How urban renewal in megacity influences jobs-housing spatial relationship of industrial park: A case study of Caohejing Development Zone

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Abstract

Taking Shanghai Caohejing Development Zone as a case study, this paper explores the influencing factors of jobs-housing spatial relationship of industrial park in megacity under the background of urban renewal, in order to provide some policy suggestions for planning response. Firstly, the evolution of jobs-housing spatial relationship is measured by mobile phone signaling data. Secondly, Internet map API and online data source are used to explore the influencing factors, in addition that Bivariate Local Moran I is used to verify the spatial correlation. It is found that the influence of urban renewal is formed by the combined effects of employment opportunities, housing opportunities and commuting time costs. The industrial transformation in the industrial park has created a large number of employment opportunities. If urban renewal fails to provide new housing opportunities nearby simultaneously, and rail transit expands the spatial range of acceptable commuting time cost, the jobs-housing spatial relationship will change drastically, with the residential enclaves connected by rail transit coming into being. Finally, two planning suggestions are proposed for the urban renewal of industrial park, including simultaneous housing opportunities and multiple railway lines, for reducing long-distance commuting needs and relieving railway pressure.

Keywords

Industrial Park, Urban Renewal, Jobs-housing Spatial Relationship, mobile phone signaling data, Caohejing

1. Introduction

As economic development has moved from a high-speed growth stage to a high-quality development stage, urban renewal has become an inevitable requirement in China^[1]. By reshaping space and resetting functions, urban renewal promotes the optimization of urban spatial structure. The renewal of old industrial areas is included, which has become more and more important in China in the past ten years. It's particularly popular in megacities, such as Beijing, Shanghai, and Guangzhou, for the development of urban industries and the improvement of city quality^[2-3]. The urban renewal of industrial parks located in the central urban areas of megacities generally takes place simultaneously with the industrial transformation and upgrading. As industrial transformation is the motivation and purpose, urban renewal is the result and the means. The industrial transformation process is generally manifested as a shift from traditional manufacturing to financial, scientific and technological innovation and other productive services^[4-5]. This change in employment structure will bring about the replacement of employees. This process has also occurred in the urban renewal of developed western cities such as London, resulting in a series of social problems^[6-7].

Back in China, taking Shanghai as an example, the "12th Five-Year Plan" to "14th Five-Year Plan" all outline the propose to accelerate the promotion of industrial transformation and upgrading, with modern service industry as the mainstay, strategic emerging industries as the lead, and technological innovation as the driving force. Driven by the industrial transformation policy, the urban renewal of the industrial parks in the central city has continued to advance. It has aroused the attention of the academic community. Existing studies have paid attention to the industrial policy ^[8], land system ^[9], and transformation mechanism ^[10]. However, these researches are all based on the economic perspective, focusing on the maximization of input and output benefits, while the spatial rationality of the updated functional layout has not been incorporated into the evaluation system ^[11].

Meanwhile it's found that the jobs-housing spatial relationship of some industrial parks has changed a lot, especially those which have undergone the urban renewal. Continuing to take Shanghai as an example, industrial parks in the central urban area such as Caohejing, Zhangjiang, and Jinqiao that have undergone or are undergoing industrial transformation and urban renewal, have all experienced abnormal jobs-housing separation ^[12]. Sampling surveys and cell phone signaling data calculations have found that compared with other areas in Shanghai's central urban area, the commuting distance of employees in these industrial parks has been abnormally increased, and there has been a significant jobs-housing mismatch ^[13-14]. At the same time, the commuter flow of railway lines across these central urban industrial parks has increased rapidly, a large-scale one-way tidal rail transit passenger flow coming into being ^[15].

These abnormal changes in the jobs-housing spatial relationship are related to the large-scale employment turnover in the urban renewal process. As urban renewal has become a requirement for high-quality urban development, it is necessary to conduct in-depth research on potential social issues such as the jobs-housing spatial relationship of the industry park, so as to avoid blindly emphasizing economic development and ignoring accumulated social contradictions in the process of urban renewal ^[16]. This paper takes Caohejing Development Zone in Shanghai as an example to explore the impact mechanism of the urban renewal on the evolution of the jobs-housing spatial relationship, in order to put forward some planning suggestions for the urban renewal of the industrial parks.

2. Research framework

2.1. Research case

Shanghai Caohejing Development Zone (hereinafter referred to as "Caohejing") was officially completed in 1988. It covers an area of 5.98 square kilometers and is located in the southwest of downtown Shanghai. Caohejing is one of the first 14 economic and technological development zones constructed in China. At the beginning, it developed manufacturing and processing industries such as electronic information and biomedicine. Starting from 2005, Caohejing began to accelerate the industrial transformation led by technological innovation. It vigorously developed high-value-added modern service industries such as technological services and financial services. As of 2019, the tertiary industry accounted for more than 86.31% of the regional GDP ^[17].

2011 is an important time node for both the industry transformation and the urban renewal in Caohejing. It's the first time that the tertiary industry surpassed the secondary industry in the regional GDP. Also, it's the beginning of large-scale functional replacement and spatial renovation. Old factories, old warehouses, and old buildings have been implemented one after another ^[18-19]. According to historical satellite image statistics, more than half of the construction land in Caohejing has been renewed, 70% of which took place after 2011.

2.2. Research methods

Mobile phone signaling data has been a common technical method to quantify the jobs-housing spatial relationship, and it has been widely used in the research of different scales ^{[12][20]}. Since mobile phone signaling data has only time and space information, socioeconomic statistics and other multi-source data are also collected for further analysis of the influencing factors. What's more, exploratory spatial analysis methods are used to explore the impact mechanism of urban renewal on the jobs-housing spatial relationship of industrial parks in central urban area of megacity at a macro level.

This research is divided into three steps. First, the industrial transformation and the employment turnover brought about by the urban renewal in Caohejing is illustrated by economic statistics and enterprises information, while the evolution of its jobs-housing spatial relationship is measured by mobile phone signaling data. Secondly, use Internet data to calculate the housing supply around the industrial park and the corresponding commuting time. In this way, it's possible to quantify the availability and affordability of housing, in addition to verify its impact on the evolution of the jobs-housing spatial relationship. Finally, through the discussion of job opportunities, housing opportunities and commuting time cost, the mechanism of the evolution of the jobs-housing spatial relationship can be illustrated under the background of urban renewal.

2.3. Data description

The mobile phone signaling data used in this study are China Mobile's signaling data from October 18 to 31, 2011 and China Unicom's signaling data for the entire month of November 2019. Both are anonymous data and do not include personal socioeconomic attributes. Based on the mobile phone user's mobile positioning trajectory, the cumulative time method is used to identify the user's residence and work place ^[21], located on a network of 1km*1km grid (hereinafter referred to as the "kilometer grid"). On this basis, commuting distance is calculated by the line distance of the grid center point. Because this research focuses on the evolution of the jobs-housing spatial relationship, commuters who work and live in the same grid are not taken into consideration. Due to different data sources, there is no need to compare the absolute number of people identified in the two years. The commuting distance and the spatial distribution are used to measure the evolution of the jobs-housing spatial relationship for Caohejing employees. Economic statistics come from the "Xuhui Yearbook" (2006-2020), including the region's GDP, the number of employees, the proportion of the secondary and tertiary industries, etc. The enterprises information comes from the Qichacha network platform, an online enterprise credit inquiry system, including the name, spatial location, registration time, industry category, etc.

3. Evolution of the jobs-housing spatial relationship

3.1. Increase and replacement of employees

According to economic statistics, at the end of 2005, the number of employees in Caohejing was 98,000, which increased to 263,000 at the end of 2019, with an increase of 168.4% in 14 years. The growth was the most dramatic in 2011, with a one-year increase of 35%.

According to the enterprise information, among the enterprises set up after 2005, the proportion of advanced manufacturing has dropped significantly, and the proportion of technological services and financial services has risen rapidly (Figure 1). Changes in the industry structure mean changes in the types of jobs, and the demand for high-tech talents is increasing day by day. In addition, the number of enterprises in Caohejing in 2005 was 947, of which only 527 have survived so far, and nearly half of the enterprises have been cleared. It shows that in the process of urban renewal in Caohejing, industrial

transformation has brought about a dramatic increase in the number of employees and a significant change in the employment structure. A large-scale employment turnover has already occurred.

Figure 1. Changes in the employment structure in Caohejing. Source: Author

3.2. Variation of commuting distance

Compared with 2011, the average and median of the employees' commuting distance have increased by 42% and 69% respectively. That's to say the jobs-housing spatial relationship has changed significantly, especially that a large number of long-distance commuters has led to the larger increase in the median.

Furthermore, compared with cross-grid commuters who both work and live in downtown Shanghai, the variation of commuting distance in the context of urban renewal can be shown clearly (Table 1). In 2011, the average and median commuting distance of employees working in Caohejing were both 1.5 times that of downtown Shanghai. In 2019, they were 1.8 times and 2 times respectively. This shows that the jobs-housing separation among Caohejing employees has strengthened significantly.

Table 1. Changes in commuting distance (measured by km). Source: Author

Year	Shanghai City		the central urban area*		Caohejing	
	average	median	average	median	average	median
2011	5.83	3.16	5.39	3.99	8.22	6.07
2019	8.28	5.82	6.47	5.09	11.65	10.28

*The central urban area means the space within the outer ring road of Shanghai.

3.3. Variation of residential distribution

Considering that the count of commuters identified in the two years is not comparable, cluster analysis is used to explore the variation of residential distribution instead of density maps. Use Anselin Local Moran's I statistics to identify statistically significant high-high cluster of the employees' residential distribution (hereinafter referred to as "residential HH cluster"), with the contiguity-based spatial weight matrix and the confidence of 99%. It can be seen that the residential HH cluster was around the industrial park in 2011 (Figure 2a), while there was a linear extension along Metro Line 9 toward the southwest of the industrial park and away from the city center in 2019 (Figure 2b). The newly added residential HH cluster is far away from Caohejing and is not continuous in spatial distribution. But it is basically located within 2 kilometers from Jiuting Station, Sijing Station and Sheshan Station, with a clear high-low

boundary on the periphery. It shows that the newly added residential HH cluster of Caohejing employees is highly correlated with the Metro Line 9.

Figure 2. Cluster Analysis of Distribution of Caohejing Employees' Residence.

Left: (a) Year 2011. Right: (b) Year 2019. Source: Author

From 2011 to 2019, Caohejing experienced a large-scale replacement of employees and drastic changes in the jobs-housing spatial relationship. On the one hand, the average commuting distance of employees has increased significantly. On the other hand, the residential distribution has evolved from simple "near-field matching" to the coexistence of "near-field matching" and "long-distance matching" in the form of enclaves connected by rail transit.

4. The influencing factors of the evolution of the jobs-housing spatial relationship

4.1. Commuting time

Considering that commuting time is a better indicator of commuting cost rather than commuting distance, explore the changes in the commuting time of Caohejing employees through online web service API. Taking the grid center where the employee resides as the starting point and the Metro Station Caohejing as the end point, and supposing that the employee goes to work at about 7:30a.m. by public transport, commuting time by rail transit (Figure 3a) and bus only (Figure 3b) are both calculated based on Baidu Map API. Compared with commuting by bus only, the reachable space of commuting by rail transit within the same time cost expands in multiple directions continuously.

Considering that 70 minutes one-way is close to the upper limit of acceptable commuting time in the central urban area of Shanghai, it's taken as a threshold for quantitative analysis. By overlapping commuting isochronous circle and the high-high cluster of Caohejing employees' residential distribution, it can be found that commuting by rail transit for 70 minutes can cover 88.5% of the residential HH cluster in 2019. In contrast, the reachable space of the same commuting isochronous circle without rail transit is greatly reduced. If you don't take the rail transit, you can only reach 5-6 kilometers away from the industry park in 70 minutes.

The results above show that although the residential enclaves far away from the industry park appear, as well as increasing commuting distance, the commuting time cost has not increased significantly. The calculation of the commuting isochronous circle based on the Internet map confirms the railway transit has greatly expanded the reachable space of 70 minutes, making long-distance commuting still within an

acceptable time range. Last but not least, it should be noted that the extended reachable space of commuting by rail transit shows continuous and multi-directional characteristics, which cannot explain the fact that the newly-added residential HH cluster obviously deviate from the city center and present the characteristics of "enclaves" in one direction .

Figure 3. Isochronous Circle of Commuting from Caohejing (overlapped with residential HH cluster)

Left: (a) with rail transit. Right: (b) without rail transit. Source: Author

4.2. Housing supply

The housing choices of new employees in industrial parks in the central urban area are also restricted by the location and price of available houses. Generally speaking, employees will choose to live nearby, for saving commuting cost. When the surrounding housing is insufficient or too expensive to cover, they have to find a house relatively far away.

Obtain the information of all available houses in Shanghai from the Fangtianxia website, an online real estate transaction network platform, and locate all the neighborhoods on the kilometer grid above. In this way, the count of neighborhoods in each grid can be calculated, as well as its completed year. Considering that 2005 is the beginning of the industrial transformation in Caohejing, new employees engaged in emerging productive service industry have a greater chance of obtaining the houses constructed after 2005. The proportion of newly built houses is used to characterize housing availability (Figure 4a), and the average housing price is used to characterize housing affordability (Figure 4b). Take all kilometer grids where Caohejing employees reside into consideration, and realize spatial visualization classified by Natural Breaks (Jenks).

Focus on the spatial range of commuting for 70-minute from Caohejing by rail transit, the proportions of newly built houses within and outside the outer ring road are 0.17 and 0.55, respectively, while the average housing prices are 77,000 yuan and 44,000 yuan. It shows that the housing availability in the central urban area is relatively low, and the housing affordability is relatively poor. Meanwhile, the housing availability in the direction away from the city center is gradually increasing, and the housing affordability is gradually optimized. In addition, the proportion of newly built houses within 5km of Caohejing is only 0.18, while the average housing price is 72,000 yuan. That's to say, there are some available new houses around Caohejing, but they keep few and expensive.

Figure 4. Housing supply (overlapped with 70-minute commuting range)

Left: (a) proportion of newly built houses. Right: (b) average housing price. Source: Author

Bivariate Local Moran's I is used to explore the correlation between the residential distribution of Caohejing employees and the housing supply in 2019, with the kilometer grid as the spatial unit and the 70-minute commuting range as the research scope. The spatial weight matrix is constructed based on Queen contiguity method. Taking the proportion of newly built houses and the average housing price as the first variable, and the count of commuters as the second variable, a statistically significant clustering result with a confidence of 99% is selected (Figure 5).

The grids that passed the significance test can be classified into three clusters, as well as two types. For one type, near-field cluster, the proportion of new housing and the count of commuters are mainly low-high correlation (Figure 5a), while the average housing price and the number of commuters all perform high-high correlation (Figure 5b). It reflects that a small number of high-priced houses will also become ideal options. Distance directly determines the jobs-housing spatial relationship around the industry park. For the other type, two sets of discontinuous long-distance clusters, the proportion of new housing and the count of commuters are mainly high-high correlation (Figure 5a), and the average housing price is low-highly correlated with the count of commuters (Figure 5b). It shows that over a certain spatial distance, within the acceptable commuting time, areas with more newly built houses and lower housing prices attract more employees to reside, leading to the long-distance residential "enclaves".

Figure 5. Correlation Between the Residential Distribution and Housing supply (Bivariate Local Moran's I)

Left: (a) proportion of newly built houses. Right: (b) average housing price. Source: Author

5. The evolutionary mechanism of the jobs-housing spatial relationship in the context of urban renewal

It is generally believed that job opportunities, housing opportunities, and commuting costs lead to personal choice of where to live and where to work, further influencing the urban spatial relationship of occupation and residence^[22-24]. Job opportunities are reflected in the location of the workplace and the type of employment. Housing opportunities are embodied in the available housing locations and housing prices. Commuting cost is directly reflected in commuting distance, which actually depends on commuting time. The transportation mode of commuting dominates the relationship between distance and time.

5.1. Industrial transformation affects employees' employment opportunities

The urban renewal and industrial transformation have brought about a significant change in the types of jobs in the industrial parks, leading to a large-scale employment turnover. Beginning in 2005 and accelerated from 2011, the urban renewal has not only changed the employment structure of Caohejing Development Zone from manufacturing to productive services, but also increased the count of employees by 1.7 times. For the newly-increased employees engaged in the productive service industry, their work location is fixed in the industrial park, and their residence location depends on housing opportunities and commuting time costs. As the employment turnover brought about by the urban renewal of the industrial park is inevitable, housing opportunities and commuting cost will ultimately determine the jobs-housing relationship.

5.2. Housing opportunities and commuting time cost jointly determine the changes in the jobs-housing spatial relationship

Next is to find out how housing opportunities and commuting time costs make effects. Firstly, the residential location of employees must be within an acceptable commuting time. Secondly, personal income level must be taken into consideration, whether buying or renting a house.

Nowadays, the construction has been saturated in the central urban area of Shanghai, which means the newly-built housing supply is the product of urban renewal. For the newly-increased employees brought about by the industrial transformation, the urban renewal around the industrial park provides new housing opportunities, which determines the possibility of choosing a residence nearby. The change in commuting time cost brought by rail transit determines the possibility of long-distance commuting. These two factors work together on the evolution of the jobs-housing spatial relationship, and the mechanism is shown in Figure 6.

Figure 6. The evolutionary mechanism of the jobs-housing spatial relationship in the context of urban renewal.
Source: Author

In fact, there has been no significant increase in housing supply during the renewal of the Caohejing Development Zone and its surroundings. Meanwhile, Metro Line 9, which opened in 2007, basically in sync with the start of the large-scale renewal of Caohejing, extends the reach of 70-minute commuting time. Within this range, there have been lots of houses built around Metro Station Sijing and Jiuting in the past ten years, providing a large number of housing opportunities, in addition that the housing prices and rents are affordable. Due to the housing opportunities and commuting costs, new employees choose their residence far away from the industry park, leading to the jobs-housing relationship of "long-distance matching" in the form of residential enclaves connected by rail transit (Figure 2b). For these employees, the commuting distance is lengthened, but the commuting time is still acceptable.

For industrial parks in central urban areas of mega cities, the housing opportunities brought about by urban renewal directly affect the choice of residence. If it fails to provide housing opportunities in the near area, where the Caohejing employees can reach in 70 minutes by bus only, the rail transit plays an important role in the evolution of the jobs-housing relationship. It helps reduce commuting cost by saving commuting time, so that long-distance commuting is acceptable. However, there is only one rail transit line across Caohejing for a long time during the renewal process. Although it has eased commuting burden, it can't be neglected that there has been a sharp increase in the passenger flow of Metro Line 9, resulting in the overload during morning and evening peak hours.

5.3. Suggestions on planning strategies for urban renewal of industrial parks

On the basis of clarifying the mechanism of the evolution of the jobs-housing relationship in the context of urban renewal, two suggestions can be drawn for the urban renewal planning of the industrial parks in the central urban area of the megacity.

First, the urban renewal of industrial parks should not only focus on industrial transformation, but also provide new housing opportunities within and around the park. Sufficient and simultaneous houses must be built in the surrounding area, where can be reached within the reasonable commuting time of 45-60 minutes. That's to say, the surrounding area should be taken into synchronous planning during the renewal of the industry park. Within this scope, urban functions shall be uniformly arranged, and various types of land use and building capacity shall be coordinated.

Second, rail transit must be taken into consideration in the urban renewal of industrial parks. In the case that the urban renewal in the surrounding area cannot provide enough new housing opportunities

simultaneously, rail transit can expand the reachable space of a reasonable commuting time cost, providing more housing opportunities in a larger area. What's more, if there are multiple railway lines across the industrial park, the pressure of rail transit during peak periods will be reduced. Particular attention should be paid to industrial parks that are not supported by rail transit. In this situation, simultaneous and affordable housing opportunities must be provided in and around the park during the process of urban renewal.

6. Conclusion

6.1. Conclusion

Taking Shanghai's Caohejing Development Zone as a case, a quantitative study was carried out on the evolution of jobs-housing spatial relationship from 2011 to 2019 and the impact of urban renewal in and around the industry park, leading to the following three conclusions.

First, urban renewal affects the jobs-housing spatial relationship of the industrial parks from two aspects. On the one hand, the urban renewal of industrial parks is bound to be accompanied by industrial transformation and upgrading. Industrial transformation leads to a large-scale replacement of employees, affecting the job opportunities. On the other hand, whether the industrial park and surrounding areas can provide new house during the urban renewal affects the housing opportunities, which is reflected in the new employees' choice of the residential location.

Second, in the context of urban renewal, the evolution of the jobs-housing spatial relationship of industrial parks is determined by the combined effects of job opportunities, housing opportunities, and commuting time costs. The job opportunities brought about by the industrial transformation make new employees work in the industrial park. Housing opportunities and commuting time will determine the location of individual residence. If urban renewal fails to provide new housing opportunities in the surrounding area simultaneously, in addition that rail transit expands the reachable space of acceptable commuting time, the jobs-housing spatial relationship will evolve into an "enclave" form of "long-distance matching" relied on rail transit.

Third, it is necessary to alleviate the changes in the jobs-housing spatial relationship of the industrial park caused by urban renewal. On the one hand, urban renewal planning must consider providing simultaneous and affordable housing opportunities in and around the park. On the other hand, attention must be paid to the rail transit, especially multiple lines across the industry park, which can alleviate the impact caused by the urban renewal.

6.2. Research outlook

This article explains the evolution and mechanism of the jobs-housing spatial relationship of the industrial park in the central urban area of a megacity from the perspective of job opportunities, housing opportunities, and commuting time costs. At the individual level, new employees also have differences in occupation, position, and income. Different people have different preference for housing opportunities and commuting time cost. Studies have found that differences in individual social attributes can lead to different residential choices of employees in the same work place ^[25]. Since the Caohejing case uses anonymous basic data, it is impossible to know the social attributes of the employees, nor can it further understand the social differentiation in the jobs-housing relationship. This aspect worth further study.

This article has explained that changes in the employment structure during the urban renewal of the industrial parks in the central urban areas of megacities have brought about large-scale employment turnover, which has led to an intensified situation of jobs-housing separation. It's worthy of further attention whether it will lead to other changes in the surrounding social structure, and consequently

other social issues. For the urban renewal of industrial parks, in addition to issues such as industrial, institutional, and spatial changes, it is also necessary to pay attention to social issues brought about by the replacement of employees.

7. References

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