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Homeownership-based segregation and urban amenity differentiation in Shanghai

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Abstract

Chinese cities have attracted increasing scholarly attention to research the emerging patterns and mechanisms of residential segregation. The extant literature has revealed low levels of spatial segregation by socio-economic status, but high levels of spatial division by residents' housing tenure (owning versus renting) in urban China. However, how homeownership-based residential segregation relates to inequality of access to key urban resources remains under-researched. Using a combination of the six census data and urban amenity data of Shanghai, this research investigates the overlapping and contrasting relationships between homeownership, socio-economic status and urban amenity provision, focusing on state-led development versus market-led development. We found that a high level of spatial concentration of work-unit housing and commodity housing is respectively associated with the distribution of distinct social groups and neighbourhood amenity features. Arguably, the centralised housing system and the subsequent gradual housing reforms have persistently shaped the relationship between homeownership-based segregation and accessible urban amenities, reflecting the local government's dual intention to reinforce the central business district development and reduce the financial budget in suburban land development.

Keywords Residential segregation · Homeownership · Urban amenities · Land-use planning · Shanghai

Introduction

Residential segregation has long been a focal point of academic research (Hamnett, 1994). Policymakers worldwide also have endeavoured to tackle the risks of increasing segregation for the creation of inclusive societies, as exemplified by the extensive adoption of social mix in housing policies (Lees, 2008). At the heart of

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residential segregation research is the urban ecology theory proposed by the Chicago School of Sociology, which offers an enlightening perspective to understanding how urban spaces evolve into mosaics of different social groups and functions (Park et al., 1925). According to this theory, a stronger social group can invade the space of a weaker group when two groups compete for urban land and resources. Despite an extensive volume of research that has analysed residential segregation from socio-economic features, recent studies stress that institutional factors, such as land regulations and state-led (re)development, can play a key role in mitigating or accelerating the process of residential segregation (Tammaru et al., 2020; Trounstine, 2020). The institutional perspective has gained prominence in the study of residential segregation for multiple reasons: firstly, state activities are increasingly seen in the uneven configuration and reconfiguration of urban land, housing and infrastructure and, secondly, urban policies are structural causes that render people's asymmetric rights to urban space.

Furthermore, it is no longer just a matter of 'where different social groups live' in an increasingly segregated urban world. Studies on the geography of opportunities have raised new questions regarding how residential segregation relates to people's unequal access to key resources, such as education institutions, employment centres and healthcare services (Briggs and Souza, 2005). Access to urban amenities at the neighbourhood scale is particularly important for the vulnerable and those with low mobility, including children, the elderly and the disabled groups. Moreover, suburbanisation processes have intensified the fragmented governance and the consequent uneven distribution of urban amenities (Chen & Yeh, 2021; Eker et al., 2012). For instance, suburban gated communities are provided with high-end private amenities, while marginalised peripheral neighbourhoods lack the equipment of essential public amenities. The sharply contrasting provision of accessible amenities in neighbourhoods is intricately interwoven with residential segregation. This accessibility dilemma calls for extending the research from 'who lives where' to 'how people live there' to enrich the understanding of the relationship between accessibility and residential segregation.

In urban China, researchers acknowledge that residential segregation has emerged and intensified since the housing commodification reform at the end of the 1970s (Huang, 2004; Huang & Li, 2014). Using Shanghai as a critical case, scholars have disclosed a high level of spatial division by housing tenure, while attributing residential segregation to the disparity of occupation, education and *hukou* of residents (Gu et al., 2021; Li & Wu, 2008; Pan et al., 2021; Shen & Xiao, 2020). However, the dynamic patterns, processes and mechanisms of homeownership-based residential segregation in Chinese cities still remain under-researched for threefold reasons. First, while existing research highlights housing tenure differentiation, i.e. owning versus renting, in the production of residential segregation, it tends to neglect the fact that diversified homeownership pathways (e.g. purchase from work units or purchase through the market) have emerged during and after the reform. Second, the accessibility dilemma in residential segregation has not been fully investigated in China's rapid urban development context, except for a few studies that investigate the 'amenity effect' on housing prices (Wen et al., 2017; Yuan et al., 2020). Third, the coexistence of state-led and market-led approaches in the provision of

housing and urban amenities has substantially complicated the landscape of residential segregation.

Against this backdrop, this study endeavours to question the relationships between socio-economic profiles, access to urban amenities and homeownership divergence, by focusing on different mechanisms for the state and the market in the development of owner-occupied housing (i.e. work-unit housing and commodity housing) and urban amenities (i.e. public amenities and commercial amenities). Such an institutional perspective contributes to understanding how the role of the state (re)shapes urban social space and accessiblity, and how the transition from a centralised housing provision system exerts lasting influences on residential segregation in China.

In the rest of the article, we first provide a review of the literature on the relationship between residential segregation and access to urban amenities, unfolding these relationships in the context of diversified pathways to homeownership. After presenting methods and analyses, we discuss the persistence of state power in shaping residential segregation, and explain the contrasting relationships between accessibility and residential segregation. Conclusive remarks and research implications are given in the final section.

Literature review

Residential segregation and access to urban amenities

The underlying mechanisms for the production of segregated residential spaces have been extensively and intensively investigated from social, economic and institutional perspectives. Within the extant residential segregation literature, the theme of accessibility has received growing attention (Ellis et al., 2004). Increasing inequality in the provision of urban amenities can be a stimulus of segregation, because the scarcity of accessible urban amenities, particularly educational institutions, might lead to the expropriation of opportunity and upward mobility of younger generations. Meanwhile, the segregation level of a space can be manifested by the quantity and quality of urban amenities. In some cases, the level of neighbourhood segregation is a central consideration in urban governance, as it is profoundly associated with the provision of public goods, such as water supplies (Bharathi et al., 2022). Given the deeply intertwined relationship between accessibility and segregation, Kwan (2013) has called for the inclusion of accessibility in the investigation of social segregation, thereby extending the research from the static residence to a variety of times and places in which people's lives unfold.

Neighbourhood is are an imperative type of space where unequal access to key resources primarily occurs, including but not limited to, urban amenities of education, utility supply and healthcare. Two strands of literature has unpacked the complex relationship between access to urban amenities and residential segregation, mostly based on evidence from Western counties. The first strand of research emphasises the socio-economic perspective. In multi-ethnic contexts, racial/ethnic minorities, as being excluded from mainstream societies, are often

concentrated in deprived neighbourhoods, where the property tax base is often too weak to support the provision of sufficient public services (Phillips, 2007). Logan and Schneider (1984) further reckon that spatial patterns of racial segregation have changed little over time in Northern American cities, where racial minorities are trapped in prolonged poverty and can barely access neighbourhood amenities. Moreover, scholars find that economic inequality overwhelms racial factors in contexts with less racial/ethnic diversity but a higher Gini index (Hochstenbach, 2018; Tammaru et al., 2020). The spatial assimilation theory also considers that low-income groups lack a chance of acculturation offered to other groups. For example, using evidence from French low-income immigrant neighbourhoods, McAvay (2019) argues that the intergenerational transmission of deprivation is caused by the lack of accessible educational facilities and job opportunities close to their homes.

Another strand of literature has stressed an institutional perspective to review the intricate relationship between urban amenity accessibility and residential segregation. Scholars have argued that spatial invasion and succession, as proposed in the urban ecology theory, are inevitably attributed to institutional configurations of land use, urban functions and resource allocation rather than being a natural process (Nelson et al., 2004). K'akumu and Olima (2007) reveal that the apartheid regime and the colonialism history of African cities have led to residential segregation between formal neighbourhoods and informal settlements. Their research highlights the sharp inequality of healthcare facilities and education facilities provided for the two types of neighbourhoods.

Furthermore, institutional drivers of residential segregation have become more divergent during suburbanisation processes. Trounstine (2020) disclose that land-use regulations in American cities can be directed to generate segregation for the privatised interests of homeowners rather than to minimise expenditure on local public goods. As her research shows, restrictive land use policies are supported by suburban neighbourhoods to maintain homogenised and to segregate unwanted people. The economic logic of club goods has also gained great popularity in suburban neighbourhood development, featured by the market delivery and management of urban amenities. Such private governance of urban amenities is typically seen in suburban gated communities, which have long been recognised as high-end segregated neighbourhoods in the US (Mckenzie, 1994). Recently, the club-like means of public goods provision has been adopted by local governments in French peri-urban communes, reflecting the transformation of territorial governance 'into a market logic from a political and philosophical standpoint' (Charmes, 2009: 191). Although witnessing the growing role of the market in suburban governance, Ekers et al., (2012: 418) remind future studies 'not to view the state as monolithic' because the state plays a dynamic role in influencing housing and infrastructure development in different contexts. Therefore, examining the role of the state and the market in the configuration of urban amenities can enrich the understanding of the institutional forces that shape residential segregation.

Homeownership-based segregation

Many scholars have underscored the prominent role of housing in (re)shaping residential segregation (Arbaci, 2008; Rodríguez-Pose & Storper, 2020), focusing on incorporating housing in the measurement of residential segregation and examining how housing markets and housing policies contribute to residential segregation. Housing tenure, in addition to income/poverty, education, employment and occupation, are utilised to illustrate the concentration of well-off neighbourhoods and deprived enclaves. In market economies, how much one can pay for housing, either rental or homeownership, determines where he/she can live. In rapid urbanisation contexts, the skyrocketing housing prices have become a barrier for low-income groups to purchase a home, consequently leading to the intensified residential segregation of the wealthy versus the poor as well as formal housing versus informal housing (Gu et al., 2021). The majority of the existing literature focuses on the segregation of housing by tenure type and price across neighbourhoods, and foremost centres on the spatial division between renter- and owner-occupied housing (Cui et al., 2016; McKee, 2012).

However, few studies have touched upon the varied types of owner-occupied housing, defined as how homeowners achieve homeownership. Homeownership is characterised by fragmentation and differentiation (Murphy, 2012). As Doling (1999) argued, owner-occupied housing does not necessarily circulate as a free-market commodity, since it can be attained with the support of state subsidies, and access to it may not be completely determined by financial ability. Particularly, in a nation which has undergone radical institutional reforms, the provision of housing has been tremendously restructured and various pathways to homeownership can exist due to the complicated power relation between the state and market (Cui et al., 2021). Driven by neoliberalism and globalisation, many states have withdrawn from the housing sectors and transferred the responsibility for housing provision to the market, including the UK, Central and Eastern Europe and China (Elsinga et al., 2014; Rolnik, 2013). The prior public housing has been privatised by transferring the property ownership to the sitting tenants at highly subsidised prices, which resulted in widened access to affordable homeownership for that generation. Then, the market was given an unprecedentedly important role, and, consequently, commodity housing became the main pathway to homeownership, the access to which depends fundamentally on one's earning capability. When, where and for whom each type of owner-occupied housing is built are determined by joint market forces and institutional interventions (Gu et al., 2021; Wang, 2022).

Housing reforms and spatial sorting in urban China

The varied means to achieve homeownership need to be differentiated, as their attached benefits and accessibility can vary considerably. In Chinese cities, reformed work-unit housing and commodity housing are the main pathways to homeownership; yet, they are available at a specific time period and location

and are targeted at different groups of people. In the pre-reform era, Chinese cities were featured by state-led industrialisation as 'cities of production'. At that time, residential space was developed and governed primarily through the state work-unit *(danwei)* system, in which housing was treated as state welfare and was rented to state employees according to their job rank, seniority and political status (Huang, 2004; Tomba, 2014; Wu, 2002). Urban amenities, such as canteens, barbershops, kindergartens and clinics were provided by work units rather than by the market in each residential compound. In the absence of a housing market and alternative job opportunities, individuals' needs for housing and urban functions were highly dependent on their work units. The spatial sorting process was therefore produced by the state, as it monopolised the construction, provision and distribution of housing and resources (Tomba, 2014). In a sense, the state welfare housing system minimised private consumption of material goods and services for the sake of bolstering an egalitarian society. The segregation of residential space was mostly reasoned to the position of work units in the redistribution hierarchy (Walder, 1986).

Since China's economic reforms in 1978, the state's provision of welfare housing has been gradually phased out, while a radical promotion of private homeownership has been endorsed. Two approaches to homeownership emerged: first, tenants of former work-unit housing were entitled to purchase their homes at subsidised prices, thereby becoming private homeowners; and second, individuals were encouraged to purchase new commodity housing from the newly established housing markets. Housing reforms have transformed urban China into a society of homeownership at unprecedented scale and speed, with the homeownership rate rising from 20% in 1980 to 75% in 2010, which is higher than that in many developed countries (Huang & Li, 2014).

Along with the housing reforms, a bifurcated residential sorting process emerged, reshaping the relationship between housing and access to urban amenities. On the one hand, those who were privileged under the socialist housing allocation system were the beneficiaries, and are found living in higher quality and more accessible housing in the city (Fang et al., 2015). On the other hand, commodity housing in gated communities was packaged with private amenities, such as green space and leisure facilities, exclusively for the wealthy middle class (Hendrikx & Wissink, 2017; Pow, 2009; Xiao et al., 2016; Wu, 2010). The extant literature illuminates that the quality of facilities and services accessible to the neighbourhood is closely tied to the market value or the location of housing, and acts as an important mechanism for the spatial sorting of residents. While community and housing traits help to explain the process of residential sorting, lately, scholars have recently called for greater attention to be paid to residents' unequal access to certain types of urban amenities, such as parks (Xiao et al., 2017, 2019), medical resources (Rong et al., 2020), and schools (Wen et al., 2017), as new features of residential segregation in post-reform China.

In a nutshell, housing reforms have created varied pathways to homeownership and different logics of homeownership-based residential segregation in urban China (Fig. 1). The dynamics between homeownership and urban amenities necessitate more nuanced research, particularly on the visible role of the state in the (re)

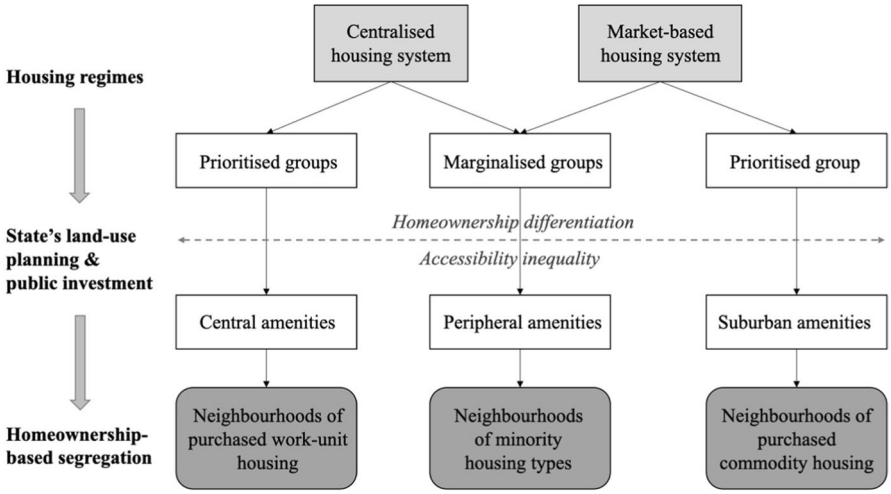


Fig. 1 The relationship between homeownership differentiation and amenity inequality in residential segregation

construction of urban space, from which to offer evidence contextualised in China to engage with the international literature on residential segregation.

Data and methods

Study area

This study aimed to investigate housing differentiation at the finer spatial level of the neighbourhood (i.e. *juwei*). A neighbourhood was the basic spatial unit of urban governance, as each neighbourhood was administered by its respective *juweihui*, which, as an arm of the local government, was responsible for supervising population and providing basic welfare services in the neighbourhood (Li & Wu, 2008). Because of its administrative nature, a *juwei* was taken as the lowest tract of the government's census survey in Shanghai. The sixth census survey (of 2010) employed in this study comprised two sectors, with the first sector covering 23,019,196 individuals and the second covering 876,430 households. All individual and household level information was aggregated into 5,432 neighbourhood tracts. On average, a neighbourhood unit accommodated 4,200 individuals.

The variation in homeownership in Shanghai was derived from its critical role in China's urbanisation. Historically, Shanghai was an administrative town, with traditional housing mostly built in the central, colonial and peripheral areas. From 1949, Shanghai was planned as a production centre for industrial development, resulting in a large-scale urban sprawl and a concentration of state-employed workers. During this centralised era of urbanisation, work-unit housing, as a form of state welfare, was a key housing type that developed to host the urban population. With the

unfolding of market-oriented reforms in 1978 and globalisation in the recent decades, Shanghai became the dragonhead of economic growth for the region and country, attracting enormous inflows of population and capital investment. Unprecedented housing marketisation occurred, especially after the termination of state housing allocation in 1998, and commodity housing gradually became the dominating homeownership type. Such transition of the housing provision system has left prominent imprints at the spatial level. In sum, Shanghai provides ample evidence to examine the spatial differentiation of housing and explore how the socio-economic status and the construction of neighbourhood amenities are associated with housing development.

Data source and measurement

Dependent variables. In this study, The homeownership proportions of commodity housing and work-unit housing in the respective neighbourhood were treated as dependent variables, representing the spatial concentration of housing development led by the market and the state. Meanwhile, to show the specialisation of a homeownership type in the spatial unit of a neighbourhood relative to a larger geographical unit of the municipality, we employed a location quotient index, which indicated whether a spatial unit was dominated by a particular homeownership type.[1]It was noted that the census recorded five homeownership types: purchased commodity housing, purchased second-hand housing, purchased reformed work-unit housing, purchased public affordable housing (i.e. *jingji shiyongfang*) and self-built housing. We chose to focus on purchased commodity housing and purchased work-unit housing for twofold reasons. First, they were the most important homeownership types because they were much larger in scale than the minor types of homeownership – the number of commodity housing purchases (204,201) and the number of purchased work-unit housing (116,079) were much larger than the number of self-built housing (99,239), affordable housing (2,516) and second-hand housing (50,100). Second, neither second-hand housing nor self-built housing portrayed a clear path of housing development. Ownership of second-hand homeownership could contain hybrid housing sources as, for instance, privatised public housing could be freely traded on the second-hand housing market. The ownership of self-built housing might pertain to an urban heritage management organisation or be collectively owned by urban villagers. Therefore, purchased commodity housing and purchased work-unit housing were more reflective of the market and state pathways of

[1] The location quotient is a technic for measuring and mapping levels of concentration or discreteness of a sub-area to an entirety, measured by the formula below:

$$LQ_i = (X_i / \sum_{j=1}^{k} X_j) / (N_i / \sum_{j=1}^{k} N_j)$$

where LQ_i is the location quotient of the i housing type, X_i is the amount of i housing type in a spatial unit of neighbourhood, $\sum_{j=1}^{k} X_j$ is the amount of all housing types in this spatial unit, N_i is the amount of i housing type in the municipality, $\sum_{j=1}^{k} N_j$ is the amount of all housing types in the municipality.

homeownership than the other minor housing types. They were thus conceptualised as representative of market and state housing development.

Socio-economic features. The first set of independent variables measured were the socio-economic features of a neighbourhood unit. In the sixth census survey, up to 36 dimensions of individual socio-economic status were collected, including gender, educational level, *hukou* type (i.e. household registration status), income source, job type and health status. New techniques were needed to generate fewer components from a large set of variables for further analyses, while ensuring that the discarded components had a low loss of information. Following the commonly used social-ecological method, we measured the socio-economic variables by first calculating the proportions of the 36 items in each neighbourhood as a means of standardisation, and then computing the main components from these items through a method of dimensional reduction. This dimensionality reduction of the main component method constructed six new variables as linear combinations of the original 36 variables, while retaining most of the original information.

Neighbourhood amenity features. The second set of independent variables measured were the neighbourhood amenity features of a spatial unit. Urban amenity data were captured by applying a web-crawling Python programme to the API provided by Amap (ditu.amap.com), which, as one of the most widely used online maps in China, encoded every amenity with its location and category information. The earliest records of urban amenity that we accessed were those from 2013. This dataset provided a relatively close scenario of, though not a perfect, match of urban facility provision to that of the census year, given the relative stability of urban amenities. To filter out neighbourhood amenities from all urban amenities, we firstly crawled 17,020 geographical locations of housing projects (i.e. *xiaoqu*) in Shanghai from anjuke.com – one of the most widely used online housing brokers – to identify valid housing projects that were built before 2010; secondly, we created buffer zones with a radius of 1.8 kms for each housing project; and thirdly, we calculated the amount of amenities located in the buffer zones.[2]As there was no consensus on the categorisation of urban amenities, we classified the types of amenities per the national standard codes for land development (Ministry of Housing & Urban–Rural Development, 2018). This rule sorted urban amenities based on the land use functions, with 36 land-use types being subordinated to nine main land-use functions. As a result, we obtained four types of amenities belonging to public administration and public facility land (public facilities for short), one amenity type from green facility land, one amenity type from transportation facility land, and four types of amenities belonging to commercial services and commercial facility land (commercial facilities for short). Furthermore, we assessed the diversity level of neighbourhood amenity types from all land-use functions, commercial functions and non-commercial functions

[2] The maximum radius of the neighbourhood amenity zone was created by setting the maximum walking time to 15 min and the walking speed to 1.2 m/s. Different urban amenities located within these buffer zones were considered as neighbourhood amenities. This method was later adopted by the Shanghai 15-Minute Neighbourhood Planning, which defined what and where neighbourhood amenities should be implicated to serve residential uses.

Table 1 Descriptive Statistics of homeownership in Shanghai's neighbourhoods (N = 5432)

	Homeownership proportion		Homeownership location quotient level	
	Mean (S.D.)	Range	Mean (S.D.)	Range
Commodity housing	0.2 (0.3)	0–1.0	1.0 (1.3)	0–4.3
Work-unit housing	0.1 (0.2)	0–0.9	1.0 (1.6)	0–7.0

using the Shannon Diversity Entropy Index (Shannon, 1948), which revealed the diversification of neighbourhood amenities. The number of neighbourhood amenities was measured by employing the following formula:

$$E = -\sum_{i=1}^{k} (p_i \times \ln p_i)$$

where E is the diversity entropy value, p_i was the proportion of i type amenity in all neighbourhood amenities in the spatial unit, k is the number of amenity types counted.

Model construction

As proposed in the theoretical framework, we tested how a neighbourhood's socio-economic status and amenity provision were associated with different homeownership development in Shanghai. The geographical nature of our data presented problems of spatial autocorrelation, requiring models to account for spatial dependencies. Specifically, housing development, social space and neighbourhood amenities were all spatially clustered with a high degree of spatial autocorrelation. To control for the influence of neighbours (i.e. spatial autocorrelation), we applied the spatial lag regression model as follows:

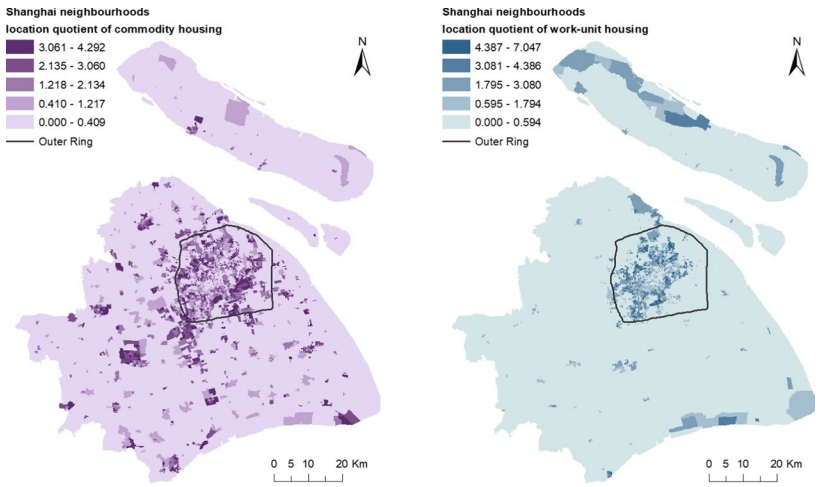
$$H_i = \rho W H_j + \alpha + \beta_i X_i^T + \varepsilon_i$$

where H_i is the proportion of a homeownership type in the spatial unit i, W is a matrix of spatial weights, H_j is the set of homeownership values other than that of spatial unit i, α is the constant, X_i is the matrix of all independent variables, β_i is the vector of coefficients and ε_i is the model error term.

Descriptive analyses of homeownership, socio-economic status and neighbourhood amenity

Spatial differentiation of homeownership

The spatial differentiation of housing respectively illustrated the market and state homeownership pathways. As seen in Table 1, the rates of commodity housing ownership and work-unit housing ownership in a residential neighbourhood were considerably low by 2010, at 0.2 and 01, respectively. In terms of the level of spatial concentration of housing (shown in Fig. 2), we found that work-unit



(a) Location quotient of purchased commodity housing (b) Location quotient of purchased work-unit housing

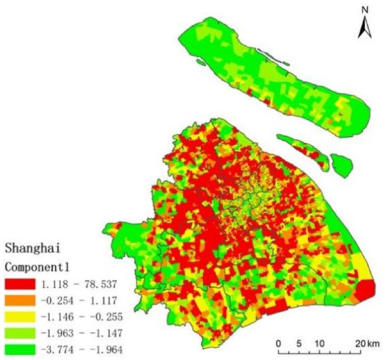
Fig. 2 Location quotients of commodity/work-unit housing homeownership in Shanghai. (**a**) Location quotient of purchased commodity housing (**b**) Location quotient of purchased work-unit housing

housing ownership had a larger standard deviation, a higher maximum value and a more central location than commodity housing. Some neighbourhoods were highly concentrated in work-unit housing compared to the city average, with a location quotient up to 7.0 times higher than their city average. In a nutshell, commodity housing owners covered a wider range of neighbourhoods during suburbanisation processes, while work-unit housing owners were more densely clustered in a few central neighbourhoods.

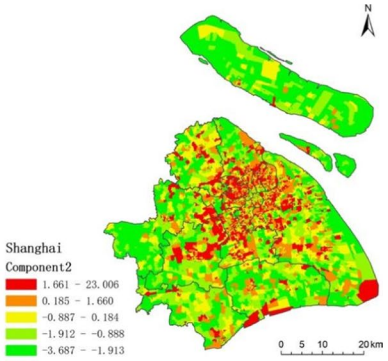
Spatial differentiation of socio-economic features

The principal component analysis generated six principal components out of 36 attributes of socio-economic features of residents. The Cronbach's alpha score and the Kaiser–Meyer–Olkin scores respectively reached 0.89 and 0.65, indicating a high internal consistency of attributes and an acceptable dimensional reduction effect of the model. Overall, these main components had eigenvalues greater than one and accounted for 77.4% of the cumulative variance. Figure 3 demonstrated the spatial distribution of each principal component, with a higher loading score indicating a higher level of concentration of the component.

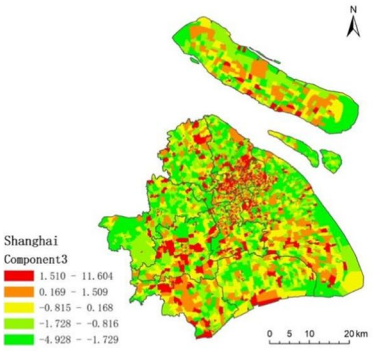
Component I represented the social group of low-skilled migrat working labour, as attributes of non-local *hukou*, workers in manufacturing and transport industries, and income derived mainly from work pay, had leading positive factor loadings in the analysis. Component II refered to the privileged social groups, with the largest factor loadings contributed by having a university degree and having a superior job, which included government cadres, Chinese Communist



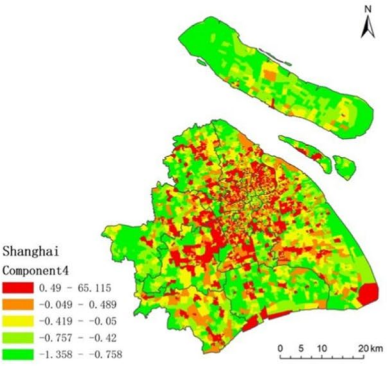
(a) Spatial Distribution of the migrated worker



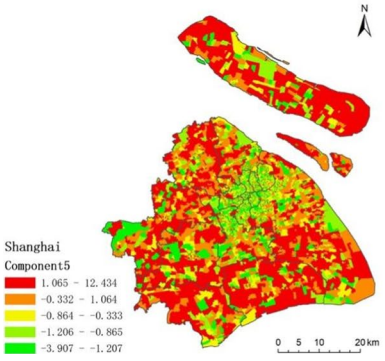
(b) Spatial Distribution of the privileged



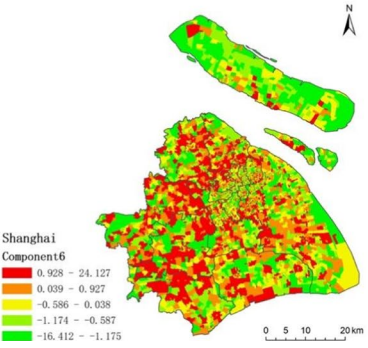
(c) Spatial Distribution of the aged



(d) Spatial Distribution of university graduates



(e) Spatial Distribution of the agricultural worker



(f) Spatial Distribution of the unemployed

Fig. 3 Spatial patterns of neighbourhood socio-economic features. (**a**) Spatial distribution of the migrated worker (**b**) Spatial distribution of the privileged, (**c**) Spatial distribution of the aged (**d**) Spatial distribution of university graduates (**e**) Spatial distribution of the agricultural worker (**f**) Spatial distribution of the unemployed

Party (CCP) cadres, enterprises managers or technical professionals. As shown in Fig. 3(a-b), the two social groups demonstrated adverse trends in spatial concentration, resulting in distinct features of their social space. The highest ranked spatial units of Component I were predominantly located in suburbs, particularly along the west and the north transport corridors of regional importance. These neighbourhoods became social spaces for migrat frontline workers in manufacturing and transport. The result was in line with the development of satellite towns for factories in the centralised economy era, as well as the planning of industrial zones and manufacturing-related new towns after the 2000s in the city of Shanghai. Additionally, Component I had a large variance of 10.4, suggesting a high degree of unevenness in the spatial distribution of this social group across different neighbourhoods. On the contrary, Component II scored high in the city centre and inner suburbs. It suggested that central neighbourhoods, as parts of the central business district (CBD) of a global city, functioned as a social space for the privileged social group. Yet, the high-density central neighbourhoods showed little trendency to accommodate the low-skilled migrat frontline workers, who were excluded from both employment and homeownership opportunities.

Component III portrayed the aged social group as it had high loadings on attributes of being over 60, living on a pension, and reporting various unhealthy statuses. As seen in Fig. 3(c), the differentiation among neighbourhoods was mild. The spatial structure of the top quintile of the component score showed dual cores, namely the city centre and the urban periphery in the southeast and southwest, representing the social space of urban seniors and that of rural seniors. As for Component IV, the main factor loadings came from the percentage of undergraduates, the percentage of postgraduates, and the percentage living on family support, suggesting the social group of university graduates. Doubtlessly, the social space of university graduates clustered in high-tech industrial parks and university towns, most of which were located in the near-suburbs, as shown in Fig. 3(d). Conversely, the percentage of illiterate people and the percentage of unschooled people mainly contributed to Component V. It also had a high loading on the job industry of agriculture, forestry, fishing and stock raising. This component described the social group of low-skilled workers in the primary sector. Such social space was identified in approximately 80% of neighbourhoods, extending from the inner suburbs to the peripheries, as seen in Fig. 3(e). It confirmed Shen and Xiao's (2020) earlier study, which recognised suburbs in Shanghai as a socially heterogeneous space for both the middle class and the rural villagers. Finally, Component VI revealed the unemployed social group who relied on the government minimum allowance or household assets as the main source of income. The principal component was distributed in a fragmented pattern across different neighbourhoods, as shown in Fig. 3(f). This social group hardly developed into a uniform social space due to becoming unemployed with different reasons. For example, employees of a state-owned enterprise were laid off during the economic transition, and the young generation of the low-skilled workers lost their jobs during the economic globalisation.

Table 2 Descriptive statistics of neighbourhood amenities (standard deviation in parentheses)

	Whole city		Commodity housing (low ownership LQ)	Commodity housing (high ownership LQ)	Work-unit housing (low ownership LQ)	Work-unit housing (high ownership LQ)
	Range	Mean	Mean	Mean	Mean	Mean
Average amount neighbourhood amenities by land-use functions						
Land-use function A: Public administration and public facilities						
A. Culture	0–112.0	12.3 (15.5)	14.8 (17.5)	9.5 (12.2)	9.7 (14.9)	16.0 (15.6)
A. Education	0–88.0	24.9 (20.9)	27.3 (22.6)	22.3 (18.5)	20.0 (21.0)	31.9 (18.8)
A. Sports	0–34.2	3.5 (3.9)	3.7 (4.2)	3.3 (3.5)	2.6 (3.1)	4.8 (4.5)
A. Health care	0–136.5	23.2 (27.2)	27.1 (30.0)	18.8 (22.8)	18.7 (27.3)	29.6 (25.7)
Land-use function B: Commercial services and commercial facilities						
B. Commerce	0–3559.5	575.6 (523.8)	627.9 (586.0)	515.0 (433.3)	487.9 (553.1)	699.1 (451.7)
B. Business	0–339.6	49.1 (54.7)	55.7 (60.9)	41.5 (45.4)	40.0 (54.6)	62.0 (52.3)
B. Utility business	0–291.6	28.5 (37.9)	32.2 (40.7)	24.2 (33.8)	25.2 (40.3)	33.1 (33.8)
B. Other	0–66.0	14.7 (9.6)	14.4 (9.9)	15.0 (9.4)	12.5 (9.5)	17.8 (9.0)
Land-use function G: Park and plaza						
G. Green park	0–63.0	4.3 (6.3)	5.1 (7.4)	3.4 (4.5)	3.4 (6.0)	5.6 (6.5)

Table 2 (continued)

	Whole city		Commodity housing (low ownership LQ)	Commodity housing (high ownership LQ)	Work-unit housing (low ownership LQ)	Work-unit housing (high ownership LQ)
	Range	Mean	Mean	Mean	Mean	Mean
Land-use function H: Road and transportation						
H. Transportation	0–59.0	7.5 (8.9)	8.7 (10.0)	6.1 (7.1)	6.1 (9.2)	9.5 (8.1)
Index of diversity entropy of neighbourhood amenities by land-use functions						
Diversity of public facilities (land-use function A)	0–1.8	1.3 (0.4)	1.3 (0.4)	1.3 (0.3)	1.2 (0.4)	1.4 (0.2)
Diversity of commercial facilities (land-use function B)	0–1.2	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.2)	0.5 (0.1)

LQ = location quotient; low LQ refers to LQ ≤ 1; high LQ refers to LQ > 1

Features of neighbourhood amenities

Furthermore, Table 2 displayed the diversity level of neighbourhood amenities and the amount of different amenities provided in neighbourhoods. The results demonstrated apparent disparities in terms of amenitythe accessibility of different amenities. In general, commercial amenities were more accessible than amenities from the public provision. On average, within a 15-minute walk distance from home, residents reached approximately 576 commercial amenities and 49 business amenities provided by the private sector, whereas they reached only four sports facilities constructed on the public facility land and seven transportation facilities provided by the public sector. Taking green parks as an example, the standard deviation value was greater than the mean value, and the maximum value was 14.7 times the mean, both indicating that the distribution of accessible green parks was highly discrete and polarised among neighbourhoods. In addition, the diversity entropy mean of public facility land was 2.6 times as high as that of commercial facility land, and the standard deviation of the former was larger than that of the latter. It revealed the provision of public amenities was more comprehensive than the commercial amenities provision at the neighbourhood level. Nonetheless, the inequality of amenities across different neighbourhoods was evident, and this was particularly the case for the provision of public acilamenities. In a sense, while some neighbourhoods enjoy holistic urban functions with a comprehensive provision of urban amenities, others might lack essential urban functions due to the inadequate provision of amenities.

The intra-group difference of neighbourhood amenities was overtly seen when comparing neighbourhoods of a low concentration level ($LQ \leq 1$) with those of a high concentration level ($LQ > 1$) in both work-unit housing and commodity housing scenarios. Specifically, the average provision of amenities was overwhelmingly higher in neighbourhoods where work-unit housing ownership was more concentrated than in their counterparts. Conversely, neighbourhoods with a high LQ of commodity housing ownership had a lowerprovision of neighbourhood amenities than neighbourhoods with a low density of commodity housing ownership. When neighbourhoods of high LQ work-unit housing ownership were compared with those with a high LQ of commodity housing ownership, the advantages of accessibility remained for the former type of space. These facts suggested that the centralised housing provision regime has exerted influences on accessibility, as the areas where work-unit housing wass concentrated benefit from the preferential provision of neighbourhood amenities.

Socio-economic stratification and amenity differentiation by homeownership

We further employed spatial lag models to test for statistical associations between the socio-economic features, neighbourhood amenities and homeownership, thus examining how different social groups and neighbourhood amenities were sorted into state-led and market-led housing development in Shanghai. No collinear attribute was reported in the Variance Inflation Factor (VIF) tests. Two sets of spatial lag models were conducted on

Table 3 Spatial-lag regression results for homeownership proportions

	Model 1		Model 2		Model 3		Model 4	
	B	S.E	B	S.E	B	S.E	B	S.E
Constant	0.119***	0.008	-0.008	0.069	0.058***	0.005	0.299***	0.054
Spatial lag	0.433***	0.015	0.292***	0.022	0.587***	0.013	0.462***	0.021
Location (suburb = 1)	0.043***	0.007	0.028**	0.011	-0.002	0.004	0.007	0.008
Socio-demographic features								
The migrated worker	-0.022***	0.001	-0.023***	0.002	-0.003***	0.001	-0.010***	0.002
The privileged	0.083***	0.002	0.089***	0.003	-0.013***	0.001	-0.019***	0.002
The aged	-0.049***	0.002	-0.054***	0.003	0.039***	0.001	0.052***	0.002
The university graduates	-0.005**	0.002	-0.009***	0.002	-0.005***	0.001	-0.005***	0.002
Agricultural workers	-0.010***	0.002	-0.042***	0.009	-0.017***	0.001	-0.002**	0.007
The unemployed	0.001	0.002	-0.026***	0.005	0.002	0.002	-0.004	0.004
Neighbourhood amenity features								
A. Culture			-0.041*	0.020			0.004	0.015
A. Education			0.012	0.029			0.015	0.022
A. Sports			-0.003	0.015			0.045***	0.012
A. Health care			-0.037	0.023			-0.016	0.018
B. Commerce			0.110**	0.036			-0.086**	0.028
B. Commercial business			-0.055 +	0.028			0.046*	0.022
B. Utility business			-0.040*	0.017			-0.024 +	0.013
B. Other			0.056*	0.024			-0.016	0.018
G. Green park			-0.031*	0.016			0.009	0.012
H. Transportation			-0.009	0.017			-0.023 +	0.013
Diversity of public facilities (A)	-0.021**	0.008			0.007	0.005		
Diversity of commercial facilities (B)	0.061***	0.017			-0.011	0.011		

Table 3 (continued)

	Model 1		Model 2		Model 3		Model 4	
	B	S.E	B	S.E	B	S.E	B	S.E
R^2	0.486		0.491		0.584		0.472	
Likelihood ratio	1551.802***		416.200***		688.543***		152.930***	
Observation	5432		5432		5432		5432	

*all models are significant; Model 1&2 for commodity housing, Model 3&4 for work-unit housing; ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.1$*

5,432 neighbourhood units, with dependent variables being the proportion of purchased work-unit housing and the proportion of purchased commodity housing (Table 3). In each set of analyses, the independent variables ranged from a combination of socio-economic components, neighbourhood amenity features and neighbourhood locations. For all models, significant p-values were found for spatial lag coefficients, Moran's I values and likelihood ratio test results, indicating that the spatial agglomeration of homeownership had spatial spillover effects across surrounding neighbourhoods. That was, when the proportion of work-unit/commodity homeownership in surrounding neighbourhoods increased, so did the proportion of homeownership in each neighbourhood, even when other features of socio-economic status and neighbourhood amenities were held constant.

Model 1 and model 2 showed the correlations of socio-economic features and neighbourhood amenities features with the concentration of purchased commodity housing owners, reaching relatively high model goodness of fit. Both models demonstrated significant influences of socio-economic features on the proportion of commodity housing ownership. Specifically, groups of migrated workers, university graduates, seniors, agricultural workers and the unemployed possessed a low likelihood to concentrate in neighbourhoods where commodity housing ownership was densely developed, indicated by their negative coefficients. In contrast, only the privileged social groups presented a significantly positive correlation with the proportion of commodity housing ownership, and the absolute value of the coefficient was much larger than the remaining socio-economic features. This component denoted that groups of the highly skilled or public officials had a greater chance of acquiring ownership of a commodity housing. Besides, suburban neighbourhoods were likely to reach a higher proportion of commodity housing homeownership than their counterparts located in the central city. This verified that commodity housing was possibly the main approach for suburban land development.

Regarding neighbourhood amenities, the results of model 1 revealed critical and opposite relationships between the diversity level of neighbourhood amenities and the concentration of commodity housing ownership. While both amenity diversity indexes were significantly correlated with the of commodity housing owners, we identified that the higher diversity index (i.e. a more comprehensive provision with a wider range of facility types) of public facilities in the neighbourhood was negatively correlated with the agglomeration of commodity housing ownership, while the higher diversity index of commercial facilities exhibited a positive association. When the diversity entropy of amenities was replaced by explanatory variables for each type of neighbourhood amenities, intriguing relationships emerged. Only the amount of commercial amenities (e.g. grocery shops) provided by the market was aligned with the development of commodity housing. Specifically, one unit increase in the amount of commercial amenities was associated with a significant increase in the proportion of owner-occupied commodity housing. Contrarily, the number of cultural facilities (e.g. museums) and green parks, both belonging to the public provision, were negatively related to the spatial concentration of commodity housing. Utility services (e.g. post offices), though constructed on commercial services land, were run by the public sector and showed a negative relationship with the concentration of commodity housing homeownership. It was possible that commodity housing buyers had relatively high consumption capability and were inclined to

fulfil their needs through the market provision of commercial goods, while the needs for public goods (e.g. green space) were satisfied by the pre-packaged 'club goods' offered in gated neighbourhoods (Hendrikx & Wissink, 2017; Xiao et al., 2016). More importantly, commodity housing ownerships were less densely locate near urban CBDs where commercial businesses (e.g. financial services) were held, nor were these housing projects developed on publicly serviced land. The spatial nexus between public/private amenities and commodity housing homeownership reflected the countervailing logic between the public sector and the private sector in preparing serviced land for market-led housing development.

Model 3 and model 4 used neighbourhood features of socio-economic status and amenities for explaining the clustering of work-unit housing owners. The results of both models exhibited consistent associations between the socio-economic status and the homeownership rate of work-unit housing. Relatively disadvantaged groups of non-local or low-skilled workers possessed relatively scarce access to the ownership of work-unit housing, and advantaged groups of higher economic income or social status advantage also had a negative association with the ownership rate of work-unit housing in urban neighbourhoods. This was because the former social group benefited little from the housing reforms, while the latter affluent group was attracted to high-end commodity housing rather than sticking to work-unit housing. The only significantly positive effect was identified from the concentration of the aged social group on the probability of owning work-unit housing in residential neighbourhoods. These intriguing outcomes suggested that cohort differences played a key role in determining one's access to work-unit housing. The purchase of work-unit housing began in the early 1990s, and the allocation of work-unit housing as state welfare was terminated at the end of 1998. The current elderly population might have been state employees who were accommodated in work-unit housing in the pre-reform era when Shanghai was planned as the production centre of China. The privatisation of work-unit housing enabled these former state employees to purchase ownership of their work-unit housing.

Apart from the socio-economic features, the contribution of the geographical location and the diversity levels of amenities was not statistically significant for the neighbourhood homeownership rate of work-unit housing in model 3. Yet the model coefficient gave a hint that a diversified provision of public amenities was positively correlated to the dependent variable, while the comprehensiveness of commercial amenities at the neighbourhood level was negatively associated with the dependent variable. In model 4, the diversity index of amenities was further replaced by specific types of ties to investigate the underpinned relationships between neighbourhood amenity provision and the development of work-unit housing. Commercial amenities were less likely to be found in a neighbourhood mainly composed of work-unit housing owners, as one unit increase in the number of commercial amenities represented a significant decrease in the neighbourhood ownership rate of work-unit housing, holdingother attributes constant. Both utility businesses and transportation facilities (e.g. subway stations) were weakly negatively associated with the spatial concentration of work-unit housing owners. This might be due to the limited nature of work-unit developments, which were designed to offer state employees with accommodation near their workplaces and to minimise their daily needs in

a centralised economic regime. The centrally planned and serviced work-unit housing resulted in a lack of space for the new development of service amenities. However, the market development of business amenities and the public construction of sports amenities (e.g. sports stadiums) were significantly positively correlated with the dependent variable. The possible explanation for this was that, in the past, work-unit housing was developed close to existing employment centres, which were transformed into CBDs to host business activities and sports-related mega-events. These neighbourhood amenities reflected the decisive role of the state in land-use planning and urban development.

Discussion and conclusion

More than three decades of housing reforms and urban development have produced distinct pathways to homeownership in post-reform urban China. Different types of housing have become spatially clustered, mirroring the patterns and ongoing processes of residential segregation in urban spaces. Furthermore, residential segregation at the neighbourhood level has resulted in varied social spaces and differentiated provision of key resources. Under these circumstances, this study examined homeownership-based residential segregation by focusing on the specific mechanisms of work-unit housing and commodity housing in urban China, and extended the study of residential segregation from the stratification of residents in terms of socio-economic status to its association with differentiated accessibility (Ellis et al., 2004; Kwan, 2013). While homeownership-based segregation was found to be phenomenal, we did not intend to dichotomise residential segregation in urban China into state-led housing exemplified by work-unit housing and market-led housing illustrated by commodity housing. Rather, the main objective was to examine whether and how the role of the state exerted influence over residential segregation through housing policy and land-use planning after the transition of cities from egalitarian societies to a market-oriented economy.

Based on the findings, we first argue that, unlike racial/ethnic feature segregation or economic inequality in many Western contexts (Logan & Schneider, 1984; McAvay, 2019), residential segregation based on homeownership is much more pronounced in the Chinese context, and moreover, institutional factors, especially the welfare housing regime and the gradual housing reforms that followed, have profoundly sculpted the segregation of both state-provided and market-purchased homeownership. In multiracial or capitalist contexts, being in the racial majority or possessing economic advantages endows people with stronger socio-economic capabilities; thus, they are generally more able to occupy neighbourhoods with favourable terms, such as high homeownership rates and sophisticated provision of accessible amenities (Briggs & de Souza, 2005; Hochstenbach, 2018). However, the case of Shanghai showed that it was the cohort differences that determined the probability of buying into a neighbourhood of state-prioritised development. In other words, the spatial differentiation of work-unit housing stemmed from a combination of institutional and historical reasons; that was, the state decided to offer welfare housing for employees in the era of centralised economy, and again to give their employees the antecedence to buy properties during the privatisation reforms of work-unit housing from the 1980s to the

end of the 2000s. The closure of work-unit housing provision did not necessarily imply the dismantling of state power in homeownership-based residential segregation. Rather, the effects of institutional factors have been consistently observed in the segregation of ownership of commodity housing, as the privilege of obtaining commodity housing was deeply rooted in one's institutional advantages, such as being employed by the government or having CCP membership status. Beneficiaries of state housing allocation retained to play a privileged role in the housing market. As suggested by Wang (2022), mainstream employees were more likely to purchase commodity housing with their accumulated assets and wealth obtained from the reform of the welfare housing system. In short, the homeownership-based segregation of both work-unit housing and commodity housing reflects the persistence of institutional power in the (re)configuration of residential landscapes and the acceleration of spatial differentiation in Shanghai (Bian & Logan, 1996).

Second, local governments' land-use planning and public infrastructure investment decisions profoundly influenced the association between accessibility and residential segregation. The development of accessible urban amenities reflected local governments' bifurcated intention in urban governance, which was to reinforce the regeneration of the CBD while reducing the financial budget for suburban land development (Wu, 2022). Specifically, neighbourhoods with a high proportion of work-unit housing ownership continued to enjoy the preferential provision of all types of amenities. Amenities of commercial business, rather than those of a daily use nature, were more likely to be located within an accessible distance to homeowners of work-unit housing. Given that work-unit housing neighbourhoods were more likely to accommodate the elderly, the mismatch in accessible amenities between the local supply and residents' demand was apparent. One possible reason for this mismatch could be that the commercial business amenities in these centrally located neighbourhoods were not designed to serve the residents of work-unit housing, but to strengthen the economic competitiveness of the city centre by retrofitting the central business environment and upgrading the land-use function. This partly explained the massive scale of the state-led regeneration of old and shantytown neighbourhoods in Shanghai and other Chinese cities. As various studies have demonstrated, the regeneration of the city centre increased the exchange value of land and attracted further business investment, reflecting the entrepreneurial turn of the local state in China's urbanisation processes (He & Wu, 2005).

Nevertheless, local governments tended to leave the provision of neighbourhood amenities to the private sector in the development of commodity housing during suburbanisation processes (Hendrixk and Wissink, 2017; Lu et al., 2020, 2022). This was evident in commodity housing neighbourhoods that were located in the suburbs, where the land-use functions of public administration and public facilities were barren and those of commercial services and commercial facilities from the market provision were diversified. As the literature suggested, in order to reduce the financial burdens of suburban governance, local governments were likely to withdraw from the provision of serviced land, especially in privatised housing developments, such as gated communities and homeowner associations, by leaving the responsibility of service provision to the market forces (Wu, 2010, 2022). As Fig. 1 demonstrated, the development logics of work-unit housing and commodity housing were distinct. The state's dual intention in urban development has further complicated the relationship between a neighbourhood's access to urban amenities and residential segregation.

Notably, migrant working labour and agricultural workers were largely excluded from owner-occupied neighbourhoods. Instead, these groups were accommodated in formal rentals in suburban satellite towns, informal rentals in peripheral villages, or manufacturing dormitories in industrial parks. Their marginalised position was reinforced by non-local or non-urban *hukou*, which denied them access to many local urban welfares. Specifically, migrants and primary industry workers had little access to own work-unit housing because they were outside the state welfare system that provided housing and accessible amenities. Nor were they the priority group in the urban housing market to choose housing in fully equipped and accessible neighbourhoods. The dominance of the centralised housing system and housing market consequently pushed the marginalised groups into peripheral neighbourhoods with limited accessibility for both institutional and practical reasons. In other words, institutional factors such as *hukou* policy and urban land-use planning continued to make people's rights to housing asymmetrical during and after housing reforms.

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