

Article

Spatial Heterogeneity of Housing Space Consumption in Urban China: Locals vs. Inter-and Intra-Provincial Migrants

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Abstract: The relationships between migration and housing congestion have attracted attention in engaging the public against the COVID-19 pandemic and some other public health crises. In recent years in China, promoting the citizenization (“shimin hua”) of migrants and improving the quality of urbanization have become the focus of attention in the new-type urbanization today. The housing space consumption of migrants is one of the important indices to look into regarding their real living status in the receiving cities: how do the housing consumption behavior and residential quality vary between the local, inter- and intra-provincial migratory patterns? This article uses the micro household data of the 1% population sampling survey conducted in 2015 by the National Bureau of Statistics of China to look into the spatial variance of the aggregate housing space consumption behaviors of the local and non-local population at the prefectural level and above in urban China. This study finds that: (a) the longer migratory pattern indicates a thriftier housing space consumption that implies a higher probability of residential overcrowding among the inter-provincial migrants; at the same time, the locals enjoy the greater living comfort than their migrant peers; (b) the spatial variance in terms of housing space consumption can be attributed to a series of destination city contexts, such as the geological background, city administrative rank, areal location, local-nonlocal demography, municipal economic growth, and the local residential development levels. The results show that the more “targeted” housing policies are needed to solve the housing difficulties with migrant workers for a goal of human-centered urbanization development. Although we lack the more detailed data-sets to examine the correlation between public health risks (like the COVID-19 pandemic) and housing congestion problems (especially with the population on the move), this research is still illuminating in terms of how to cut down the public health risk in a highly mobile and rapidly urbanizing context like China.

Keywords: migrants; locals; housing space consumption; migratory pattern; mainland China

1. Introduction

The degree of housing congestion is not merely a widely acknowledged indicator of poverty and deprivation, but also a target for policy-making in the sphere of public health [1]. As reported, the overcrowding problem in the rapidly urbanizing areas has become more severe in the past decades than in the OECD (Organization for Economic Co-operation and Development) areas [2]. Since population flow is a correlated factor explaining the spread of COVID-19 in early 2020 in urban China, and because housing overcrowding has a direct or indirect relationship with public health crises, it is thus believed that the relations between migration and housing congestion have attracted much attention in engaging

the public against the epidemic. Shen, Ai et al., Ying et al., and Kraemer et al. all indicated in their research on COVID-19 spread that the massive population movement was one of the most important triggers of COVID-19 transmission [3–5]. Disadvantaged residential status and housing conditions (e.g., displacement, crowded housing, and housing insecurity) were associated with lower security attainment, along with higher risks of disease spread. For instance, in New York City and California it was reported that higher residential density and severe housing crowding were conducive to the COVID-19 spread. Besides, social distancing [6–9], quarantine, handwashing and some other sanitation measures were not easy for those living in high-density, precarious or insecure housing conditions.

Since the market-oriented reform and open-up, China's rapid economic growth has promoted large-scale migration, especially the concentration of rural population to the cities and towns [10], which accelerated China's urbanization process to a great extent. In the past four decades, the number of China's migrants has expanded rapidly. As of 2016, China's migrants had reached 245 million, as high as 18% of the total population. The receiving cities' tolerance and their supply of public infrastructure and services including urban housing have profoundly affected the basic living conditions of the expansive migrants [11,12]. As the spatial representation of the social stratification progress across the urban populations, the housing spatial differentiation is an important entry point for measuring and evaluating the socio-spatial inequalities of different migratory groups, which brings great challenges for public health and environmental governance. Wolf's study revealed the close relations between infectious disease spread and socio-spatial inequalities [13]. Some scholars argued that the large-scale urbanization process may lead to an increased vulnerability to the spread of infectious diseases, and they emphasized that population changes and the infrastructure were key factors [14]. This makes the housing problems with migrants more and more concerned by the policy makers and researchers in a diversity of domains, including public policies against pandemics [15].

Housing space consumption (i.e., living area or degree of congestion) has been an important indicator for evaluating the quality of living [16]. Scholars have conducted a series of explorations on the housing crowding problems faced by migrants. Some studies on the United Kingdom [17,18], Germany [19], Austria [20,21], New Zealand [22], Spain [23], the United States [24], African countries [25] and other countries have shown that although the standards for insufficient space vary depending on the socio-economic conditions of the countries, the migrants, whether international or domestic, are normally related with the higher levels of housing congestion in the destination cities [26,27]. Studies on China have also shown that, although the contribution of internal migrants to urban development is obvious, migrants in the housing markets in the destination cities are characterized by the poor living quality and high congestion level [28,29], reflecting the contradictions between the economic growth and equality of well-being that need to be resolved urgently in the rapidly urbanizing and industrializing periods in China today.

The above studies laid the foundation for understanding the housing situations of the migrants. However, in existing research, migrants are often considered as homogeneous groups. In reality, they may differ. Due to a longer-distance migration, inter-provincial migrants would assume higher risks and costs than the intra-provincial migrants, and they also show differences in housing consumption behaviors [30]. This paper uses the micro data from the 2015 national 1% population sampling survey to focus on the migratory and geographical variance of migrant housing space consumption in China today. To be more specific, the characteristics of the spatial distribution of migrant housing space consumption are analyzed and visualized at the prefectural scale and above, for an overall view of Chinese migrant living conditions and their housing consumption capacities and preferences.

On this basis, the spatial regression analysis is conducted to reveal the influencing factors for such a regional variance in the housing situations of the migrants. Our study provides a reference and basis for housing policy making in different kinds of cities, to promote the wellbeing of migrant workers in transitional China. Although we lack detailed datasets to examine the correlation between public health risks (such as the COVID-19 pandemic) and housing congestions (especially for the population

on the move), this research is still illuminating in terms of how to cut down the public health risk in a highly mobile and rapidly urbanizing context like China.

2. Migration, Housing Space Consumption, and its Health Effects

Housing crowding has attracted much attention in the past decades, especially in metropolitan regions like New York, London, Tokyo, Hong Kong, Beijing and Shanghai [31]. WHO (2000) confirms that overcrowded environments are more likely to spread diseases [32]. It is pointed out that migrants are more likely to be exposed to multiple deprivations and greater risks of transmission of the disease (including tuberculosis) [33–35]. With further research, direct or indirect connections between the overcrowding housing conditions and the poor physical and mental health (ranging from respiratory disease, meningococcal disease, *H. pylori* bacterial infection, neurological disorders, to psychological and behavioral dysfunctions) are documented, too [36]. It is shown that housing overcrowding in childhood would increase the likelihood of poorer health conditions in adulthood [37]. In addition, it is also revealed the rural migrants live in very crowded houses, and are easily exposed to dangers (like accidents, violence, fire risk) and diseases due to the poor housing conditions. As early as 1998, when the Centers for Disease Control and Prevention issued recommendations on the prevention and control of tuberculosis among U.S. foreigners, it pointed out the complexity of the migration phenomenon and reiterated the need to supplement the epidemiological characteristics of diseases in these populations, in order to take better and more efficient prevention and control measures [38].

2.1. Institutional Background: Migration and Housing Consumption Divergence under Hukou System

The complexity of China's urban housing market is embedded in its economic transformation and institutional changes of the past four decades [29]. To date, many researchers believe that *hukou* status is still one of most important factors in predicting the individual/household housing resources in Chinese cities [8,39,40]. Similar to the Soviet Union's domestic passport system (*propiska*) [41], the pre-reform *hukou* system required official approval for internal migration, and migrants became another group of the urban society to be organized and planned, economically and socially. In the pre-reform periods, the *hukou* system (i.e., residence registration) was once intertwined with the distribution of the social welfare, security and services (such as public housing, education, and health care) [42,43]. This shows that it was the social contract between the state, locals and nonlocals that affected the housing choice and consumption preference as well as the living conditions of different residence and migratory groups [44].

Since 1978, the market-oriented economic reforms in China have promoted inter-regional or rural-urban migration, which is induced by the enduring imbalanced regional development [45]. As early as 1985, rural migrants got the official approval to work and live in cities with their "temporary residence permit" [46]. Since the late 1980s, city governments have begun to grant the blue print *hukou* and talent residence permit to investors and skilled migrants [30]. Since the late 1990s, further *hukou* reforms have led to the localization of *hukou* management that was conducive to the local economic growth [47,48]. During the 1990s and 2000s, the coastal regions and metropolises have been the main destination areas of a massive migration, due to their preferential policies to promote the inflows of foreign direct investment (FDI) and the growth of non-state sectors [49]. These push-pull forces and the increasingly relaxed *hukou* control have triggered the profound urban transformation and the dynamic geographies of the migratory landscape, with migrant residence and housing conditions being one of the most important migrant wellbeing indices. After implementing the pilot program in 1997, the central government initiated the nationwide *hukou* reform in 2001 to grant urban *hukou* to eligible rural migrants. Due to the fiscal decentralization and the GDP growth-oriented goals of local governments, receiving cities tended to use local *hukou* to attract high-skilled and wealthy migrants [50]. Recent *hukou* reforms include the unification of agricultural and non-agricultural *hukou*, as well as grading schemes for local *hukou* in some major cities [40,51]. In 2014, reforms of the *hukou* system further relaxed the migration control policy. The reform unified the *hukou* system between urban and

rural areas. The *hukou* status difference between agricultural and non-agricultural, or between rural and urban, is no longer distinguishable by an ID card and *hukou* booklet. The temporary residence permit system was cancelled, and the residence permit was established. The measure guides housing security to cover all permanent residents, so that better public services can benefit migrants. But the local-migrant divergence persists, dividing their respective residence into disparate socio-economic and geographical spheres. In addition, migrant talents [52–54], migrant children [55–58], and migrant seniors [59–61] have attracted more attention in the past several years.

Migration under the *hukou* (household registration) system can be divided into migration with *hukou* changes and migration without *hukou* changes. The latter type is referred to as migrants, which become the object of this study. Holding a residence card or not, although they may have resided in the host cities for many years, they have little access to housing security including public housing which is the preferential policy of local urban residents [43,62]. As shown by Chan Kam Wing, Zhou Yixing, and Ma J. C. Laurence, migrants are the main source of the growth of the de facto urban population in China, but they are not the fully de jure urban population [63,64]. People are on the move, from rural to urban, and from underdeveloped to more developed areas, in search of better economic opportunities and living condition improvements. In recent years, migrants have gained more and more independent decision-making power owing to the increasingly relaxed *hukou* control [65]. Nowadays, the administrative barriers to socio-spatial mobility between rural and urban areas are diluted to some extent, but the differences in *hukou*-based policies as well as the work and social environments including housing consumption still exist. Under the “migratory bird migration” model [66,67] that is based on the rational considerations at the individual or household level [68–70], migrants often choose to reduce their housing space consumption and live in dormitories provided by the work unit or market rental housing.

For instance, many studies on the housing issues of Chinese migrants have focused on the impacts of the above institutional-related factors upon migrant housing choice and consumption [71]. It was shown that a series of structural factors such as the institutional environment have played a crucial role in explaining migrant housing consumption preference and outcome [72]. For instance, it is deemed that the *hukou* system is an institutional arrangement, inseparable from the social governance, resource allocation, and redistribution of benefits, thus contributing to Chinese socio-spatial stratified structure with *hukou* as a main dimension (local vs. nonlocal) [73]. As previously analyzed by Chan and Buckingham in 2008, despite the relaxation of migrant restrictions, there has still been a lack of access to urban public housing and other substantial benefits among migrants in receiving cities [41]. In a word, *hukou* still affects residents’ access to and opportunities for housing resources. Scholars such as Huang found that *hukou* has weakened the migrants’ capacities and opportunities to access socio-economic support in urban housing markets, in terms of housing financing, purchase limits, and other types of monetary allowance and public housing quota allocation [29]. In big cities, for example, local governments require that residents purchase commercial housing and apply for public housing, based on whether they have a local *hukou* or a successive several-year stable work and residence in the host city. Chan believes that the local *hukou* and working in the public sector can offer more opportunities to improve housing consumption and ease living congestion [63].

In contrast, the urban migrant population are at a socio-economic and institutional disadvantage [62]. Today, compared with local residents, migrants have fewer opportunities to obtain affordable housing, such as low-rent housing (*lian-zu-fang*), public rent housing (*gong-zu-fang*), economic housing (*jing-jishi-yong-fang*), limited-price/size housing (*liang-xian-fang*), and housing provident funds. Migrants have to find a way out in the dynamic housing market [74]. This also means that there is a large group of migrant workers in Chinese cities whose work and life are at stake. Therefore, they usually choose to live in small-sized, poor-quality, and thus low-cost, accommodation to save expenses and enhance their ability to resist risk [75,76]. At the same time, low-cost rental houses suitable for migrants with low ability to pay are generally located in “non-mainstream” residential areas such as urban villages, urban-rural junctions, old communities, and even basements [77,78]. It is reported that

the per capita housing area of migrant tenants is far smaller than that of local residents, as 80 per cent of the latter are homeowners [79]. Group living (*qunzu*) and “ant colonies” are common, and therefore living spaces are overcrowded among migrant households. It can be seen that the lack of housing security has further strengthened the housing overcrowding problem of migrants, partially due to demolition and rent increases. In addition, unlike other developing countries, China’s urban land-use regulation and appearance management policies do not allow the construction of slum-style self-built residences in cities. For this reason, it is difficult for migrants to reside in cities informally.

Although research generally considers migrants to be in a disadvantaged position in the urban housing market, with the deepening of research, the academic community has gradually shifted from treating migrants as “passive recipients” under institutional constraints to the “enabling agents” and “strategists” who respond to housing challenges. Some studies have found that after the housing marketization reform, institutional constraints on migrant housing choice and consumption have gradually decreased, but the migrants themselves lack the motivation to improve urban housing [80]. As a result, some scholars have criticized existing research on migrant housing consumption in host cities, arguing that the relatively socio-economic disadvantages and the high mobility characteristics of migrants are the key to understanding the logic of migrant housing selection and preference, which is distinct from locals.

In the real-life scenario of rural-to-urban circular migration in China, the housing consumption behavior of migrants is related to the attribute characteristics of their demand and the consumption willingness induced by it. Wu (2004) pointed out that the previous studies paid little attention to the impact of the characteristics of temporary and cyclical migration of migrant workers on their housing choices and conditions, and therefore suggested a comparative analysis of urban housing choices of temporary versus permanent migrant workers [81]. Some studies also point out that, in addition to income constraints, the uncertainty of migrants’ intention to stay in the future also directly affects the improvement of their housing conditions. The situation of “passengers in the city” has led most migrants to have lower expectations for housing, and for this reason they may reduce their willingness to consume large and high-cost housing in the destination city [61].

Empirical analysis shows that due to the high consumption of urban housing and the attributes of expensive durable goods, combined with the low level of migrant income [82], the affordability of housing is relatively weak, which makes the housing consumption of migrants low. Compared with local residents, generally low income and relatively high market costs have raised the “sunk cost” of long-term housing consumption; and economic rationality has driven migrants to rent fewer long-term housing of better quality. At the same time, the more “frugal” urban housing consumption of migrants is closely related to their “migratory bird migration” characteristic. Some migrants also tend to compress housing consumption to obtain the maximum net income and remit home, which is their rational choice under the constraints of mobility. The migrant work orientation and high willingness to save will make them maintain the “migratory bird migration” status for a long time [83,84], which lowers the acceptance threshold of urban housing conditions among migrants and makes them prefer temporary housing with flexible leases and low prices. Such housing is often relatively small. Therefore, we follow previous findings and propose Hypothesis 1:

Hypothesis 1 (H1). *Other things being equal, the different housing consumptions owing to different residential and migratory status will lead to different housing crowding patterns.*

2.2. Impact of Migratory Patterns on Housing Consumption: Inter- vs. Intra-Provincial Migration

In recent years, with the expansion of migration scale and changes in migration characteristics, migration models have attracted widespread attention from scholars. Among them, there are many discussions on migration distance and its impact, while there are few studies on the impacts of migration distance (short- vs. long-distance category) on the housing consumption of migrants. From this perspective, migration can be divided into inter- vs. intra-provincial moves. Compared with

the intra-provincial population migration, the inter-provincial ones are the long-distance large-scale migration phenomenon [85,86], which is more significantly affected by the socio-economic disparities between regions and migration networks at the macro-scale in China [87]. It is assumed in this paper that the distinct migratory pattern (inter- vs. intra-provinces, or short- vs. long-distance) acts as one of the prominent factors in distinguishing migrant housing consumption, including space consumption in the host cities. This difference can reflect the survival and integration status of groups of different residence and migratory types in the inflow area, so it is worthy of attention.

As mentioned earlier, the housing choice and consumption of migrants are an active adaptation under constraints [39]. The original motive of the migration was mainly to pursue the maximization of benefits and achieve material needs. Migrant housing consumption is also based on the pursuit of utility maximization [88,89], under constraints of individual budgets and urban integration opportunities. Here, we treat the migratory distance as a reliable proxy to indicate the great variety of the objective socio-economic characteristics and subjective settlement intentions of the migrants. These socio-economic and psychological variances of inter- vs. intra-provincial migrants, to a certain extent, may affect the trade-off and preference of migrant housing consumption, living environment demands, and finally on aggregate housing space consumption behavior across the diverse migratory distances [90]. Therefore, we assume that there exist differences in housing space consumption between inter- vs. intra-provincial migrants.

Theoretically, migratory distance may affect the housing consumption of migrants through various mechanisms. On the one hand, migratory distance may affect urban housing consumption by affecting migrant income levels and living costs [91]. For example, some studies have pointed out that compared with long-distance migration, migrants who have migrated nearby are more familiar with the labor market; for this reason, their accumulated human capital may be more suitable for the local labor market which may bring forth higher paying jobs [92]. In addition, existing research generally proves that the nearby and in situ urbanization can reduce the costs of social integration of migrants [93]. It implies that intra-provincial migrants who are closer to their original places are more likely to save basic living expenses, in terms of food, transportation, and housing searching. For inter-provincial migrants, longer distance migration brings higher migration costs [94]. Studies have shown that the impact of migration distance on migrant consumption is mainly reflected in terms of living costs, information acquisition efficiency and social adaptation processes [95]. On the other hand, compared with short-distance migration, the higher uncertainty of inter-provincial migration will lead to a more “frugal” consumption and a stronger saving motivation of migrants to a certain extent, and then affect housing space consumption [96]. Ravenstein pointed out that population migration was dominated by short distances and long-distance migration destinations are dominated by developed industrial and commercial centers. With the territorial management of the *hukou* system, inter-provincial migrants may face more institutional and policy resistances. This will increase their uncertainty about the future, and indirectly deflate the housing consumption expectations of migrants.

In addition, the migration distance will also affect the willingness of migrants to settle, and then affect the housing consumption preference. Generally speaking, the higher the long-term expectation of migrants to work and live in the city, the more they will help increase their long-term consumption of durable consumer goods such as housing. The existing research also generally proves that nearby urbanization is conducive to the migrants’ family reunification and increases their willingness to settle down [88]. The willingness to settle has a significant positive impact on the consumption of migrant families. With other conditions unchanged, the consumption of migrant families who intend to settle in the local area is 17% higher than that of migrants who do not intend to settle locally [88]. The long-term willingness of migrants to stay in the city may not only be the result of a combination of factors such as their individually differentiated occupation types, economic conditions, and human capital structure, but also be affected by territorial characteristics such as information search [97], habitat complex and cultural dependence.

In 2014, the New Urbanization Strategy focusing on promoting human urbanization and improving quality was launched in China. With this promotion, China's urbanization development has shown new characteristics, involving speeding up the *hukou* reforms and comprehensively improving urban settlement conditions. With the relaxation of *hukou* system and the deepening of housing reform, the demarcation between non-agricultural and agricultural populations in some cities (such as Shenzhen and Guangzhou) is gradually disappearing. It is foreseeable that, compared with institutional factors, the individual or household rational decision-making will play a more active role in migrant choices of housing area and comfort.

In short, the living needs of the family, and how much area to buy or rent in the urban housing market, have attached great importance to their sense of belonging in the city and the long-term goal of living in the destination city. Migrants always make relatively rational housing choices. In this process, the considerations of inter- vs. intra-provincial migrants are different. In China, there are few studies on the housing differences of different migration modes. Based on this, this paper constructs an empirical model to measure and explain the spatial variance of urban housing space consumption of locals and inter- vs. intra-provincial migrants. The spatial regression model is conducted to reveal the influencing factors and influential mechanism of local, inter- vs. intra-provincial migrant housing space consumption. Conclusions will focus on the more "targeted" housing policies that are needed to solve the housing difficulties of migrants towards the goal of human-centered urbanization development. This research is also illuminating in terms of how to reduce the public health risk in a highly mobile and rapidly urbanizing context like China. In this paper, we propose Hypotheses 2 and 3 as follows:

Hypothesis 2 (H2). *Other things being equal, long-distance migratory patterns are more likely to lead to more crowded housing conditions.*

Hypothesis 3 (H3). *Other things being equal, regional disparities are the main proxy to differentiate the housing space consumption at the prefectural geographical and administrative level.*

3. Materials and Methods

This section introduces: (a) the data source and its reliability and representativeness; (b) the geographical scale at which the individual samplings are aggregated and at which this spatial analysis is conducted; and (c) the spatial modellings that are employed in this empirical research.

3.1. Data

This article uses the 2015 1% census micro-family data from the National Bureau of Statistics of the People's Republic of China (NBS, PRC). The comprehensive coverage and high reliability of national census data help us provide reliable results for the whole population of China. More importantly, the detailed individual/household information from the 2015 1% national census data makes it possible to investigate the variances at the household level of housing scarcity and crowding [98]. Our research questions focus on the spatial distribution of the household-level housing space consumption of the local residents, inter- and intra-provincial migrants in over 300 prefectural level cities and above in China, and the influencing factors behind this spatial variance. In this article, the housing space reported by households in the 2015 1% census is adopted as the main housing consumption index for this comparative study on the different residence and migratory populations, and the numbers of household housing space are averaged and summarized at the prefectural level. The database includes 1,331,670 micro data samples with high reliability and validity (see Table 1).

Table 1. Sample statistics.

	Locals	Inter-Provincial Migrants	Intra-Provincial Migrants	Total
Sample Size	1,221,189	78,936	31,545	1,331,670
Mean Housing Space (m ²)	92.65	77.66	81.17	83.82

3.2. Methods

3.2.1. Global Moran's I Coefficient

Spatial autocorrelation refers to the potential interdependence of some variables observed in the same distribution region. Due to the influence of the spatial interaction and spatial diffusion, the geographic data may not be isolated from each other but related. The spatial autocorrelation of the housing space index of different residence and migratory groups (locals, inter- vs. intra-provincial migrants) across the country is an important aspect of understanding migrant well-being distribution patterns in China nowadays. Moran's I index is the common method used to detect the spatial autocorrelation in data. Moran's I index is calculated as follows:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} z_i z_j}{\sum_{i=1}^n z_i^2} \quad (1)$$

In the above formula, z_i is the deviation of the attribute of element i from its average value ($x_i - \bar{x}$), z_j is the deviation of the attribute of element j and its average value ($x_j - \bar{x}$), and w_{ij} is the spatial weight between elements i and j ; n is equal to the total number of elements, and S_0 is the aggregation of all spatial weights:

$$S_0 = \sum_{i=1}^n \sum_{j=1}^n w_{ij} \quad (2)$$

If Moran's I index is positive, it is reflected as a tendency toward clustering; if it is negative, it is reflected as a tendency toward dispersion. In this paper, the Moran's I Index can measure the spatial correlation of the housing space consumption of the diverse residence and migratory groups (locals, inter- vs. intra-provincial migrants) across the country, and representing whether their housing space consumption is spatially clustered, random, or discretely distributed. In this study, we choose to use the rook spatial weight matrix.

3.2.2. Getis-Ord G_i^*

This article uses hotspot analysis to count the hotspots and coldspots of the spatial distribution of housing space consumption of the different residence and migratory groups (locals, inter- vs. intra-provincial migrants) across the country. Based on the hotspot analysis of the normal distribution hypothesis test, this method can further detect whether the spatial elements belong to high-value clusters or low-value clusters than local indicators of spatial association (LISA). The calculation formula for hotspot analysis is as follows:

$$G_i^* = \frac{\sum_{j=1}^n w_{ij} x_j - \bar{x} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{[n \sum_{j=1}^n w_{ij}^2 - (\sum_{j=1}^n w_{ij})^2]}{n-1}}} \quad (3)$$

where x_j is the attribute value of element j , w_{ij} is the spatial weight between elements i and j , n is the total number of elements, and

$$\bar{x} = \frac{\sum_{j=1}^n x_j}{n} \quad (4)$$

$$S = \sqrt{\frac{\sum_{j=1}^n x_j^2}{n} - (\bar{x})^2} \quad (5)$$

\bar{x} is the mean, S is the standard deviation, and G_i^* is the score of the index z for calculating statistical significance. From the obtained z -score and p -value, we can know where the high-value or low-value features are clustered in space, and whether they are significant or not. When z is positive,

the higher the z-score, the closer the high-value clusters are; when z is negative, the lower the z-score, the closer the low-value clusters are.

3.2.3. Spatial Regression Models

In order to study the root causes of regional differences in the housing space consumption, it is necessary to understand the socioeconomic and spatial mechanism behind housing consumption. Research on regional inequalities usually uses various conventional regression methods, such as the most commonly used ordinary least squares method (OLS), generalized moment method (GMM), and maximum likelihood method (ML). However, if there is a spatial autocorrelation that cannot be eliminated from the model, spatial regression models (SRM) will be performed. Two types of SRMs can be generated, namely the spatial lag model (SLM) and the spatial error model (SEM). This study uses three sets of complementary regressions to study the direction of influencing factors that predict the housing consumption variance in different residence and migratory patterns at the city level. The spatial lag model (SLM) is used to reflect the spatial autocorrelation and spillover effects of a spatial unit on other nearby units in the entire area. The SLM can be computed in an equation by

$$y_i = \sigma \sum_{j=1}^n W_{ij} y_j + \beta x_{ik} + \mu_k + \varepsilon_i, \quad \varepsilon_i \sim \text{k.k.d}(0, \delta^2) \quad (6)$$

where i denotes the spatial location of cities; y_i is the dependent variable (i.e., household housing space of local residents and long- and short-distance migratory residents); x_{ik} ($k = 1, \dots, 10$) represents the ten independent variables (as abbreviated later in Section 4.2: Table 3); β is the local regression parameter to be estimated; σ is the correlation coefficient in spatial regression, reflecting the spatial dependence of the objects; and W_i is a diagonal weighting matrix. The statistical data of independent variables are derived from the Chinese City Statistical Yearbook in 2016. Data about the rent level variable in each city come from Xitai data, which is China's biggest real estate transaction database, accessed from the website <http://www.cityre.cn>.

The spatial multiplier in the spatial error model (SEM) is only related to the error. Based on the spatial position of the observed value in the spatial error formula, the balance effect of the substantial covariate will not change. The SEM thus considers the error term rather than the spatial dependence of the dependent variable. In view of the spatial autocorrelation between variables, the SEM can solve the result deviation caused by the lack of independent error terms. The SEM is generally based on the following autoregressive model:

$$y_i = \beta x_{ik} + \mu_k + \varphi_i, \quad \varphi_i = \rho \sum_{i=1}^n W_{ij} \varphi_j + \varepsilon_i, \quad [\varepsilon_i \sim \text{k.k.d}(0, \delta^2)] \quad (7)$$

where ρ is the spatial autocorrelation coefficient of the error term; φ is the error term of spatial autocorrelation.

4. Results

4.1. Spatiality of Housing Space Consumption: Locals, Inter- vs. Intra-Provincial Migrants

Our research focuses on Tobler's first law of geography and the theories on spatial interaction—distance has a retarding effect on human interaction because there are increasing penalties in time and cost associated with longer-distance, more expensive interchanges [99]. When it comes to housing consumption behavior and housing quality, our research Hypotheses 1 to 3 highlighted the impacts of the institutional barriers (*hukou* differentiating local or nonlocal) and distance of migration (inter- or intra-provincial migrants) on people's housing consumption and crowding. That is, the longer migratory pattern indicates a thriftier housing space consumption that implies a higher probability of

overcrowding among the inter-provincial migrants; at the same time, the locals enjoy a greater living comfort than their migrant peers. In reality, the contexts are actually quite complicated when it comes to tenurial attributes. Renting is a pure housing consumption behavior, but housing purchasing has multiple motivations that include investment and consumption at least. It is difficult to guess the motivations for buying if it is a very small apartment situated in a high-quality public-school zone.

Based on the literature on relations between migration pattern and housing consumption, *hukou* has exerted a great influence on the degree of housing congestion. In this study, we observed the spatial aggregation and dispersion of the housing space consumption of locals and nonlocals (inter- vs. intra-provincial). It would be quite appropriate in the context of transitional China to consider and measure the huge areal heterogeneity across the different regions and administrative levels. The next analysis includes two research objectives: (a) measuring and mapping the regional heterogeneity of housing space consumption of inter- vs. intra-provincial migrants compared with local residents; (b) explaining the above spatial distribution mechanism of housing space consumption across different residence and migratory modes.

Table 2 shows the global spatial autocorrelation of housing space consumption of locals, inter- and intra-provincial migrants at the prefectural level in China in 2015. The Moran's I value of housing space consumption is reported as 0.486, 0.349 and 0.445 for locals, inter- and intra-provincial migrants, respectively, indicating a medium level of the significantly positive spatial agglomeration across the urban units in China ($p = 0.001$ for each group). Z values of the three residence and migratory groups all exceeded the critical value of 1.96 at the confidence level of 0.05. Based on this, it can be considered that the spatial distribution of housing space consumption is distributed in the non-random state for locals, inter- and intra-provincial migrants, showing a positive spatial correlation and agglomeration characteristics. Using ArcGIS 10.2 software, the spatial distribution and hotspot maps of the housing space consumption in 2015 were drawn and are shown in Figure 1.

Table 2. Global spatial autocorrelation.

	Moran's I	Z (I)	p
Locals	0.486	14.848	0.001
Inter-provincial migrants	0.349	10.122	0.001
Intra-provincial migrants	0.445	13.152	0.001

On the whole, the spatial differentiation of housing space consumption in China is obvious. For urban local residents, their household housing space generally demonstrated a highland in Mid-Eastern China and a lowland in Northern and Northeastern China (see Figure 1a,b). For migrants, the eastern coastal area is an economically developed region with high population density, strict land management, and therefore higher housing and rental prices, as well as a high level of housing crowding (see Figure 1c–f). Comparatively, the housing expenses in the vast Central China are lower than in the more advanced coastal area, and relatively higher wage levels in the “economically active regions” surrounding the Greater Wuhan metropolis and the Guangdong megalopolis would explain the high-value cluster among migrant workers (see Figure 1c–f). The better living conditions would be another economic strength to attract the highly mobile migrant labour force to the “transitional zones”, with a location advantage bridging the more advanced coastal and the less developed inland economies.

Research shows that, in general, the locals who are mostly homeowners in the context of urban China may live in more spacious housing than migrants who are mostly renters. Migrants' pragmatic housing choices (urban village, basement, co-renting, etc.) made to cut down “unnecessary” expenses in the receiving cities can also explain their thrifter consumption preference, and the resulting housing crowding among migrants compared to the locals. This is true especially for inter-provincial migrants in the main reception cities in coastal China (Figure 1c,d), where local governments need to attach more importance to housing crowding and the public health issues of their cross-provincial migratory groups. The above features not only suggest targeted policies to solve properly the housing problem

with different migratory groups and regions, but also remind us of the different risks and preventions against contagious diseases (such as COVID-19) since short- and long-distance migrants are clustering in different ways (Figure 1d vs. 1f).

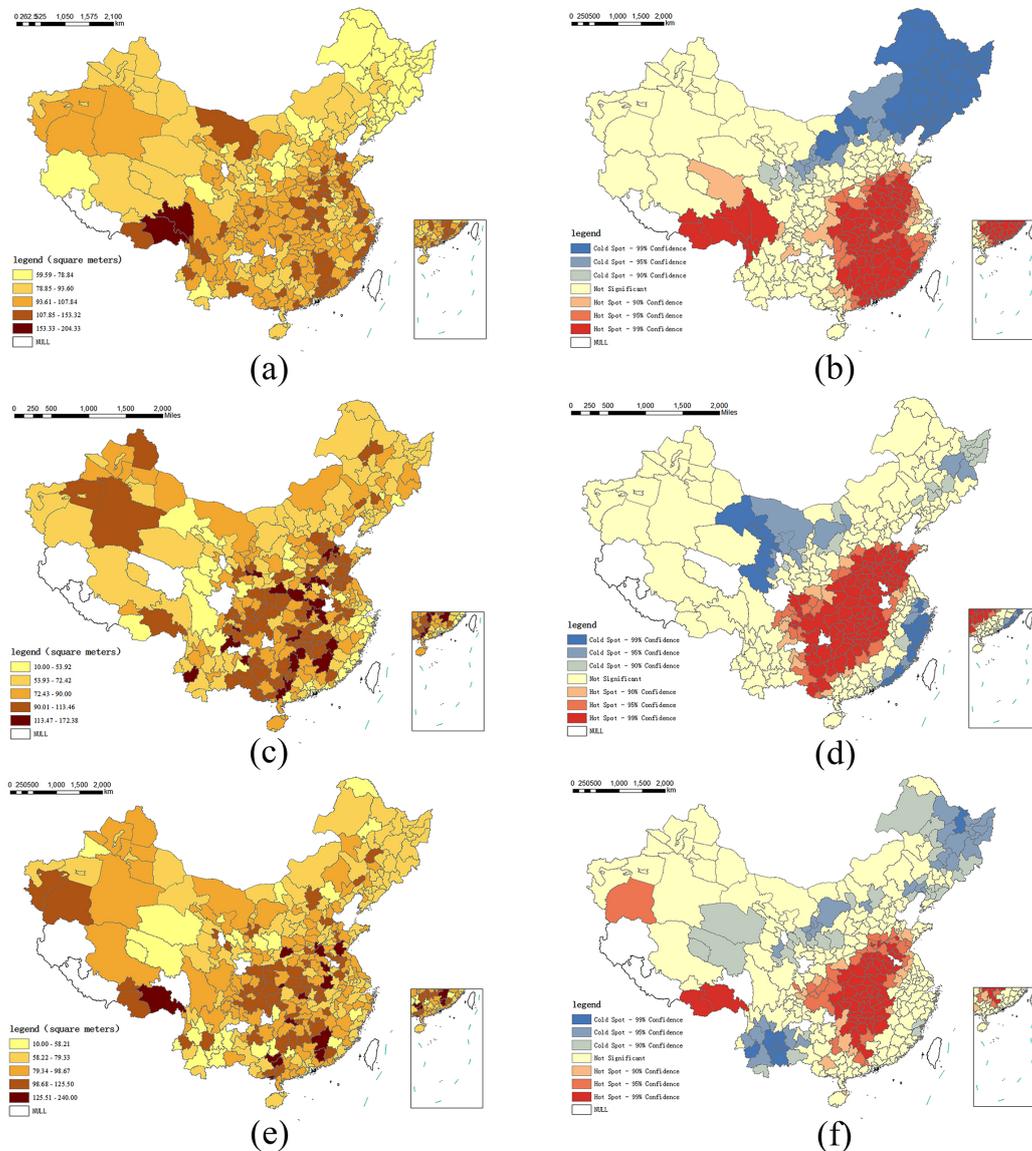


Figure 1. Spatiality of the household housing space consumption of locals, inter- and intra-provincial migrants in urban China: (a) local household housing space (m^2); (b) hotspot analysis of local household housing space; (c) inter-provincial migrant household housing space (m^2); (d) hotspot analysis of inter-provincial migrant household housing space; (e) intra-provincial migrant household housing space (m^2); (f) hotspot analysis of intra-provincial migrant household housing space.

4.2. Influence Factors Explaining Spatial Variance of Local vs. Nonlocal Housing Space Consumption

4.2.1. Variable Selection

Whether from a macro- or micro-perspective, the consumption of urban housing space is affected by a series of factors, ranging from the individual/household dimensions towards local territorial features [100,101]. This paper discusses the influence of the socio-economic characteristics of prefectural-level cities on local and migrant housing congestion in the different regions in China. It is assumed in this paper that the regional disparity is a main proxy to differentiate the housing space

consumption at the prefectural geographical and administrative level. The regression models select the following regional-level factors to interpret the spatial variance of the local, inter- and intra-provincial migrants' housing space consumption: (a) geological and environmental background that is measured by slope (slope is the ratio of climbing height to horizontal movement distance of the ground; the higher the value is, the steeper the slope is); (b) city rank (provincial level—centrally administrated municipality or not); (c) areal location (East China or not); (d) local-nonlocal demographic structure that is measured by the proportion of migrant population; (e) municipal economic growth levels that are indexed by GDP (Gross Domestic Product), employee wage, and fixed asset investment; and (f) the local residential development that can be measured in terms of residential land expansion, residential investment, and rental level. As assumed, the same set of factors would have quite different influence on the spatial variance of housing consumption of different migration pattern (locals, inter- vs. intra-provincial migrants). Influential factors with strong explanatory power are described in Table 3 below.

Table 3. Dependent and independent variables in the spatial regression models.

	Variable Group	Variable	Variable Description
Explained variable	Housing consumption	Housing space	Household housing space (square meters)
	Geological background	SLOPE	Slope
	City rank	RANK	Provincial level as reference
	Areal location	AREA	East China as reference
Explanatory variables	Local-nonlocal demography	POP	Proportion of migrant population
	Municipal economic growth	GDP	Gross domestic product in each city (thousand yuan)
		WAGE	Average wage of employees on duty (thousand yuan)
		FAI	The fixed asset investment in each city (billion yuan)
	Local residential development	LAND	Average annual expansion rate of residential land
INVEST		Per capita residential investment (thousand yuan)	
RENT		Housing rental level in each city (yuan)	

Three models are used for a regression analysis, that is, the ordinary least squares model (OLS), the spatial lag model (SLM) and the spatial error model (SEM). The variable relations can be modeled:

$$\ln P_i = \beta_1 \text{SLOPE}_i + \beta_2 \text{RANK}_i + \beta_3 \text{AREA}_i + \beta_4 \text{POP}_i + \beta_5 \text{GDP}_i + \beta_6 \text{WAGE}_i + \beta_7 \text{FAI}_i + \beta_8 \text{LAND}_i + \beta_9 \text{INVEST}_i + \beta_{10} \text{RENT}_i + \lambda$$

$$i = 1, 2, \dots, N$$

where $\ln P$ is the dependent variable indicating the housing space consumption index, i is the regional unit, λ is the constant term, β_1 – β_{10} is the regression coefficient of each of the independent variable and is the random error term.

In addition to the above structured factors listed in Table 3, some other factors that can be hardly calculated or quantitatively expressed are important in the spatiality of housing crowding, too. For instance, cultural behavior and lifestyle may also influence overcrowding to some extent. People living in different cultural areas or ethnical communities may be inclined to make different living choices, and some may prefer living in the same high-density cultural or ethnical areas [102–104]. In the Oriental value system, clan and collectivist cultures may be keen on compact communities. East Asian societies have traditions of patriarchal, Confucian, family-oriented, and collectivist values, and are inclined to live in crowding environments [105]. But in face of the COVID-19 pandemic, areas with a strong individualistic culture may be more comfortable living in isolation, and therefore it may be easier for them to implement quarantine and social distancing measures. More considerations should be given to integrate these more complicated cultural and social factors into the research framework in the future.

4.2.2. Regression Analysis Results

In this paper, we analyze the driving factors that can explain the spatial variance of housing space consumption among different migration types by using ordinary least squares (OLS), the spatial lag model (SLM), and the spatial error model (SEM). In conducting the GeoDa, it is recommended to use AIC (Akaike information criterion) as a metric for model fitting, where a smaller AIC indicates a better fit of the model. It is found that the SLM is more appropriate in the regression model explaining the spatiality of housing space consumption among: (a) the local residents ($R^2 = 0.93$, AIC = 2581.88); and (b) intra-provincial migration ($R^2 = 0.73$, AIC = 3028.51). However, SEM is better for inter-provincial migration ($R^2 = 0.58$, AIC = 3165.39). The detailed results are listed in Table 4.

Table 4. Regression results.

Variable	Locals			Inter-Provincial Migrants			Intra-Provincial Migrants		
	OLS	SLM	SEM	OLS	SLM	SEM	OLS	SLM	SEM
CONSTANT	1.205	−2.997	1.853	13.528 ***	6.296	12.281 ***	2.094	−1.093	2.201
SLOPE	−1.432	−0.185	−0.977	−5.499 **	−3.431	−4.421 *	−4.428 **	−3.270	−4.343 **
RANK (Provincial as ref)									
Sub-provincial	62.883 ***	57.349 ***	62.370 ***	54.738 ***	47.735 ***	51.893 ***	64.736 ***	59.564 ***	64.222 ***
Prefectural	88.794 ***	82.392 ***	88.370 ***	73.284 ***	65.235 ***	70.843 ***	84.608 ***	78.782 ***	84.348 ***
AREA (East China as ref)									
South China	−0.494	−0.447	−0.023	7.403	6.385	8.380	5.391	4.945	5.394
Central China	6.805 ***	6.946 **	6.681 ***	21.521 ***	19.841 ***	23.730 ***	11.841 ***	11.276 ***	11.670 ***
North China	−5.645 **	−5.330 **	−5.364 **	1.421	0.892	1.808	−1.039	−0.807	−0.814
Northwest China	−5.760 **	−5.000 *	−6.219 **	4.490	4.165	4.263	−3.449	−2.967	−3.485
Southwest China	2.205	3.094	2.180	18.390 ***	17.929 ***	20.501 ***	4.107	4.519	4.112
Northeast China	−20.590 ***	−17.630 ***	−20.590 ***	−4.910	−2.550	−1.488	−12.037 ***	−10.226 **	−11.839 ***
POP	4.054	7.168	5.114	−30.672 **	−20.234	−21.313	−26.472 **	−22.035 **	−26.442 **
GDP	−0.037	−0.026	−0.035	−0.041	−0.035	−0.059	−0.048	−0.040	−0.047
WAGE	0.022	0.021	0.019	−0.020	−0.025	−0.029	0.062 *	0.060 *	0.061 *
FAI	0.052 ***	0.048 ***	0.054 ***	0.062 ***	0.054 ***	0.058 ***	0.064 ***	0.059 ***	0.064 ***
LAND	3.640 ***	3.634 ***	3.500 ***	0.737	0.680	0.303	−0.267	−0.247	−0.271
INVEST	−0.345 ***	−0.323 ***	−0.341 ***	−0.148	−0.140	−0.132	−0.575 **	−0.561 **	−0.570 **
RENT	522.360 ***	461.940 ***	449.900 ***	−235.587	−233.498	−98.756	190.065	165.480	193.488
R ²	0.925	0.928	0.926	0.561	0.572	0.582	0.726	0.729	0.726
Sigma ²	107.056	97.760	99.244	587.554	544.518	531.729	382.479	359.553	363.222
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Log likelihood	−1279.460	−1272.940	−1276.742	−1571.460	−1568.100	−1565.694	−1497.830	−1496.250	−1497.741
AIC	2592.920	2581.880	2587.480	3176.910	3172.190	3165.390	3029.670	3028.510	3029.480

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Ordinary least squares is known as OLS, the spatial lag model as SLM, the spatial error model as SEM, and the Akaike information criterion as AIC.

5. Discussion

5.1. Disparate Patterns of Housing Crowding: Locals, Inter- vs. Intra-Provincial Migrants

As revealed in Table 2 and Figure 1, the different residential and migratory groups have shown their disparate patterns of housing crowding. Relations between migration and housing congestion are embedded in their perspective residential or migratory status, together with macro-level regional contexts. Our research attests the Hypotheses 1 and 2 as follows. The spatiality of housing crowding is differentiated among the locals, inter- and intra-provincial migrants in the following ways.

Hypothesis 1 (H1). *Other things being equal, the different housing consumptions owing to different residential and migratory status will lead to different housing crowding patterns.*

Hypothesis 2 (H2). *Other things being equal, long-distance migratory patterns are more likely to lead to more crowded housing conditions.*

For urban local residents, their household housing space generally demonstrated a highland in Mid-Eastern China and a lowland in Northern and Northeastern China (see Figure 2a). To be more specific, high-value spots were scattered sparsely in Mid-Eastern China, rather than sprawling in a continuous manner. The large housing space consumption regions were generally surrounding the regional central cities (including provincial level cities like Shanghai and provincial capital cities like Guangzhou and Wuhan), but shunning these high property value cities. Interestingly, Shanghai, Fuzhou, Zhengzhou-Kaifeng, Jinan, Guangzhou and Wuhan have been identified as the “hollowing” in such a “doughnut-like” high-value concentration. High-value spots were mainly found in Suzhou, Wenzhou, Putian, Quanzhou, Dongguan, and some other rapidly urbanizing areas surrounding their regional central cities (see Figure 2a). In these rapidly urbanizing second-tier cities, their new residential investment and construction, together with a high purchasing power, can explain the relatively larger housing space consumption among urban local residents. Besides, Changdu, Linzhi and Lijiang on the Qinghai–Tibet plateau also saw large housing space consumption for locals due to their high socio-economic development and habitability levels. The relatively crowded areas covered North and Northeastern China, including the border of the Inner Mongolia Autonomous Region, Shaanxi, Shanxi, and Hebei Provinces, which averaged at 70–80 square meters per household among local residents. This was attributable to the lagged industrial restructuring and urban (re)development in these areas. Figure 2b demonstrates clearly a “mid-eastern and southern highland vs. north-northeastern lowland” contrast, as well as a hotspot in the rapidly urbanizing areas of the Qinghai–Tibet plateau. In general, housing comfort in Southern China is better than that in Northern China, and the housing space in Central and East China is significantly higher than that in Northeastern and Northwestern China (see Figure 2b). The better living conditions for the local *hukou* populations were accompanied by higher levels of economic development and industrial restructuring, with regional central cities as exceptions owing to the housing unaffordability and the complicated housing reform, preservation and redevelopment policies in these historical megacities (see Figure 2a,b). The active population migrations, together with the persisting *hukou* regulations in the Chinese coastal cities, however, have exerted more complicated and differentiated impacts on inter- and intra-provincial migrants. There, therefore, have formed different housing space consumption landscapes between the local and nonlocals.

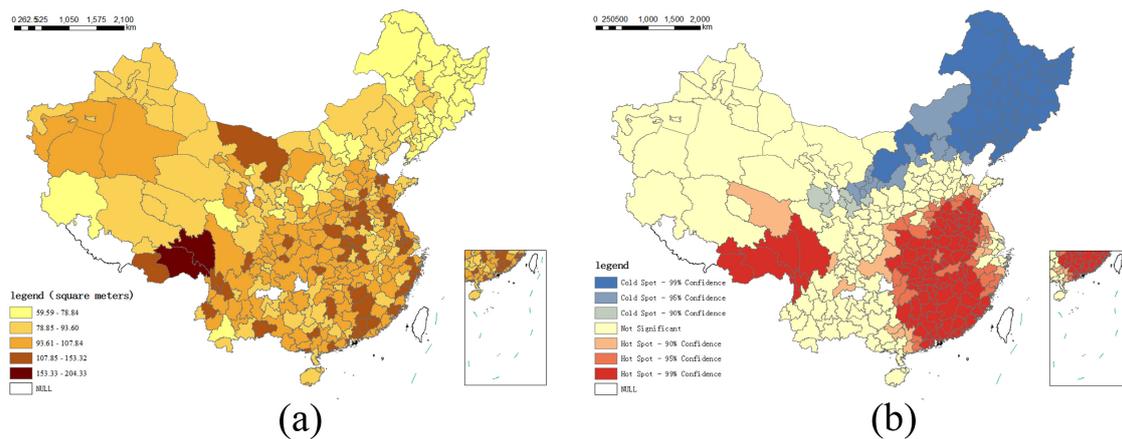


Figure 2. Spatiality of the household housing space consumption of locals in urban China: (a) local household housing space (m^2); (b) hotspot analysis of local household housing space.

For inter-provincial migrants who are in long-distance migratory groups (see Figure 3a,b), it is interesting that the vast Central China (from Southern Hebei and inland Shandong stretching south towards Guangxi) has showed a high-value concentration. But compared with the locals and shorter-distance migratory groups (shown in Figure 2a,b and Figure 4a,b), long-distance migrations across the provincial boundaries have displayed some distinct features, owing to the influential cross-provincial spillover effects from the main coastal and inland megalopolises, such as the Pearl River Delta and the Greater Wuhan metropolis [106]. First, the Southern Hebei and inland Shandong Provinces witnessed a continuous high-value concentration, with two cities situated on the provincial border as its peaks. But the Shandong peninsula that is more export-oriented has seen relatively low values, compared to the above inland areas. The relatively low housing and rental prices in the inland Shandong, alongside the higher housing expenses in the Shandong peninsular areas (like Qingdao, Yantai and Weihai), could explain such an inland-coastal divide to some extent. Second, in the case of Henan Province which is affected by both the Zhengzhou and Wuhan urban clusters, there have been shaped two high-value belts: a) Xuchang, Kaifeng and Shangqiu surrounding the Zhengzhou Metropolis; and b) Nanyang and Xinyang situated on the Henan–Wuhan provincial border that is more attracted by the Greater Wuhan Metropolis. This cluster pattern can be partially attributed to the robust spatial interactions including their cross-provincial demographic migrations, along with relatively lower housing costs, thus resulting in a comparatively stronger housing affordability for inter-provincial migrants in the above areas. Third, in Hubei Province, there was still a “doughnut-like” large housing space consumption concentration of inter-provincial migrants, with Wuhan (as the provincial capital) identified as the “hollowing” of “doughnuts” owing to the relatively unaffordable housing and rental prices in the large metropolis. Fourth, several cities in Hunan, Jiangxi and Guangxi Provinces (such as Fuzhou and Ganzhou in Jiangxi Province, Wuzhou and Yulin in Guangxi Province, and Yongzhou and Hengyang in Hunan Province), were all on the border with Guangdong and Fujian Provinces and near their respective provincial capital cities. These cities displayed the strip-like high-value cluster situated on the border between the more advanced coastal economy (like Guangdong and Fujian Provinces) and the less developed inland economies (like Hunan, Jiangxi and Guangxi Provinces). These border zones that are also “transitional zones” with a location advantage, have attracted inter-provincial migrant workers whose wages enable them to afford the relatively lower housing costs there. Fifth, the high-value clusters of the above border and “transitional zones” have contrasted with the housing crowding clusters in the coastal belts, which stretch from the Yangtze River Delta to Fujian and Guangdong’s coastal cities (see Figure 3b). Figure 3b demonstrates the coldspot dispersed in the following three regions: (a) northeastern lowlands; (b) low-value clusters in the Inner Mongolia Autonomous Region and Gansu Province; and (c) the strip-like low-value cluster along the coastal areas in Yangtze River Delta, Fujian and Guangdong Provinces. This implies a coexistence of

housing crowding problems with inter-provincial migrants, in both the resource-exhausted cities and the traditional manufacturing regions in Northeastern, Northern and Northwestern China, and also situated in the most active open-up coastal China. However, inter-provincial migrant households of the vast Central China have consumed a significantly larger housing space, indicating a better living and thus a higher level of habitation in these places for longer-distance and cross-provincial migrants.

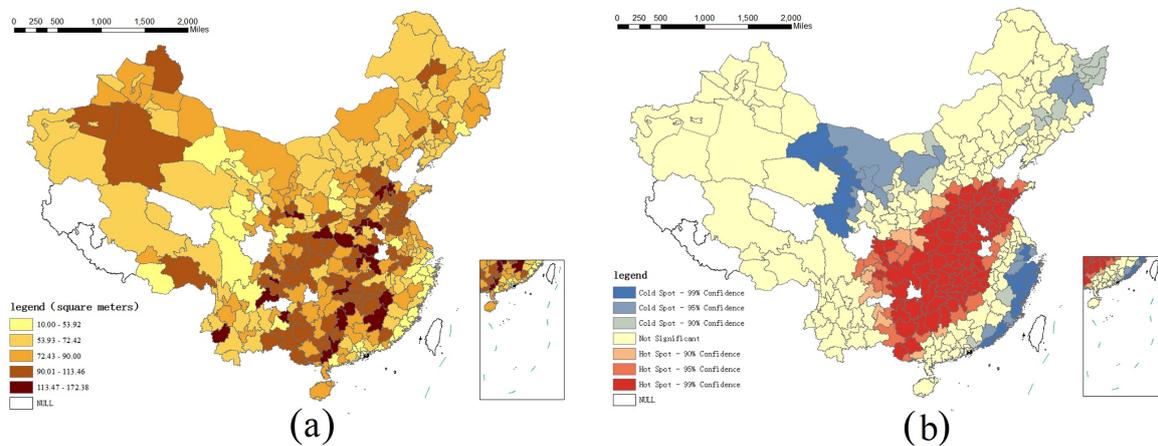


Figure 3. Spatiality of the household housing space consumption of inter-provincial migrants in urban China: (a) inter-provincial migrants' household housing space (m^2); (b) hotspot analysis of inter-provincial migrants' household housing space.

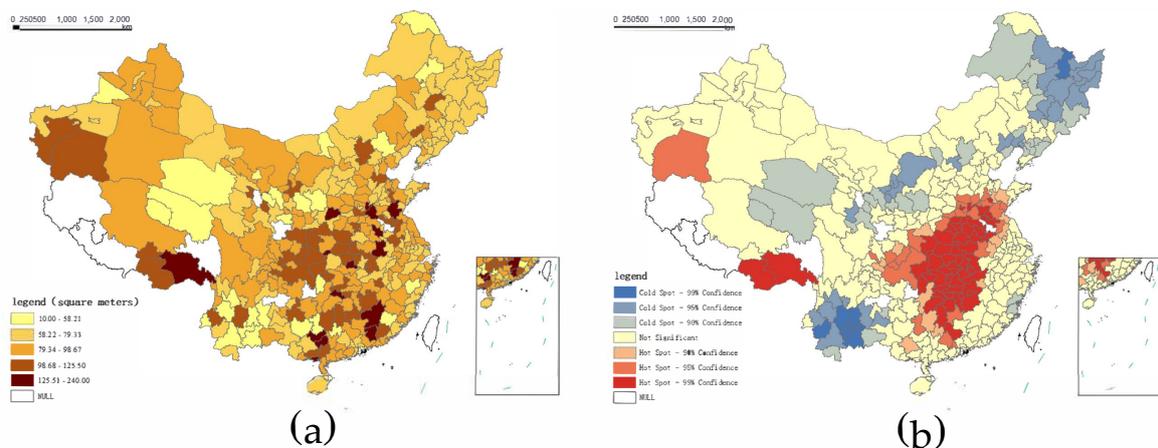


Figure 4. Spatiality of the household housing space consumption of intra-provincial migrants in urban China: (a) intra-provincial migrants' household housing space (m^2); (b) hotspot analysis of intra-provincial migrants' household housing space.

For intra-provincial migrants who were experiencing a shorter-distance migration (Figure 4a,b), their high- and low-value areas of household housing space consumption are basically the same as for their inter-provincial peers, but their specific scope has shrunk and expanded in different kinds of areas. The main symptoms of high-value locations for the intra-provincial migrants are as follows. First, there was a shrink of high-value clustering in Central China (see Figure 4a,b), compared with inter-provincial migrants (Figure 3a,b). As shown in Figure 4a, the geographic concentration of the intra-provincial migrants' housing space index in Central China was composed of six local clusters: (a) several high-value spots on the border of Shandong, Henan and Anhui Provinces (such as Linyi and Heze in Shandong Province, Puyang in Henan Province, and Bozhou and Lu'an in Anhui Province); (b) the "doughnut" in Hubei Province with Wuhan as its "hollowing" was acknowledged, somewhat similar to the inter-provincial migrant peers, but in a less dense cluster with medium-high value; (c) Chongqing and its surrounding cities on the border of Southern Shaanxi, Northeastern Sichuan and

Southwestern Hubei have been another medium-high value cluster, and in a close adjacency to Hubei's "doughnut-like" medium-high concentration; (d) the provincial border regions between the coastal Guangdong and the inland Jiangxi and Hunan Provinces have shaped a high- and medium-high value clustering in Southern China; (e) coastal belts (ranging from the Circum-Bohai-Sea Region, Shandong Peninsula, Yangtze River Delta, Fujian Province, and Pearl River Delta) were the dispersed distributions; and (f) the rapidly urbanizing areas of the Qinghai–Tibet plateau have also witnessed a cluster of high values. As shown in Figure 4b, intra-provincial migrants' housing crowding areas were present in the Northeast, Northern, Northwest and Southwest China, as well as Ningde and Fuzhou in the coastal Fujian Province. A relatively low wage level in the inland and rustbelt areas, and a high concentration of migrants in some coastal cities can explain the housing crowding problems with the intra-provincial migrants.

5.2. Explaining Spatial Variance of Housing Crowding: Locals, Inter- vs. Intra-Provincial Migrants

The regression analysis in Table 4 attests Hypothesis 3 that other things being equal, regional disparities are the main proxy to differentiate the housing crowding at the prefectural geographical and administrative level.

According to the above regression results in Table 4, we can see that the geological feature that is indexed by slope (SLOPE) has exerted a negative impact on housing space consumption across all the three residence and migratory groups (i.e., locals, inter- vs. intra-provincial migrants), and have either marginally or highly significant impacts on the migrant populations. The higher the slope, the greater the difficulty and cost of building construction—this explains the relatively housing crowding in the areas with a physical feature and landform of the higher or steeper degree of "tilt".

The provincial, sub-provincial and prefecture-level cities have different administrative ranks. The provincial cities refer to municipalities directly under the Central Government, and there are four cities in China. The sub-provincial city is a city with a sub-provincial administrative structure, whose predecessor was a city with a separate plan. The prefecture-level city is the main body of prefecture-level administrative areas, accounting for most of the total number of prefecture-level administrative areas. As shown in Table 4, it is found that the city administrative rank (provincial level cities, i.e., centrally administrated municipality, as reference) is one of the significant indicators here, across all the three residence and migratory groups. This is due to the higher real estate value of higher-ranked municipalities. Almost all the residence groups are aggregately sensitive to the long-lasting housing unaffordability issues in the megacities. The locals and non-locals have consumed the significantly more spacious housing when living in the sub-provincial and prefectural level cities than their peers in the provincial level cities. The crowded housing situation in Chinese first-tier cities (such as Beijing, Shanghai, Guangzhou and Shenzhen) is a good example. The higher the administrative level of a city is, the more the gap between migrants' origins and destinations will affect the settlement intention of migrants, thus reducing their will for greater housing consumption in the destination city.

It is also impressive that the index of areal location (East China as reference) has exerted a distinct influence on the housing space consumption across the different residence and migratory groups. The locals and nonlocals in Central China enjoy significantly more spacious housing than their peers in East China; meanwhile, the locals and nonlocals in Northeast China, which is a typical "rust-belt", have consumed less than their peers in East China (significant for the locals and intra-provincial migrants, while insignificant for the longer-distance inter-provincial migrants). A boom of the Central China economy (e.g., surrounding the Greater Wuhan Metropolis and also bordering the Guangdong Megalopolis), and the relatively higher wage level while lower housing expenses in the vast Central China would explain the better housing conditions across all the three residence and migratory groups (locals, inter- vs. intra-provincial migrants) in Central China. Residents in Southwest China have reportedly consumed more spacious housing than those living in East China; and this areal variance is reported as significant for inter-provincial migrants. Figure 3a,b shows a cluster of housing crowding phenomenon in Yunnan Province; however, the greater Southwest China (e.g., Chongqing, Sichuan and

Guizhou Provinces) has witnessed high values, too. This tells the reason for the results gap between the spatial analysis and visualization in Figure 1 and the regression results shown in Table 4. Besides, the locals in North and Northwest China have consumed more crowding housing than their peers in East China, owing to a relatively slow industrial restructuring in these manufacturing belts and inland less developed regions in China.

The local demographic feature (POP, that is the proportion of non-local-*hukou* population in the total population) also shows an opposite-directional impact on the locals and nonlocals. The housing space consumption among the local residents is more inelastic to the influx of migrants than that of their migrant peers. The intra-provincial migrants would consume significantly smaller housing space if the destination city is attractive to migrants. This housing choice preference is also apparent for inter-provincial migrants, but not as significant as for the intra-provincial migrants. As the “transitional” layered residence and migratory category between the local *hukou*-holders and longer-distance cross-provincial-boundary migrants, the short-distance intra-provincial migrants would be more sensitive to the structural demand change in housing markets in the destination city. But the locals and inter-provincial migrants who are situated at the two ends of residence stratification can either access the housing privatization and local public housing, or are more likely to be stuck in temporary and circular migration, therefore, with a preference for an under-consumption in shelter. This explains why a short-distance intra-provincial migration in the context of transitional China is reportedly more sensitive to the dynamic housing market changes owing to the great influx of migrant workers.

The municipal economic growth (measured in terms of GDP, WAGE, and FAI) together with the local residential development (indexed by the residential land expansion, residential investment per capita, and housing rental level) have shown similar “screening effects” towards different residence and migratory groups. As shown in Table 4, the impact from GDP is insignificant. The FAI (i.e., fixed asset investment) has a positive influence on all the three residence and migratory groups, implying that the locals and nonlocals would gain the better housing conditions in the better improved built environment. A similar positive but marginally significant influence from WAGE (i.e., employee wage) is merely reported for the intra-provincial migrants, but not for the longer-distance inter-provincial migrants. Here, the greater uncertainties in cross-provincial boundary migration would discourage housing spending to some extent, even among the higher-paid inter-provincial migrant workers.

The faster residential land expansion in the cities can predict the significantly improved housing conditions in terms of housing space consumption for the local *hukou* holders. However, this impact on two migrant groups is reported as insignificant, probably owing to a quite high homeowner ratio for locals but very low homeowner ratio for migrants in the context of China. A real estate boom with the Chinese characteristics has complicated influence on the different residence and migratory groups, as demonstrated in Table 4. INVEST (residential investment per capita) has a negative impact on housing space consumption, which is significant in the model of the local *hukou* holders and intra-provincial migrants, but insignificant for inter-provincial migrants. This may be related to the strong demands in the housing markets in the regions with vast housing investments, and therefore probably high housing prices and rentals. Both locals and nonlocals in these areas would trade off the housing comfort for more savings. This is consistent with previous research results [72,87]. Lin pointed out that the cost of living is inextricably linked to urban housing prices [107,108]. This is especially true in the areas with the real estate fever. The inter-provincial migrants are reported as a little more “alien” to the highly invested and fevered real estate markets, partially owing to the pragmatic housing strategies (like urban village, basement, co-renting, etc.) to cut down on “unnecessary” housing expending in the host cities. RENT (housing rental) exerts the different impacts on different residence and migratory groups, too. The locals live in a greater comfort in high-rental regions, as beneficiaries of local housing market development, and owing to their quite high homeowner ratio but very low tenant ratio among the local *hukou* holders in urban China. However, a reported negative relation between RENT and inter-provincial migrants’ housing space consumption tells another story about the longer-distance migration to the host cities: the inter-provincial migrants are more disadvantaged in the urban real

estate market than the locals and shorter-distance migrants. Apparently, different residence and migration patterns would affect the housing choices and consumption behaviors, as revealed in our comparative studies shown here.

Due to a lack of more detailed dataset on COVID-19 diffusion in all cities in China, this paper was unfortunately unable to examine the correlation and mechanism between the public health risks (such as the COVID-19 pandemic) and housing crowding levels (especially with the population on the move). Although the COVID-19 pandemic is not the main focus of this article, this study is still instructive because targeted policies (e.g., social distancing, quarantine, handwashing and some other sanitation measures) on housing crowding areas and groups can help control the spread of COVID-19 and prevent new outbreaks. For instance, quarantining and self-isolating measures are important, but highly dependent on people who have access to secure and spacious housing. According to the above analysis, quarantine and social distancing are more applicable among the locals, rather than migrants. This is especially true in the coastal metropolises, wherein migrants are suffering from crowding, and this is more severe among inter-provincial migrants. What is more important, quarantine and social distancing are almost impossible in some informal tenements (such as urban villages and basements) that house low-wage migrant workers [7,109]. Our research has revealed the need to design and implement disparate measures towards the different residential and migratory groups in face of the COVID-19 pandemic, since that they are in quite different crowding patterns in different parts of the whole of China. More specifically, long-distance migrant workers in coastal metropolitan regions are those most likely to be exposed to the diseases. More prudent measures should be taken in crowding environments, to better protect rather than isolate the migrants living in high-density, precarious or insecure housing conditions.

6. Conclusions

Migration, urbanization and high population density are the main factors affecting the spread of diseases [110,111]. In the context of a public health crisis caused by COVID-19 and a highly mobile society, this study systematically analyzed regional heterogeneity of housing crowding and its influencing factors. The results show that there is a large gap between the housing area consumption of groups with different residential and migratory patterns. The results show that the longer the migration distance, the lower the consumption of housing space in the destination city, which means that inter-provincial migrants are more likely to be overcrowded, while local people enjoy a higher level of comfort than their peers. This confirms the hypothesis on the relationship between housing consumption behavior and housing quality. In the context of urban China, pragmatic housing choices for migrants to reduce “unnecessary” expenditures in receiving cities may explain their more frugal consumption preferences. Then, the spatial regression model was used to examine the influencing factors of housing crowding patterns in different residential and migratory groups. Correlation and regression analyses show that the spatial differences in housing space consumption are attributed to a series of destination city backgrounds, such as geological background, city administrative rank, areal location, local-nonlocal demographic composition, local economic growth, and local residential development levels. The influence of the above factors varies with different residential and migratory groups.

Our findings are consistent with previous literature on the housing status of migrants, which highlights that this group is generally at higher risk of housing overcrowding. New findings emerged when examining the differences between inter- and intra-provincial migration. The crowding is more severe among longer-distance migrants than that of their short-distance peers, especially in coastal metropolitan regions. This implies that longer-distance migrants in coastal metropolitan regions are those easiest to be exposed to the diseases. The targeted measures (e.g., social distancing, quarantine, handwashing and some other sanitation measures) on housing crowding areas and groups can help control the spread of COVID-19 and prevent new outbreaks. According to our analysis, quarantine and social distancing are more applicable among the locals, rather than migrants, especially in the coastal

metropolises. For this reason, more prudent measures should be taken in crowding environments, to better protect rather than isolate the migrants living in crowding.

In the absence of more detailed data sets, this paper was unable to examine the correlation between public health risks (such as the COVID-19 pandemic) and housing crowding levels, particularly in situations of population mobility. Although the COVID-19 pandemic is not the main focus of this article, our research has revealed the need to design and implement disparate measures towards the different residential and migratory groups in face of the COVID-19 pandemic, since they are in quite different crowding patterns in different parts of the entirety of China.

What is more, changes in housing prices were pronounced in major countries such as China and the United States because of COVID-19. According to data from the National Association of Realtors (NAR), in the USA, the median annual growth rate of national housing sales prices has remained at 8%, rising to \$280,600 by March 2020. A similar situation occurred in China. In January–February, various indicators of the real estate industry (such as real estate sales amount, sales area, development investment and new construction area) all fell, hitting their lowest level in nearly 20 years. However, from January to April, the average transaction price of newly built commercial housing in 100 cities in China was 15,517 yuan per square meter, up by 11.9% year-on-year in China. These data indicate that the complex interaction between pandemic diseases such as COVID-19 and housing conditions needs to be further analyzed in the study [112,113].

In general, as highlighted in our study, few studies have looked at housing overcrowding under different residential and migratory patterns, since most studies have treated migrants only as homogeneous groups. In our systematic review and spatial analysis, there are some limitations due to the lack of public health data and the limited selection of variables, which may lead to underreporting of overcrowding issues and public health risks. Despite the above limitations, the empirical results are still of great significance for understanding the patterns of housing crowding across different *hukou* and migratory groups in China. The study also has implications for how to reduce public health risks in the context of high mobility, rapid industrialization and urbanization in China. It is revealed that long-distance migrants in coastal metropolitan regions are those most likely to be exposed to the diseases. More prudent measures should be taken in these overcrowding environments to better protect rather than isolate the migrants living in high-density, precarious or insecure housing conditions. Besides, some other factors that can be difficult to calculate or quantitatively express are important in the spatiality of housing crowding, but not considered as structured factors in our regression analysis (see Table 3, such as cultural behavior and lifestyle). More considerations should be given to integrate these more complicated cultural and social factors into the research framework in the future.

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