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Jobs-Housing Spatial Distribution and Commuting Efficiency in Megacities: A Case Study on Shanghai

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Abstract: Theoretically, the adjustment of jobs-housing land use planning in cities can improve commuting efficiency, but to what extent such ideal planning can be converted into a practical benefit is often complicated and unknown. Based on existing literature and theories, this paper analyzes the limitation of jobs-housing balance and the multiple factors that affect actual commuting efficiency. Taking Shanghai as an example, the paper uses housing prices, economic census, and other socio-demographic data to estimate the coefficient of geographical association and Gini coefficient. The potential factors that cause excess commuting in Shanghai, including the resident-enterprise behavior choices, the objective laws of economic development, the complexity of market effect, and the level of jobs-housing matching are discussed. Finally, the paper proposes rational public transportation-oriented development, targeted transportation subsidies, and promotion of employment information symmetry.
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Keywords: jobs-housing spatial distribution; jobs-housing balance; commuting efficiency; coefficient of geographic association; Gini coefficient; Shanghai

0 Introduction

Megacities in China have experienced rapid and enormous urbanization in the past decades, accompanied by interactions among urban land expansion, booming population, changing socio-economic structures, economic growth, and industrial transformation. These substantial changes have intensified the profound and complex evolvement of jobs-housing spatial distribution, which is mixed with a range of urban problems such as traffic congestion and overlong commuting.

In this regard, researchers and professional planners have been working on multi-dimensional theories and models to promote planning policies and practices, with growing attention on jobs-housing balance and excess commuting. Meanwhile, in order to improve commuting efficiency, planning practices also support the jobs-housing pattern in terms of improving access distance between employees' residences and employers' workplaces. However, from a planning perspective, to what extent an ideal approach can result in realistic benefits will be affected by a wide range of factors, including behaviors and choices of residents and employers, the complexity of market functions, and changing social structures. The deviation between the ideal case and reality could be particularly remarkable in megacities of China, which have a substantially complex environment. Therefore, it is of great significance to assess the current urban jobs-housing distribution and clarify various factors influencing urban commuting efficiency.

This study focuses on the effectiveness of jobs-housing balance based on related theories and discusses different factors that affect commuting efficiency. In addition, with empirical research on jobs-housing distribution in Shanghai, the study demonstrates how various factors may influence commuting within the city and proposes potential strategies.

1 Limitation of existing theories and applications

1.1 Limitation in the application of commuting indicators

Various indicators are used in current planning research and practices to measure commuting efficiency while applying a single indicator to guide policy development usually has limited effectiveness. According to the 88 evaluation indicators in the national territory spatial planning implemented by the

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Ministry of Natural Resources of China, the proportion of residents within 45-minute commuting time and the average weekday commuting time are used as indicators to assess commuting efficiency. However, such indicators depend on specific city scales, which are difficult to be used for comparison among cities. The ratio of the number of jobs to the number of households is used as the commuting indicator within the 97 evaluation and monitoring indicators for the Shanghai Master Plan (2017–2035); this indicator is dependent on the scale of its own definition and therefore further research on how to define the study range is needed.

The theory of excess commuting, in contrast, establishes a more comprehensive and flexible measurement framework, which includes four basic indicators: actual average commuting distance (T_{act}), theoretical minimum commuting distance (T_{min}), theoretical maximum commuting distance (T_{max}), and random average commuting distance (T_{rand}). A series of additional indicators are developed, such as excess commuting rate (C_{ex}), normalized commuting saving (C_{Ne}), commuting capacity used (C_u), and Effort index [1]. Nonetheless, limitations still exist when a single indicator is applied, given different city scales, changes over time, the ability of policy analysis, and calculation difficulties. Thus, selection and use of multiple indicators become critical to measure commuting efficiency, promote quantitative studies to guide the planning of jobs-housing distribution, and ensure jobs-housing balance in planning practice.

1.2 Limitation in performance of the jobs-housing balance

Many researchers in the field of urban economy and public policy believe that unbalanced jobs-housing spatial distribution could be defined as the primary factor influencing commuting efficiency. Accordingly, adjusting and optimizing the jobs-housing distribution to reach a balance serve as an effective approach to reduce commuting time and distance. Focusing only on the physical distribution of jobs and housing without considering their correlation in quality and living preferences of residents, most residents could theoretically reach at least one job nearby. However, the actual commuting, namely, the necessary transportation due to jobs-housing isolation, is always longer than the theoretically planned commuting. In other words, the match of jobs-housing distribution in quantity has only some or even little impact on commuting.

Reference [2] explored the jobs-housing distribution pattern in the Los Angeles region in the United States in 1980, which suggested that the theoretically required commuting time and distance were far less than what actually happened. Such a significant gap indicates that some factors other than jobs-housing balance exert a great impact on commuting efficiency. For example, people would prefer a location with future potential job opportunities instead of considering the effect of the current situation, racial issue, or residents' preference for specific housing and neighborhood environment on their choice of residential communities.

1.3 Stability of commuting time

The development of transportation technology has improved the flexibility and changeability of jobs-housing distribution. Although commuting distance has generally increased, the actual average commuting time remains relatively stable, given that transportation technologies improve mobility and the residents and employers also adjust their locations correspondingly. Reference [3] presented a comparison of household travel data between 1968 and 1988 for the Washington metropolitan region in the United States, which suggested that the work-to-home time appeared consistent or even decreased despite the increased average commuting distance within the 20-year period. As rational locators, residents and employers would control the commuting time within an ideal range by increasing average trip speed or mutually co-locating jobs and housing to ensure reasonable life quality and working efficiency. Such a phenomenon is especially obvious under a multi-center urban spatial structure. Thus, subjective initiatives and improvement of mobility make it difficult to break the stability of commuting time solely by adjusting the jobs-housing spatial pattern.

2 Other factors influencing commuting (efficiency)

2.1 Common laws of economic and social development

The common laws of economic development and changes in social household structures have an important impact on commuting time and distance. As land scarcity is associated with economic benefits, job opportunities generally concentrate in central city areas. At the same time, high housing price in the center region has pushed a large proportion of residents to suburban areas, resulting in the isolation of jobs and housing as well as long commuting distance. High-paying job opportunities have also attracted more long-commuting residents. In this study housing price and per-capita output value of enterprises (as an alternative because detailed income data are not available) are used for analysis. In addition, dual-earner households have gradually dominated the modern society. Reference [4] suggested that women's increased labor force participation would affect household commuting efficiency. Since it is difficult to meet the commuting needs of both commuters in a family, living close to one commuter's job usually means a longer commute for the other commuter. As a result, jobs-housing balance and distribution reflect a large extent of collective decisions or mutual compromise among household members.

2.2 Traditional social-economic unit: Danwei

As the economic unit constructed during the planned economy period, "Danwei" served as a socialist working

place where economic activities and daily social life were integrated within the same local area. Reference [5] concluded that commuters living in Danwei had shorter commuting time and distance as well as less automobile use than those living in commercial residence. Such an organizational pattern led to unique characteristics of jobs-housing spatial relationships in cities of China. However, after China's reforms and opening up, diminishing Danwei and significantly increasing market-oriented residence have brought enormous changes to commuting and jobs-housing patterns.

2.3 Contradiction between planning ideals and market function

Decision-makers in the government ideally plan to build a jobs-housing balance to improve commuting efficiencies; however, it's usually hard to achieve such balancing in the real world due to the impact of market functions. Reference [6] presented a study on Suzhou Industrial Park (SIP) and concluded that the park achieved a balance of jobs and housing at the planning level, while actually most local workers of the park lived outside of or even far away from the park. The study further explained that solely depending on park construction had little control on market, as real estate developers preferred to provide more profitable high-end housing that most park workers failed to afford. At the same time, oversupply of industrial land occupied the space for public facilities and amenities, reducing the quality of life within the park. All of these factors pushed local workers from the local housing market to a larger regional market. Under the influence of the market, enterprises' natural pursuit of maximizing profits could impede the implementation of jobs-housing balance; individual employees would also choose more affordable housing that meets their expects for quality of life within the regional market.

3 Jobs-housing distribution and commuting efficiency in Shanghai

3.1 Analysis of minimum commuting

Reference [7] applied big data to study jobs-housing balance in Shanghai based on the comparison of mobile phone location data and travel survey data. The results showed that the theoretical minimum average commuting ($T_{\min}$) was 3.2 km, while the actual average commuting (T_{act}) was 8.2 km, which was 2.6 times or 5 km longer. When the range was reduced to a zone with a 6 km radius, the difference between $T_{\min}$ and T_{act} became more significant. That is to say, a large number of residents in Shanghai did not choose jobs within their minimum commuting range; such excess commuting could be a result of unbalanced jobs-housing distribution due to housing prices or industrial locations. Therefore, this article attempts to explore internal factors affecting jobs and housing balancing based on characteristics of spatial patterns in Shanghai and propose optimal strategies.

3.2 Proactive adjustment on commuting time

With the changing industrial spatial structure, urban development, and residents' pursuit of a higher quality of life, individual choice of housing is affected by various factors in addition to commuting time. Reference [8] examined how relocation affected commuting costs and indicated that 66% of households chose their current residential locations while the remaining 34% were forced to relocate. More than one-third of households said that they had moved to improve their living environment. In addition, the commuting time of households that were forced to relocate had increased significantly, much higher than the change in commuting time of households that freely chose their new residence. Accordingly, residents follow the rationale to adjust their working-living locations to maintain commuting time within a certain interval based on their individual needs of life quality in addition to jobs-housing spatial distributions.

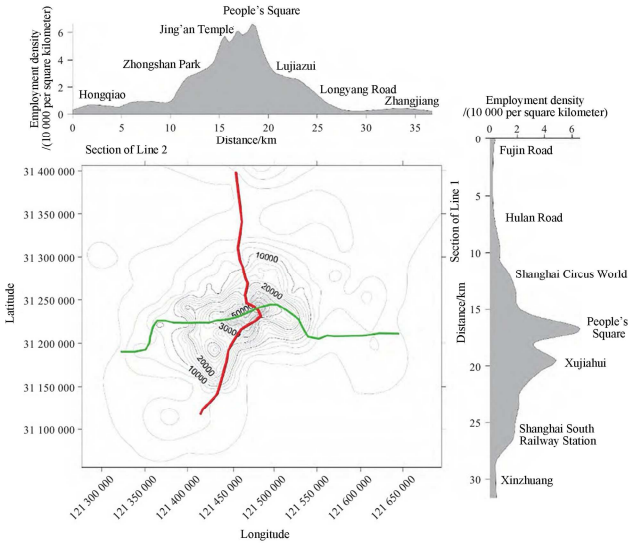


Fig. 1 Employment density along Subway Line 1 and Line 2 in Shanghai

Sources: Literature [10]

3.3 Employment agglomeration and high housing price

Job opportunities are highly agglomerated within the central city areas. According to the fourth economic census data of Shanghai[9], the enterprises in the central city (within the outer ring) accounted for 59% of all enterprises and had 58% of all employees in the city. Figure 1 shows density of employment along Line 1 and Line 2 of Shanghai Metro. The two Metro lines serve as main commuting venues in Shanghai, running through downtown Shanghai in both north-south and east-west directions, as well as intersecting at the People's Square Station in the city center. The employment density peaks at the People's Square Station and gradually

decreases along the Metro lines to the periphery of the city. Figure 2 presents a three-dimensional contour map showing concentrated employment density in the area of People's Square, Jing'an Temple, Xujiahui District, and Lujiazui Financial District in Shanghai. Obviously, the number of enterprises and job opportunities within the central city is considerably higher than that in the surrounding areas. With booming economic activities, the central city shows a significant job agglomeration effect.

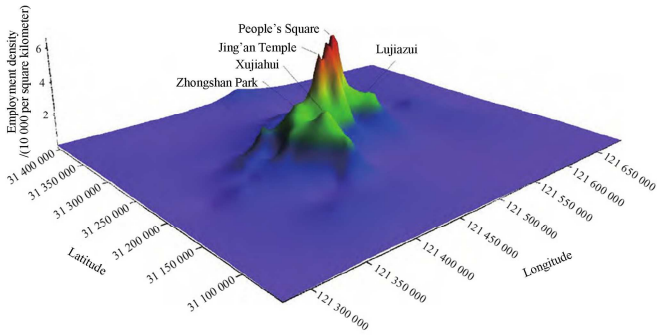


Fig. 2 3D diagram of the employment density in Shanghai

Sources: Literature [10].

Reference [11] applied mobile phone location data for jobs-housing analysis in Shanghai and the results suggested an internal employment rate (the proportion of the population living and working in the same area) of 90% in the central city, while the internal residence rate (the proportion of central city residents working in the area) was 86% and slightly lower than the internal employment rate. That is to say, most residents in the central city acquire jobs nearby, but job opportunities in the area remain attractive for residents from surrounding and farther areas. Meanwhile, 44% of employees working within the inner ring live between the inner and outer rings; in contrast, 9% of employees working within the inner ring and 14% of employees between the inner and outer rings live in farther surrounding areas. Reference [7] demonstrated that most commuters in Shanghai lived and worked within the inner ring area and therefore experienced the shortest commuting distance and the highest ratio of jobs-housing balance. Due to factors such as high housing price within the inner ring, some employees working in this area had no options but to live in the relatively outer areas, who usually bear the longest commuting distance and time.

Based on current research, this study demonstrates that housing price in Shanghai is generally high within the central city and decreases from the central areas to the outer areas (Figure 3). Meanwhile, according to mobile location data and travel survey data of Shanghai, residents between the inner and outer rings have longer commuting time than those living either within the inner ring or in the outer areas. Relatively, employees within the inner ring undertake the longest commuting time (Figure 4). Thus, people who work within the inner ring and live between the inner and outer rings might be the main group experiencing excess commuting. In other words, due to the agglomeration effect of employment within the inner ring, such groups holding job positions in the area cannot afford the high housing price and therefore have to live in the relatively outer areas.

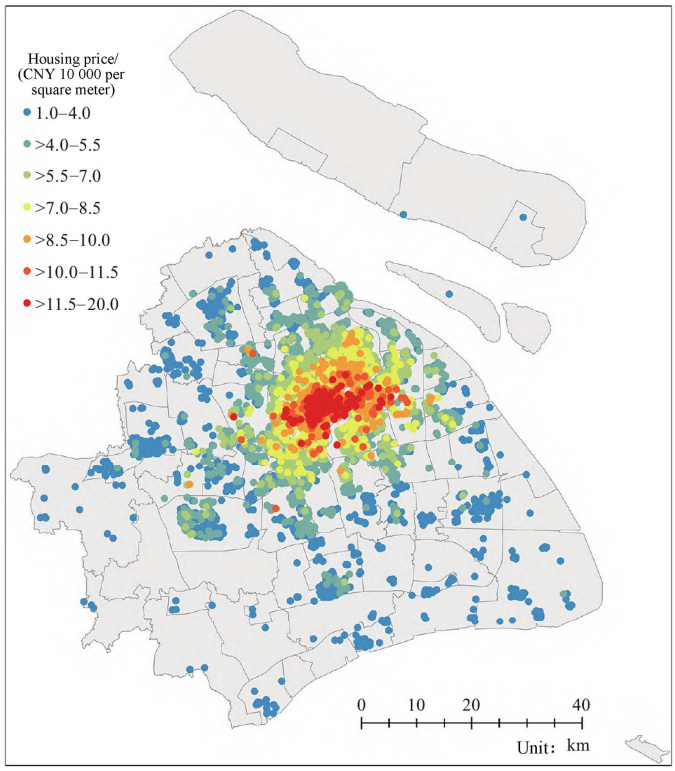
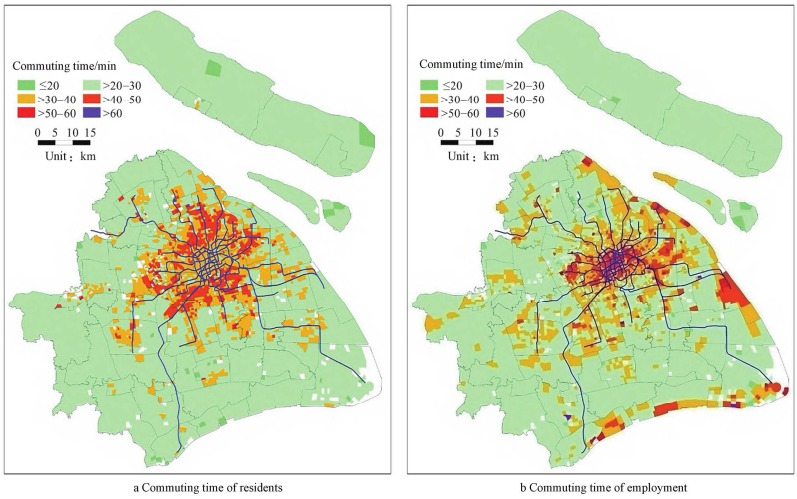


Fig. 3 Distribution of housing prices in Shanghai

3.4 Evolution of public housing communities

Many public housing units built during the planned economic period, usually called "Danwei Community," have become an important urban community type in Shanghai. Most of these public housing communities were built during the 1970s and 1980s and named with "XX New Village," such as Yangpu New Village, Quyang New Village, and Tianlin New Village. Reference [12] depicted the development of suburban industrial zones between the inner and outer rings in Shanghai in the 1960s, followed by a substantial shortage of urban housing during the 1980s when the government planned and constructed a large number of Danwei communities by expanding the industrial zones to address housing problems for employees. Currently, the Danwei communities in Pudong of Shanghai largely locate along Pudong Avenue and Pudong South Road, while those communities in Puxi of Shanghai are mostly distributed along both sides of the inner ring, forming a contiguous semi-annular shape. Most residents of such communities are employees of state-owned enterprises and institutions; public facilities and amenities are typically sufficient in these communities. The work-life social circle of residents is basically within the communities with a strong geographical connection, which substantially reduces travel demand and commuting cost.



a Commuting time of residents　　b Commuting time of employment

Fig. 4　Residents' commuting time to employment

Since the reform and opening up in China, with the transformation of old public housing communities, relocation of industrial zones, massive increase in commercial housing, and changing groups of residents within the communities, the commuting "dividend" in terms of jobs-housing balance within the Danwei communities gradually diminished. Most of the original residents in Danwei communities retired and their children, as new living groups, likely choose to work in other areas of the city. At the same time, as the privatization of the previously public-owned properties, enormous Danwei housing was sold or rented out. These Danwei housing became attractive for the emerging urban immigrants due to the relatively affordable price and superior geographical locations reaching the central city. Over the years, the residential function of Danwei communities has remained strong, while the original "dividend" of employment within the communities gradually disappeared with an increased commuting cost.

3.5　Unformed jobs-housing areas or corridors under the planning ideal

Reference [11] examined the significant unbalance of commuting venues between the inner and outer rings in the central city as well as from the northern area to the inner ring of Puxi in Shanghai, which led to single-direction congestion along the metro line during morning rush hours. Due to the lack of job positions in the northern areas, a large number of residents from northern areas massively commuting to the inner ring of Shanghai and contribute to tidal traffic. Similar problems also exist in the development of new towns in Shanghai's suburban area.

In recent years, Shanghai has implemented a series of planning policies for the periphery areas and new towns to construct jobs-housing balanced communities and to encourage employment and residency outside the central area. For example, Shanghai Anting International Automobile City, located in the west of Shanghai, is serving as the development base for the automobile industry and a livable new town. In addition to sufficient job opportunities, a large area of residential land and supporting public facilities have been planned for ensuring jobs-housing balance in this new area. The core planning region includes a residential area of 1 846 200 square meters, accounting for 36% of the overall construction area [13]. However, after examining the actual commuting efficiency of Anting International Automobile City, we found that the planned ideal high-density district with jobs-housing balance had not been formed. Figure 5 shows major commuting corridors from various areas of Shanghai to the Automobile City; it presents an obvious pattern that employment concentrates within the Automobile City, whereas residence scatters around the Shanghai city.

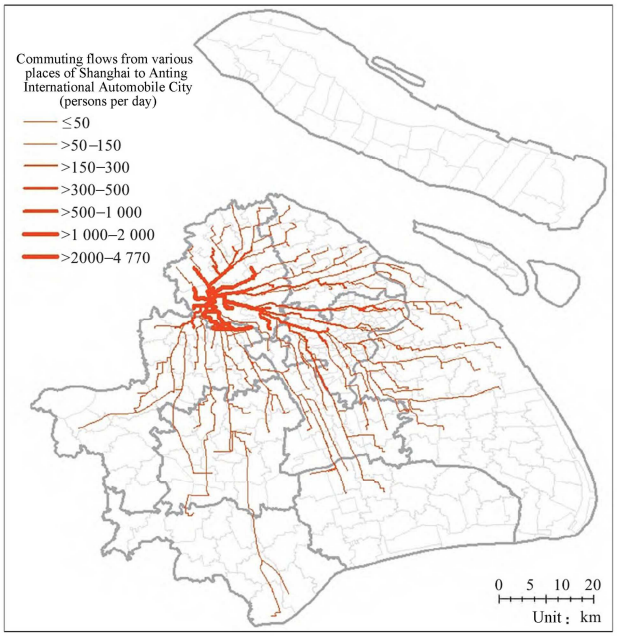


Fig. 5　Key commuting corridors in Shanghai Anting International Automobile City

Sources: Literature [14].

Construction of new towns on the periphery of Shanghai has greatly promoted suburbanization of manufactures and population migration. Nonetheless, due to the market force and other practical factors, relocation of population has not coordinately progressed with the decentralization of employment and other urban functions. Reference [15] launched an empirical study and suggested that a number of employees did move to the suburban new towns as manufacturing industries were relocated there. However, the new towns have insufficient development of tertiary industry and most high-end jobs and high-quality services are still in the central city; therefore, employees of tertiary industries living in the suburbs have to take long commuting. Meanwhile, real estate projects in some suburban new towns are relatively simple in offering options. Developers prefer low-density and large-unit residential development for larger profits; as a result, there are insufficient small-unit and high-rise communities that would better fit and attract young employees.

4 Jobs-housing quality match and optimization

4.1 Quality match of jobs-housing distribution

In this study, data of housing prices, operating income of enterprises, employment and residential population, as well as the corresponding geographic locations, are used for quantitative analysis of quality match of jobs-housing distribution in Shanghai. The coefficient of geographic association (GAC) is used to examine the relationship between factors P and S in geographical distribution. Larger GAC reflects a closer geographical association with more balanced distribution between the two factors [16]. The formula of GAC is

$$GAC = 100 - \frac{1}{2}\sum_{i=1}^{n}|P_i - S_i|. \quad (1)$$

GAC is used in this study to measure the geographical association between jobs and housing. The specific meaning of parameters in the formula is explained later.

The Gini coefficient is selected to measure the equality of distribution. As shown in Figure 6, the population is divided into four groups–a, b, c, and d–based on their income; the area between the Lorenz Curve, which reflects the actual income-population distribution, and the line of absolute equality, which reflects the ideal perfect income-population distribution, is defined as A; the area enclosed by the Lorenz Curve, the x-axis and the y-axis is defined as B. The Gini coefficient is the ratio of A to $A+B$. A small Gini coefficient represents better equality of distribution [17]. The formula of the Gini coefficient is

$$Gini = \frac{A}{A+B}. \quad (2)$$

Figure 6 shows the income distribution under different percentiles of the population, reflecting the equality of wealth distribution. In this study, the Gini coefficient is used to examine the equality of jobs and housing distribution; the calculation of the Gini coefficient and different meanings of the coordinate axis and indicators are discussed in the following.

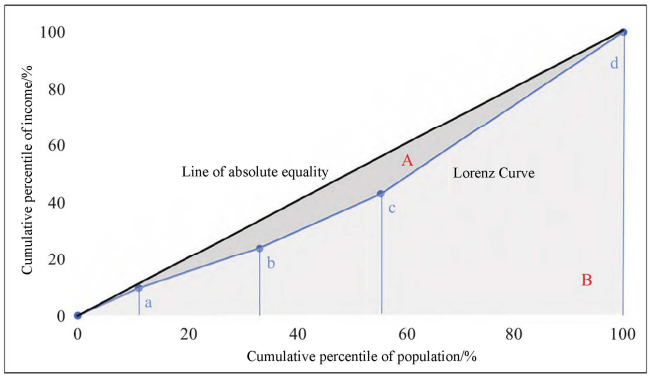


Fig. 6 Calculation of Gini coefficient

The study divides the city into 75 regions according to the spatial layout planning of Shanghai. The first analysis focuses on quantity match of jobs and housing within each region. Here P_i of GAC is the ratio of employment in each region to that of the whole city; S_i is the ratio of residential population in each region to that of the whole city. As for the measurement of Gini coefficient 1, the y-axis represents the cumulative percentile of employment and the x-axis is the cumulative percentile of residential population corresponding to employment ranked from the lowest to the highest (Table 1). The results suggest that the GAC of employment and residents is 85.64 with a Gini coefficient of 0.11, which presents a relatively balanced distribution and closed jobs-housing spatial association.

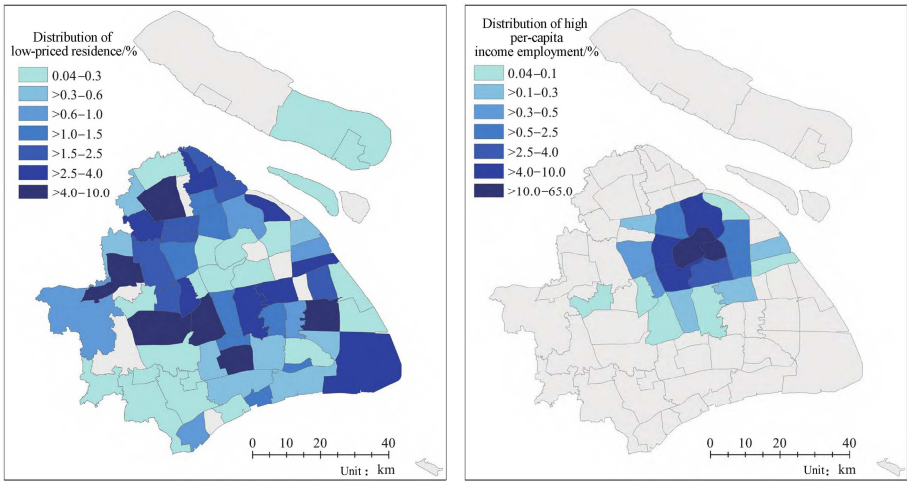
In order to further explore whether the employment matches well with residents in quality, we classify housing price and per-capita income into four quartiles (low, medium-low, medium-high, and high) in this analysis of the jobs-housing match. Here P_i of GAC is the ratio of employee's per-capita income in each region to the same metric in the whole city; S_i represents the ratio of average housing price in each region to the average housing price of the city. As for the Gini coefficients from 2 to 5, the y-axis represents the cumulative percentile of residential housing quantity for high or low housing price; the x-axis is the cumulative percentile of employee's per-capita income according to ranked residential housing quantity with low or high housing price. Theoretically, the quantity of residential housing with high housing price would match the quantity of high per-capita income employment in spatial distribution; in contrast, the quantity of residential housing with low housing price would match the quantity of low per-capita income employment in spatial distribution.

In terms of spatial distribution, high-priced residential housing is mainly concentrated in the central city, while most low-priced housing locates in the outer areas and there is limited housing in the outskirts (Figure 7). Although the

overall job density is high in the central city, the agglomeration effect of high per-capita income employment is significant; locations of low per-capita income employment are relatively scattered (Figure 8).

Tab. 1 Summary of Gini coefficient

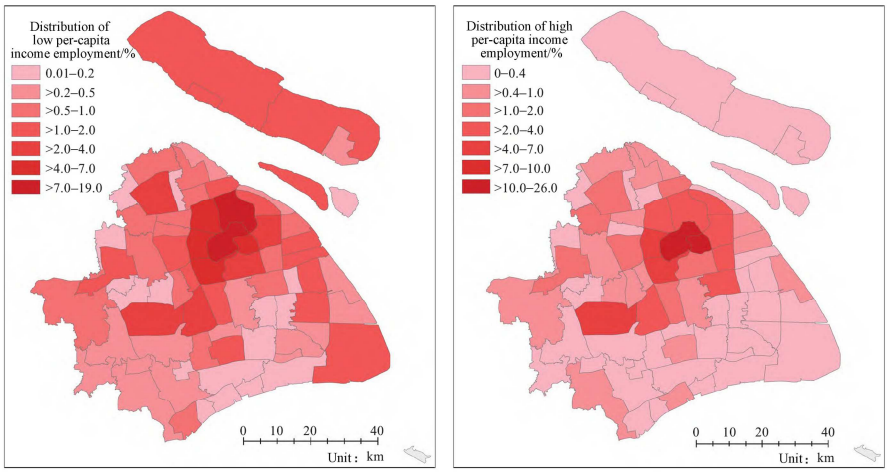
Category	*x*-axis	*y*-axis	GAC	Gini coefficient	Remarks
Gini coefficient 1	Cumulative percentile of residents according to ordinal employment ranked from the lowest to the highest	Cumulative percentile of employment	85.64	0.11	Quantity of employment–number of residents
Gini coefficient 2	Cumulative percentile of the quantity of high per-capita income employment according to the quantity of residence with low housing price ranked from the lowest to the highest	Cumulative percentile of residences with a low housing price	41.48	0.60	Low-priced residence–high per-capita income employment
Gini coefficient 3	Cumulative percentile of the quantity of low per-capita income employment according to the quantity of residence with low housing price ranked from the lowest to the highest	Cumulative percentile of residences with a low housing price	40.78	0.61	Low-priced residence–low per-capita income employment
Gini coefficient 4	Cumulative percentile of the quantity of high per-capita income employment according to the quantity of residence with high housing price ranked from the lowest to the highest	Cumulative percentile of residences with a high housing price	68.32	0.38	High-priced residence–high per-capita income employment
Gini coefficient 5	Cumulative percentile of the quantity of low per-capita income employment according to the quantity of residence with high housing price ranked from the lowest to the highest	Cumulative percentile of residences with a high housing price	62.26	0.47	High-priced residence–low per-capita income employment



a Distribution of low per-capita income employment

b Distribution of high-priced residence

Fig. 7 Distribution of low-priced housing and high-priced housing in Shanghai



a Distribution of low per-capita income employment

b Distribution of high per-capita income employment

Fig. 8 Distribution of employment with low and high per capita output values in Shanghai

The result shows that GAC of the low-priced residence and high per-capita income employment is 41.48 and the Gini coefficient 2 is 0.60; GAC of low-priced residence and low per-capita income employment is 40.78 and Gini coefficient 3 is 0.61; GAC of high-priced residence and high per-capita income employment is 62.26 and Gini coefficient 4 is 0.47; GAC of high-priced residence and low per-capita income employment is 62.26 and Gini coefficient 5 is 0.47. Accordingly, regions with high-priced residence have a greater agglomeration effect on both high and low per-capita income employment, which indicates a closer geographical correlation and more balanced jobs-housing distribution. In contrast, low-priced residence attracts neither high nor low per-capita income employment, presenting a poor geographical correlation; residents in low-priced residence have to undertake longer commuting distance. Residents in high-priced residences could be matched with high per-capita income employment nearby. However, a large number of employees of low per-capita income employment could hardly afford high housing prices within the regions; as a result, they have to live in other regions with lower housing prices and become long-distance commuters. Therefore, the jobs-housing distribution in Shanghai has not been balanced well in quality, as residents' housing affordability and their employment suggest a mismatch to some extent.

4.2 Analysis of actual travel and optimized travel

Jobs-housing spatial mismatch is largely a result of market choice, so the macro-level planning and targeted administrative intervention by the government are significant to promote the optimization of overall commuting efficiency. Reference [18] concluded that when the overall commuting pattern reaches "Pareto Optimality" (namely that excess commuting is zero as no workers could unilaterally change their residence or work locations to reduce commuting costs), compensation needs to be given to commuters whose commuting distance is longer than the average. In this regard, government decision-makers and planners need to locate such groups in their regions and provide specific policies: 1) Information technologies are used to offer certain public transit discounts or subsidies to long-distance commuters and commuters living in the lower-priced residence; 2) the development of transportation infrastructure is improved in regions where such groups are major residents, such as accelerating infrastructure deployment and network construction between the inner and outer rings as well as in the outskirts; 3) diversified job and residential opportunities are developed along the transportation corridors, including increased industrial development and employment in the northern area of the central city and along the metro lines; and 4) employment information is provided openly to residents to promote jobs-housing balance. In addition, the government should encourage the formation of clusters and improve linkage among various functional zones. The jobs-housing balance should be implemented in planning practice for new towns on the periphery of the city to form integrated employment-residence regions, where diversified employment and residence options with various prices, quality, and industry features are offered.

In addition, a reasonable transit-oriented development (TOD) pattern could effectively improve the overall urban travel and commuting efficiency. The "Finger Plan" of Copenhagen in 1947 established an urban layout with the city as an employment center and new towns developed along the railway lines as scattered residential communities. Reference [19] demonstrated that starting from the finger plan to the following Ørestad City development, the commuting problems and traffic issues within the city have been considerably reduced and a great jobs-housing balance has been achieved. Nonetheless, Reference [20] discussed that the development of public transportation in Shanghai should be practically planned in accordance with the actual need of the city. It would be inappropriate to simply increase the market share of public transportation. For instance, the well-developed rail transit network in Tokyo is a driving force behind the isolation of jobs and housing within the city. The average commuting distance of Shanghai is three kilometers shorter than that of Tokyo and the jobs-housing distribution of new town development in Shanghai is relatively independent. Thus, a strong support on non-motorized travel modes such as walking and biking could be a better choice in Shanghai. Development of public transportation for commuting corridors and integrated jobs-housing regions can improve commuting efficiency in the city; however, specific needs of the city should be considered in Shanghai's strategic planning, based on the combination of developing intraregional non-motorized travel modes and promoting interregional transit development.

5 Conclusion and discussion

Discussions on jobs-housing balance in current research have some limitations. In megacities with extremely complicated spatial and socio-economic environments, a significant gap could exist between actual and theoretical commuting efficiencies. Due to the complexity of the market, an ideal jobs-housing balanced pattern in planning is often difficult to be fully implemented in practice. As the social household structure changes, compromising each family member in determining living and working location is much needed for families with multiple workers. In addition, the general pattern of economic development is typically associated with the agglomeration of employment and rising housing prices, which results in the complex and varying jobs-housing distribution in quality.

In order to examine different factors affecting commuting efficiency in megacities, this study presents an empirical analysis using Shanghai as an example. A significant gap is found in Shanghai between a theoretical

minimum commuting (time and distance) and the actual commuting efficiency. Employment is largely concentrated within the central city, where a high-priced residence has pushed low-income employees' moving to outer areas with increased commuting costs. Regions with high-priced residence present an undifferentiated agglomeration effect on employment, while regions with low-priced residence generally have limited job opportunities nearby. With such a mismatch of jobs-housing distribution, Shanghai has shown a pattern of centralized employment and scattered residence, which is associated with increased actual commuting cost.

This study also proposes a series of suggestions to optimize urban travel and improve commuting efficiency, such as promoting reasonable transit-oriented development, providing transportation subsidies to specific groups, and enhancing employment information sharing. However, regarding specific measures to reduce commuting cost, the data of jobs-housing distribution should be combined with additional information for further analysis, including but not limited to socio-demographic and economic data, detailed city spatial data and distribution pattern, specific industrial and functional zoning, configuration of public services, as well as existing public transportation and urban roadway network.

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