different industrial parks exhibit distinct patterns of localized aggregation of vacant land, primarily categorized as "center-periphery" and "clustered development," which are closely related to the timing of park development.

Secondly, from a temporal perspective, the evolution of vacant land is dynamic, with each plot potentially becoming vacant land at some point, influenced by policy factors, corporate lifecycles, and regional development strategies. The transformation of these lands reflects the interplay between economic, social, and environmental dynamics.

In terms of specific differences, the types, causes, and mechanisms leading to the emergence of vacant land during industrial contraction differ between the two cities. In Venice, the appearance of vacant land in Porto Marghera is predominantly market-driven. The decline of the shipbuilding and chemical industries in the area has led to the abandonment of numerous industrial facilities, with some enterprises closing down due to poor performance or mismanagement, resulting in a proliferation of vacant land. Market forces have played a significant role in shaping the spatial distribution of these vacant land, as areas closer to the city center, with higher land values, are more prone to redevelopment. The vacant land in Porto Marghera is mostly brownfield, already developed but abandoned and contaminated to some extent.

Conversely, the vacant land in Nanjing Economic and Technological Development Zone is predominantly underutilized. The government has preemptively supplied a portion of the land, some of which has been leased to enterprises, while others remain in a state of preparation and are largely undeveloped. Given that China does not impose fees for land idleness, some of these lands have been left idle for extended periods. The government manages these lands by covering them with green membranes to maintain the city's overall appearance. This situation is related to the different land development systems between the two cities.

3.2. Different regeneration paths in industrial zones

The regeneration pathways of these industrial areas differ significantly between Nanjing Economic and Technological Development Zone and the Porto Marghera in Venice. The regeneration of industrial land in Nanjing is led by the government, showing a stronger ability of land consolidation and overall planning. The government has played a key role in promoting brownfield regeneration, implementing many policies and initiatives to promote economic growth, environmental improvement and social cohesion. The renewal process often involves converting brownfield sites to new urban uses, such as residential, commercial and recreational areas. This is thanks to the government's ability to consolidate land and implement comprehensive planning strategies, ensuring that the regeneration process is coherent and sustainable. Another type of renewal includes the redevelopment of underutilized land, realizing the development concept of phased development by filling in undeveloped vacant land within the development zone.

Conversely, Venice's regeneration process is primarily market-oriented, offering greater flexibility but requiring stronger authority in executing significant projects. Market forces play a significant role in brownfield regeneration, with private investors and developers often driving the process. For instance, under the supervision of the Venice Development Agency, the Industrial Transformation and Redevelopment Initiative (PRRI) serves as a focal point, and the specific brownfield redevelopment process is mainly divided into three stages.

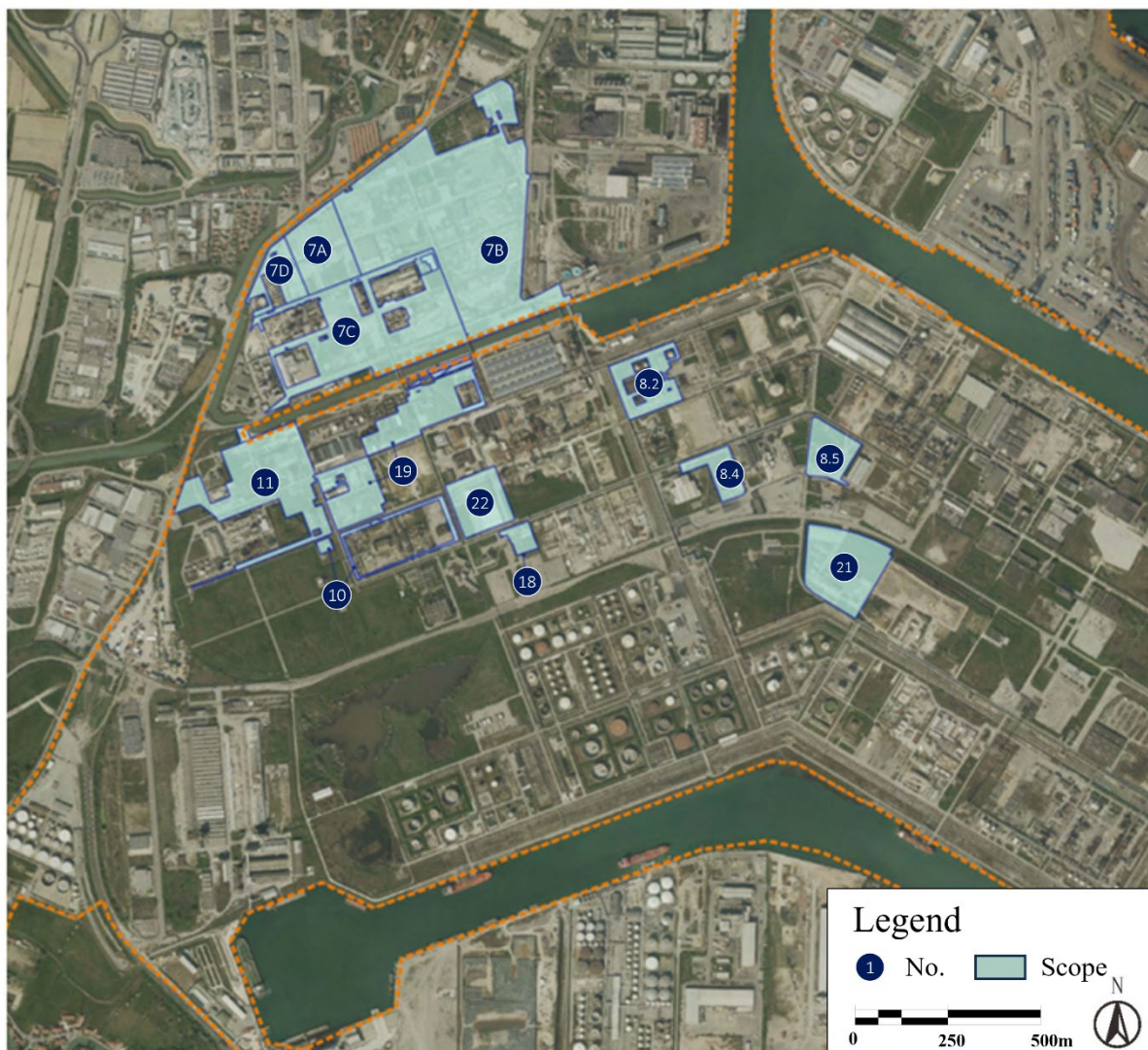


Figure 3 The information of the land parcels to be updated on the website of Venice Development Agency.
Source: <https://www.venicedevelopmentagency.org/it/home-asv>.

In the early stages of corporate decline, abandoned spaces are assigned temporary functions such as warehousing and logistics, providing partial logistics and service functions for the port to safeguard its core competitiveness in transportation; in the medium-term land idleness, professional third-party companies are introduced to coordinate and acquire abandoned and brownfield sites, handle property rights withdrawal, conduct environmental remediation and restoration, and build necessary infrastructure to meet the needs for reuse, determining the priority of development based on factors such as market value, environmental contamination, renovation costs, and planning restrictions; in the later stages of transformation, the Venice Development Agency introduces investment promotion and tax incentive policies to reintroduce brownfields into the market, with third-party companies providing cooperation and receiving dividends. The coordination among these three stages allows the renewal of vacant land in industrial zones to proceed in an orderly manner.

Despite these differences, both cities have formed relatively complete renewal processes and mechanisms in updating industrial areas, leveraging their respective institutional advantages to promote the

regeneration and transformation of urban industrial areas. At the same time, they face common challenges in the transformation and revitalization of industrial landscapes. These challenges include balancing economic growth with environmental sustainability, preserving urban memory and cultural heritage, and ensuring social cohesion and equity in the regeneration process.

4. Discussion

The contraction of industrial areas represents a transitional phenomenon arising from the mismatch between supply and demand during the shift from an extensive to an intensive development model. It is also a consequence of local governments guiding the optimization of spatial structures and industrial structures. On the one hand, the decline of enterprises and structural adjustments are outcomes of market selection. The continually released idle land resources provide new space for the future development of parks. The renewal and replacement of brownfields drive industrial upgrading within the parks, and the land within parks continuously undergoes replacement to realize the continuation of market value. On the other hand, appropriate government intervention and proactive adjustments have, to a certain extent, mitigated risks and promoted the healthy development of industrial areas.

The government-led renewal in Nanjing and the market-led renewal in Venice exemplify two of the most typical industrial area renewal pathways. However, in practice, neither government-led nor market-led approaches are absolute and often function synergistically. In 2017, the Marghera Industrial Area was recognized by the government as a region with complex industrial crises and benefited from specific national industrial policies, including financial support, infrastructure interventions, optimization of lending networks, worker reemployment, administrative procedure simplification, and environmental governance policies. Among these, over €26 million was allocated as investment incentives for certain heavy industries. These policy incentives also played a significant role in the market-led industrial area renewal of Porto Marghera.

Similarly, in Nanjing, policies guided the key transformation directions of different industrial areas, provided that policymakers conducted thorough market research and made decisions that maximized the benefits for all stakeholders in line with public interests. At the specific site level, the utilization of new industrial sites still followed a commercial bidding process, with the market determining specific actions. Therefore, both market regulation and government intervention are indispensable in the process of comprehensive industrial area renewal. Industrial areas are constantly evolving under the dual influence of market regulation and government intervention, achieving continuous renewal and development of urban industrial space.

These research results have some implications for urban planning under the background of urban industrial zone shrinkage. First, there is a need to develop more inclusive and adaptive planning to deal with the shrinkage of industrial space, in particular to balance multi-stakeholder relationships and maintain the sustainability of renewal projects. Second, government intervention is necessary to provide a coherent and sustainable framework for regeneration, but market forces should also be allowed to play their part in driving innovation and economic growth. Third, the preservation of cultural heritage and urban memory should be a key consideration in the regeneration process of industrial space. It is premised on recognising the historical and social value of brownfield sites and being able to contribute to the overall richness and diversity of the urban landscape.

Finally, although the industrial areas of the two places face different development environments and land system backgrounds, the paths and experiences in spatial shrinkage and regeneration have certain mutual

learning value. In particular, in dealing with industrial spatial contraction and urban memory inheritance, more universal and inclusive strategies and paths can be explored to provide references for industrial and spatial regeneration in other cities around the world.

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