



Social and spatial differentiation of high and low income groups' out-of-home activities in Guangzhou, China



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ABSTRACT

With China's rapid urbanisation driving its growing economy, the enlarging socio-spatial inequalities in the cities have received wide attention. Rather than following the largely studied residential spaces, this paper focuses on socio-spatial differentiation based on the spaces of one's out-of-home activities. Using data of 1006 individuals collected by door to door questionnaires, this paper sets up the spatial and temporal autocorrelation GT coefficient to examine the spatial heterogeneity characteristics of high- and low income groups' out-of-home activities in a continuous spatiotemporal framework. The factors and different mechanisms influencing the clustering of the activities are discussed to better understand social diversity in post-reform urban China. The results suggest that there is obvious spatial and temporal variation in high- and low income groups' out-of-home activities, indicating that differing social spaces are not just limited to the macro-static residence-based living space, but also exist in the individual's daily-activities space. Both high- and low income people have drastically different activity spaces and they may not interact much with each other. This is socially very significant because it means that there is considerable social isolation or segregation for both groups. The results also show that within the same income group there exists a divisive cluster with different formation mechanisms, including the job-housing relationship, the correlation of activity opportunities with those surrounding residential areas and the individual's ability to access activities (that is, space-time accessibility). Structural transition can also impact on activities choices of various social groups.

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Introduction

China's urbanisation level rose from 17.9% in 1978 to 49.68% in 2010 with a 3.24% annual growth rate (National Bureau of Statistics of China, 2008, 2011). This represents an unprecedented speed and scale of urbanisation. Based on GDP data in 2010, China has become the world's second largest economy with an important role in the world economic system. Whilst rapid economic growth has considerable potential to improve people's living standards, income inequality in China is becoming increasingly serious. Various statistical sources indicate that China's Gini coefficient was 41.5 in 2011, which exceeded the internationally acceptable warning level of 40. The quintile income ratio is now 8.4, which

means that the average income of the richest 20% of the population is 8.4 times higher than the average income of the poorest 20% of the population (United Nations Development Programme, 2013). China has become one of the world's countries with serious income inequality, which indicates that the benefits of China's rapid economic growth have not been equally shared by different levels of society. As social difference in China becomes increasingly serious (Gu & Christian, 1997; Yang, 2005), concern for social justice has attracted much attention and discussion.

It is widely recognised that post-fordist cities are often characterised by socio-spatial polarisation (Li, Wu, & Lu, 2004; Marcuse & Kempen, 2000). However, many post-socialist cities are also facing increasing socio-spatial divisions (Ruoppila, 2005). As China has transformed to a socialist market system in the last three decades or so, some new socio-spatial phenomena have emerged in the country (Ma, 2002). These include new gated communities (Wu, 2005), peasant enclaves, and *chengzhongcun* (villages in the city) for migrants (Ma & Xiang, 1998; Zhang, Zhao, & Tian, 2003).

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Many studies have examined the socio-spatial differentiation of post-reform Chinese cities and observed that post-reform urban China is characterised by residential segregation (Feng & Zhou, 2008; Gu & Liu, 2001; Li & Wu, 2008; Wu, 2002). Whilst it is important to examine social differentiation in residential spaces, it is also necessary to investigate whether social segregation happens in other places where people perform their out-of-home activities such as work, shop, and play (Kwan, 2013). This broadened focus will help us better understand socio-spatial differentiation and the complex relationships between social justice and spatial structure.

Individual behaviour has spatiotemporal characteristics. Examining individual spatial behaviour at the micro-level provides an important perspective and method for urban research. It analyzes the interaction between individual behaviour and urban space by considering how individual characteristics and demands impact on the activities system of a whole city (Chai, Liu, & Li, 2002; Zhou & Deng, 2010). Current research focuses on a series of particular behaviours, such as commuter and consumer behaviour (Giuliano & Small, 1993; Kwan, 1999; Vandersmissen, Villeneuve, & Thériault, 2003; Wachs et al., 1993; Shen, Kwan, & Chai, 2013); time allocation among different activities (Huff & Hanson, 1986; Pas & Sundar, 1995); the time allocation and changes between family members (Bhat, 1996; Golob & McNally, 1997; Mannering, Murakami, & Kim, 1994; Niemeier & Morita, 1996); multi-purpose travelling (Krzizek, 2003; Nishii & Kondo, 1992); decision-making simulation (Kitamura, 1984); and the realisation of 3D geographic visualisation (Forer, 1998; Huisman & Forer, 1998; Kwan, 2000, 2004; Yu, 2006). However, much research to date has used panel data for analysis, and studies that take into account individual behaviours spatiotemporally in a continuous space–time framework are still very limited.

Spatial behaviour and the associated activity spaces that unfold in a continuous space–time framework are important perspectives that reveal the quality-of-life and social equity issues in urban areas. Individual activity spaces are determined by three important determinants, such as home, regular activities, and travel between and around the pegs (Golledge & Stimson, 1997: 279). Thus, it consists of the visited locations, and the routes and areas one has travelled through (Schönfelder & Axhausen, 2003). The location and status of residential areas, and the frequently visited activity locations such as work or shopping would be important “anchors” of daily activity spaces. In urban China, the location and status of these “anchors” are deeply impacted by historical path dependence and urban social and economic transformation.

The widening social and income inequality in China mentioned above also manifests itself in the spatiotemporal behaviour of people (Shen et al., 2013). Recent research has found that poor people may work longer hours (thus facing more space–time constraints) and have lower mobility (because of a lack of access to private vehicles). Thus they are less free to move around and access various urban opportunities, such as shops and social and recreational facilities (Zhou & Deng, 2010). However, how would social inequality affect people’s spatiotemporal activities? What are the characteristics of the out-of-home activities clusters of different social groups? Why has the cluster formed? This paper will use case studies to examine these issues.

Income inequality intensified social differentiation during the post-reform era in China. Income is an important index for social stratification, where groups with different incomes can be used for social classification. Studies of how the daily activities of different income groups form different space–time clusters will help to reveal their social spatiotemporal segregation from a space–time perspective. This study uses spatial and temporal autocorrelation to examine the sociospatial differentiation between the activity

clusters of high- and low-income groups in a contiguous spatiotemporal framework. It presents a case study of Guangzhou based on a survey of a sample of residents’ behaviour to construct a spatiotemporal autocorrelation GT coefficient. It seeks to reveal the underlying mechanisms and factors contributing to such differentiation. Results of this research will be useful for addressing sociospatial equity issues and also optimising the allocation of urban resources.

Historical path dependence and socio-spatial differentiation of daily activities in urban China

As mentioned above, the location and status of activity “anchors”, mostly residential areas and workplaces, are deeply impacted by historical path dependence in urban China. The built environment formed in the socialist period such as *danwei* and in the post socialist era such as commercial and social housing and new industrial area, have some impact on current socio-spatial differentiation and thus impact on personal daily activities.

For decades, *danwei* was not only the basic unit of economic and social organisation, but also the spatial organiser in urban China (Bjorklund, 1986; Bray, 2005). According to Bjorklund (1986), *danwei* is a spatial framework in which social life, economic activity, and political control are integrated. Apart from offering a job, *danwei* provides its employees with a comprehensive package of welfare services for daily life, which deeply impact on not only residential but also people’s out-of-home activity choices.

After the revolution in China in 1949, especially after the socialist reform of the publicly-owned system, almost all properties and production were organised by *danwei*, with *danwei* responsible for setting up economic and social units. *Danwei* made decisions about the daily needs of individual households and became an ‘invisible hand’ which organised people’s daily activities. However, the historic path of the *danwei* system still plays its role in the current urban structure and thus on people’s out-of-home activities, especially for the employees of *danwei*.

In the socialist era, the *danwei* compound, a mix of housing, workplaces, and daily services was one of the main working and living units. People living in a compound mostly commuted by walking, resulting in mixed land use in ‘walking’ neighbourhoods. At the same time, with the development of the cities, and the lack of large pieces of land for compound construction, more and more *danwei* constructed their residential housing out of the compounds in areas called Danwei Residential Areas (单位生活区). Although it resulted in some geographical separation of jobs, housing and other services, the optimal strategy of the jobs-housing connection mostly came from the *danwei*, which tried to make this separation as small as possible. After the reform of the late 1990s, both labour and housing became more and more mobile and individual households had more decision-making autonomy. However, the *danwei* system still plays its role in the current urban structure and daily activities.

Instead of the much more socially diverse market system, social status in the *danwei* system is much less differentiated. Through the *danwei* compound providing jobs, housing and daily services, the development of mixed land use in the city is stimulated. The Danwei Residential Areas, however, encouraged some workplaces to relocate near to the large residential areas, which in turn may stimulate the mix of land use development around the living places. With the reform of the *danwei* system, some government-financed institutions and government offices, whose employees are mostly professionals and highly educated, left and the compounds of these *danwei* became one of the high-income groups’ daily activity clustering zones. At the same time, some

state-owned companies closed during this reform, and left their workers with no jobs and low incomes with subsequent low mobility in the places where some Danwei Residential Areas were located.

Thus, the much less socially differentiated status of people in *danwei* and the location of traditional *danwei* compounds and Danwei Residential Areas carry some impacts on residents' out-of-home activity even today, and become the activity clustering zones with high-income or low-income groups.

On the other hand, with the market-oriented reformation from 1978, urban China has faced social and spatial reorganisation. The transformation and increasing role played by the market such as the diversification of job opportunities, the development of the real estate market, and the improvement of household income have impacted greatly on both people's daily activities and thus the urban structure. The market has become one of the most important factors determining resource distribution, with opportunities distributed more according to individual ability. A greater diversity of high and low incomes together with different levels of mobility formed, resulting in the diversity of out-of-home activities.

Due to this dynamic system, some new high-end service and high-technology industrial areas attracted high-income earners. At the same time, older places with poor living and working conditions became areas attracting low-income earners who mostly engage in their out-of-home activities near their living places because of time constraints and low levels of mobility.

Under this dual system, planning in China still plays its role in influencing urban structure and impacts on peoples' daily activities through the housing supply and some new working places. After the reform of the economic system, China set up a dual housing provision system with subsidised social housing provided by local government for low income households and commercial housing provided by the market for middle- and high-income households

(Wang & Murie, 2000). Because of the low level of mobility of its residents, some social housing areas became low-income groups' out-of-home activity places. At the same time, with the power of planning, some new workplaces with high standards were formed and attracted high-income earners to these areas for their out-of-home activities.

Data and methods

The study area for this research is Guangzhou, one of South China's major cities and the capital of Guangdong Province. It is located on the Pearl River Delta adjacent to Hong Kong and Macao, the frontier region of China's reform and open-door policy. Guangzhou has been one of the fastest growing cities during China's development changes. Census data from 2010 show that the total population of Guangzhou was 12.70 million compared with 9.94 million in 2000, showing an increase of 27.74%. The total area is 7434 square kilometres, within which the urbanised areas comprise more than 900 square kilometres. In recent years, a lot of infrastructure has been constructed. The average road area per person has improved from 3.70 m² in 1990 to 11.20 m² in 2010, and eight underground rail lines have come into service in Guangzhou. However, traffic congestion is still a serious issue in the city. It is obvious that traffic demand has increased faster than the supply of transport infrastructure. Exploring the characteristics of people's daily behaviour will help to better understand the dynamics of traffic demand.

The data used for this study come from a random sample of household questionnaires completed in Guangzhou between May and August in 2007. 11 Neighbourhoods approximately 1 km² in size were chosen. They were selected from the central, transition and marginal districts in Guangzhou (Fig. 1), after considering the history, location, and housing types in the districts, such as

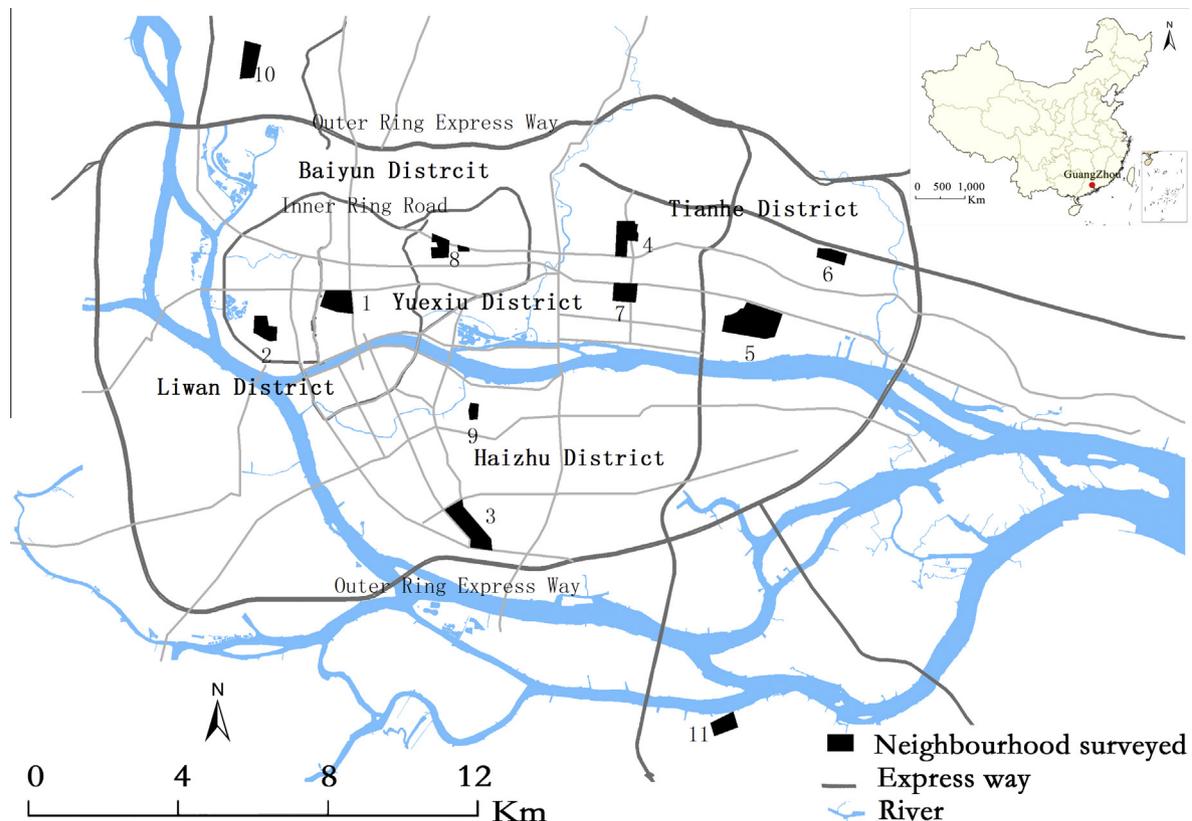


Fig. 1. Location of study neighbourhoods in Guangzhou, China.

traditional self-built housing, welfare housing, *danwei* compounds, mixed residential areas, commercial housing, and urban villages. 800 Families, comprising 1006 individuals in total were chosen randomly. One or two questionnaires were completed randomly in each family, excluding children younger than school age and unemployed people. Excluding those who did not complete the travel dairies, 982 samples were valid. Data were collected on basic social attributes, spatial information from the latest travel dairies on weekdays (travel purpose, time and mode), and so on. The places of out-of-home activities for each individual were mapped along with the attributes supplied by the questionnaires.

The spatial and temporal autocorrelation coefficient of GT was set up to examine the spatial and temporal clustering of the high- and low-income groups' activities. It was derived from the spatial autocorrelation coefficient that refers to the potential interdependence of the same variable among the observed data in a geographic area or region (Griffith, 1987). The spatial autocorrelation coefficient is one of the spatial statistical methods used for assessing the vicinity correlation and dependence across spatial locations. The integration of GIS and spatial statistics has led to important developments in spatial autocorrelation analysis, and is now widely used in many areas of research (e.g., see Basu & Thibodeau, 1998; Yu & Zhang, 2010). Cliff and Ord (1981) present an improved algorithm to calculate spatial autocorrelation index that can be used to test the statistical significance of spatial autocorrelation. They also define a local spatial autocorrelation index that can indicate high/low value clusters. López and Chasco (2007) proposed a univariate spatiotemporal autocorrelation index and expanded the original static single time-point focus to further reveal the effect of geographic correlation with dynamic changes. However, although many scholars have expanded spatial autocorrelation to a space–time model, they have adopted a given time period (such as a day or year) as the time dimension to intercept the time cross-section as the self-correlation, rather than considering time as a continuous variable, which inevitably makes the study of spatiotemporal autocorrelation asymmetric. Although adding the time variable to emphasise dynamic changes, it is only part of the interception time point, thus weakening the impact of the temporal dimension.

This study comprehensively improves upon these scholars' definition of spatiotemporal autocorrelation. The purpose of this case study is to modify the partial spatial autocorrelation coefficients G^* . The temporal autocorrelation coefficient T is defined with reference to G^* , and added to G^* to build a spatial and temporal autocorrelation coefficient of GT. This study focuses on the space–time clustering of the daily behaviour of groups with different incomes. The average individual monthly income is the observed variable. Three coefficients are defined as follows:

Spatial partial autocorrelation coefficient G^*

Getis and Ord (1992) proposed the partial G^* coefficient as a partial indicator of spatial autocorrelation for detecting high-value aggregation ('high-high' type) and low-value aggregation ('low-low' type). A significant positive G_i^* implies that large values of x_j (values above the mean x_j) are within distance d of point i . A significant negative G_i^* means that small values of x_j are within distance d of point i . Calculations were performed in ArcGIS with the Hot Spot Analysis tool (Getis-Ord G_i^*) as follows:

$$G_i^* = \frac{\sum_{j=1}^n w_{ij} x_j - \bar{X} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{ij}^2 - \left(\sum_{j=1}^n w_{ij} \right)^2}{n-1}}} \quad (1)$$

$$\bar{X} = \frac{\sum_{j=1}^n x_j}{n} \quad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^n x_j^2}{n} - (\bar{X})^2} \quad (3)$$

where x_j is the attribute value for the feature j ; w_{ij} is the spatial weight between features i and j ; and n is equal to the total number of features. G_i^* is simply a standard deviation. In our study, n is the total number of out-of-home activities' places of sample residents; x_i is the personal monthly income of sample residents' activities; and w_{ij} is the distance weight between the activity i and j , thus reflecting the degree of mutual influence between individual behaviours. We used the 'inverse distance squared' (IDS) to calculate w_{ij} in this study. A significant positive G_i^* indicated spatial clustering of high income samples' out-of-home activities, whilst a significant negative G_i^* indicated spatial clustering of low income groups samples' activities'.

Temporal autocorrelation coefficient T

The temporal autocorrelation coefficient T_i corresponds to the definition of spatial autocorrelation coefficient G_i^* (Formula (1)). Each activity has an event start time t_{i1} and end time t_{i2} , thus each activity point corresponds to a spatial coordinate (t_{i1}, t_{i2}) . The spatial autocorrelation coefficient G^* mainly measures the distance representing the relevant local interaction between spatial units. The smaller distance between two features will have more interaction between each other. This study defines time–distance z similarly with distance variables to measure the time similarity and simultaneity between two activities of two people. The smaller time–distance z examines the overlap of two activities' start times and end times. We define time distance of activities i and j as

$$z_{ij} = \sqrt{(t_{j1} - t_{i1})^2 + (t_{j2} - t_{i2})^2} \quad (4)$$

Referring to the local spatial autocorrelation coefficient of G_i^* (Formula (1)), the time autocorrelation coefficient T_i is calculated as follows:

$$T_i = \frac{\sum_{j=1}^n w_{tij} x_j - \bar{X} \sum_{j=1}^n w_{tij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{tij}^2 - \left(\sum_{j=1}^n w_{tij} \right)^2}{n-1}}} \quad (5)$$

Note that w_{tij} is the time weight between activity i and activity j – it equals z_{ij} here. The other variables are the same as for Formula (1). T_i is used to measure the time clustering of activities for different income groups. A significant positive T_i represents the time clustering of high income groups' activities; a significant negative T_i represents the time clustering of low income groups' activities.

Spatio and temporal autocorrelation coefficient GT_i

Space and time are the two continuous dimensions with the same influence, so the spatial autocorrelation coefficient partially G_i^* and temporal-autocorrelation coefficient T_i should have equal weight in constructing the spatial and temporal autocorrelation coefficient GT_i . Both G_i^* and T_i are standardised to be $N_{G_i^*}$ and N_{T_i} , and the spatiotemporal autocorrelation coefficient GT_i is calculated as following:

$$GT_i = N_{G_i^*} + N_{T_i} \quad (6)$$

A significant positive GT_i indicates spatial and temporal clustering of high income groups' activities, whilst a significant negative

result indicates the spatial and temporal clustering of low income groups' activities.

Spatial and temporal patterns of the high- and low-income groups' out-of-home activities

Taking personal monthly income as the observed variable, the standardised spatial autocorrelation coefficient N_{Gi^*} , the standardised temporal autocorrelation coefficients NT_i , and the spatio and temporal autocorrelation coefficients GT_i of each activity points were calculated and visualised in ArcMap and the Lorentz curve is plot to test the spatial unequal distribution of different groups (Figs. 2 and 3). These coefficients were divided into five levels by the Jenks method. The first level with a significant positive index represents the clustering of high income individuals' out-of-home activities, and the 5th level with a significant negative index represents the clustering of low income individuals' out-of-home activities. The figures show that the clustering of high and low values is much more significant with N_{Ti} indexes than N_{Gi^*} ones. Both spatial and temporal dimensions are important for out-of-home activities and Fig. 3 is the result of GT_i indexes.

The result of Lorentz curve in Fig. 3 showed that the distribution of high incomes' out-of-home activities is the most unequal, following with the low incomes'. Both high- and low-income people have drastically different out-of-home activity spaces and may

not interact much with each other. This is socially very significant because it means that there is considerable social isolation or segregation for both groups.

The whole sample included three categories of out-of-home activities, such as work, daily living (buying food and taking children to school) and recreation and shopping (entertainment, visiting friends and shopping). The distributions are different among them (Fig. 4). Work activities of the high-income groups are near to the new city centre, some governmental administrative office districts, and some newly developed industrial areas. Work activities of the low-income groups are mostly located in old city centre and some places near to some traditional communities, that is, the degraded worker-communities and urban villages in downtown, as well as the affordable housing in the outer ring of the city centre. Daily living activities of the high-income groups are near to some work units and some communities. Daily living activities of the low-income groups are mostly near to some traditional communities. Recreation and shopping activity places for high income groups are near to the new city centre, whilst those of the low-income groups are near to the low-income housing communities.

Spatial and temporal clustering of the high- and low-income groups' out-of-home activities

To examine the distribution pattern of the spatial and temporal clustering of high- and low-income groups' out-of-home activities,

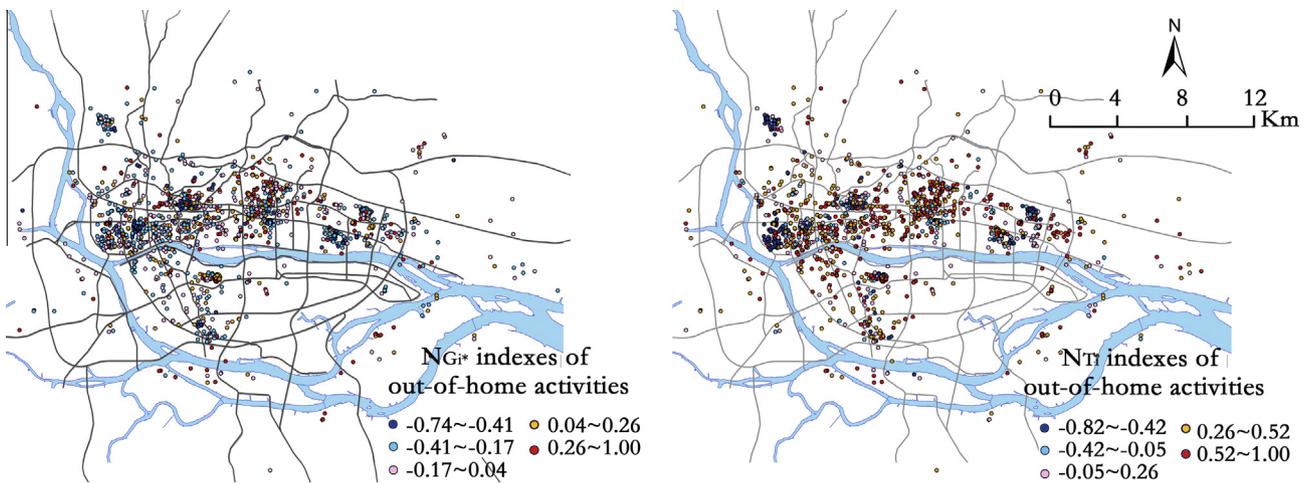


Fig. 2. The N_{Gi^*} and N_{Ti} index of out-of-home activities.

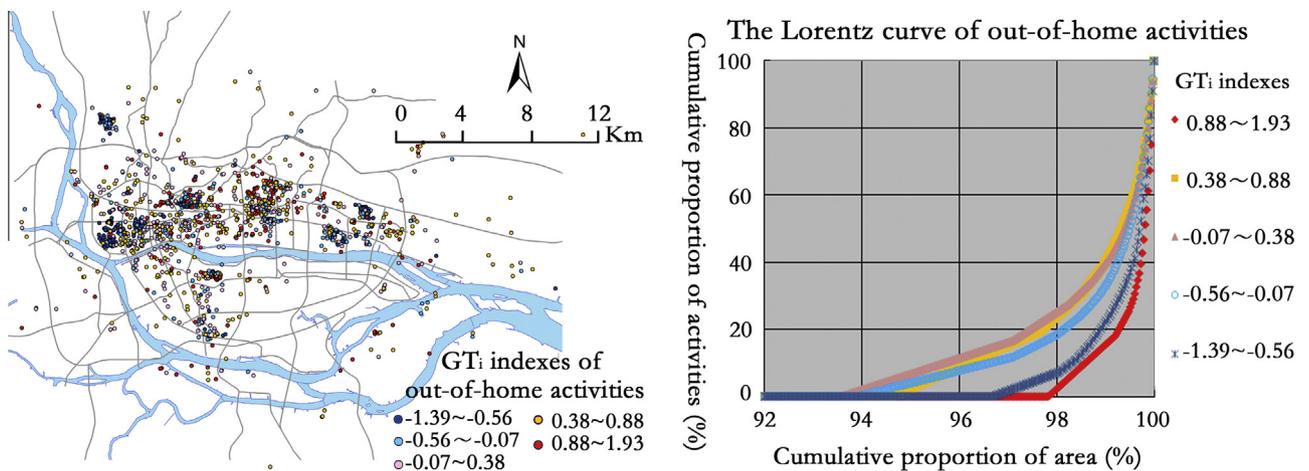


Fig. 3. The GT_i index and the Lorentz curve of out-of-home activities.

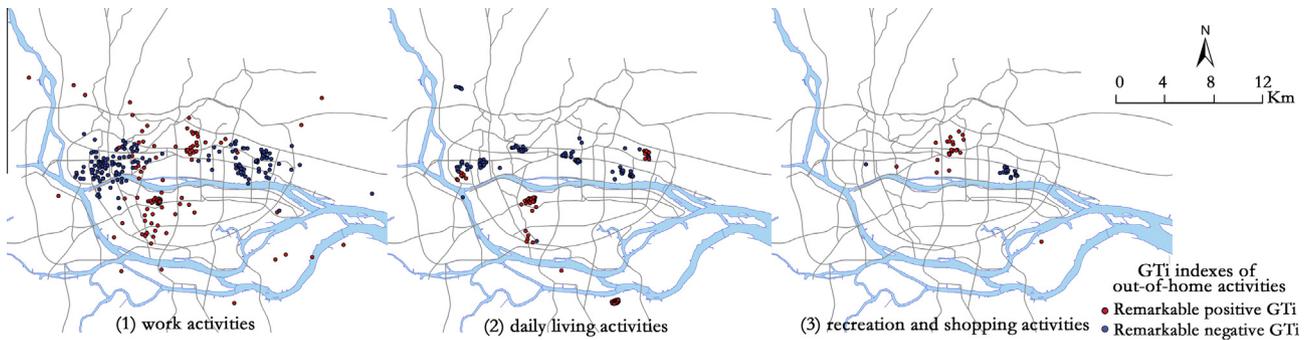


Fig. 4. The remarkable GT_i index of different out-of-home activities.

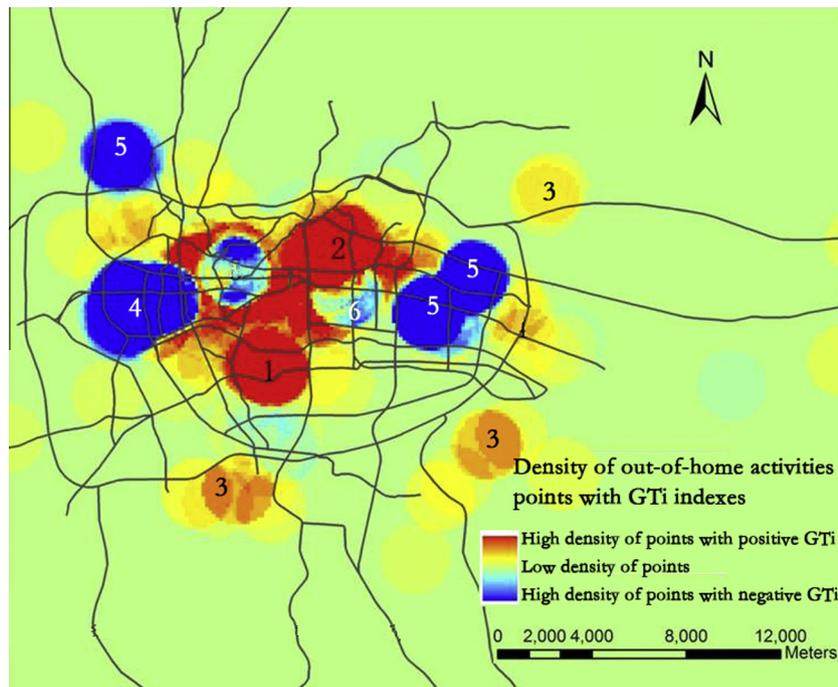


Fig. 5. The spatial and temporal clustering distribution pattern of high- and low-income groups' out-of-home activities.

ArcGIS Spatial Analyst tool of kernel density calculation was used for analysis and visualisation. Setting the GT_i of out-of-home activities points as variable, with a search radius of 1500 m, the density map to identify the typical region of high- and low-income groups' activity clustering was generated (Fig. 5).

By analysing the density map, the internally distinct activities relating to high- and low-income groups can be classified into several typical high- and low-income group's activity clustering zones (Fig. 5). The typical high-income groups space-time clusters of activities were found around the following places: the education and scientific research work units (Zone 1); the CBD (Zone 2); the suburbanised advanced and scientific industrial park, and the Higher Education Mega Centre (Zone 3). The typical low income group's space-time clusters of activities were located at the following places: the traditional old city centre (Zone 4), around traditional workers' *danwei* compounds and social housing districts (Zone 5); and in urban villages (Zone 6).

The spatial and temporal clustering zones of high-income groups

The daily out-of-home activities of high-income groups are closely related to work space. The Chinese *danwei* system (work

unit system) still has a dominant impact on this groups' daily activity space. The location of the new industrial space is another important place for the high income group's daily out-of-home activity clustering.

Clustering zone around the education and scientific research work units: the impact of the *danwei* system

The influence of the *danwei* system on social life and urban structure is gradually weakening in post-reform China. However, it still has some impact on some 'public institutions' which perform certain public service functions including education, health care, and scientific research. Differing from state-owned enterprises, these institutions are less affected by market-led economic reform. The high-income groups, whose out-of-home activities clustered in Zone 1, are the groups mostly 'within the system'. This area is a traditional *danwei* compound which has followed on from the historical period of the planned work unit system. Inherited from the 'work unit administrative society' management in the planned era, all facilities involved in daily activities including housing and job sites, canteens, hospitals, shops, banks, markets, cafes, sports venues, kindergartens and schools, etc. were constructed in a limited space (1–2 km²). These facilities and

services provide a great deal of activity opportunities to meet most residents' daily needs, hence their basic daily activities are concentrated in these *danwei* compounds. The general identity of their work units and their highly educated, professional employment characteristics, naturally led to high income groups meeting in such *danwei* compounds. As a result the compounds developed as a high-income group's gathering place with a mix of functions such as the typical unit-system management and industry.

Clustering zone around the CBD led by the supply of high service-led activity opportunities

The CBD and other business office services such as modern office space provide high-level job opportunities to attract high-income groups' clustering. The majority of people engaged in finance, insurance, advertising, consulting and other modern white-collar service sectors are mostly those with higher incomes. Employment and activities in these areas form a high-income group's out-of-home meeting space, which is dominated by high-end service activities. Zone 2 in Fig. 5 is the significant area. Driven by both planning by the government and the market, Zone 2 transformed from a rural suburb in the late 1980s into a new CBD during the 1990s and 2000s. The investment and construction of office buildings in this new CBD offer business and working spaces for high-income groups. At the same time, it also creates a strong demand for some other high-end activities besides employment, and a shift from the high income groups' employment area to a high income groups' out-of-home activity clustering zone.

Clustering zone in suburbs with new industrial and educational space

With rapid urbanisation, a shortage of land in the inner city developed. In the context of a dual economic system, both the dynamics from the commercial land use market and the incentives and strategies from the government play their roles in industrial land use relocation. A large number of secondary industrial factories and plants gradually relocated to the suburbs during the 1990s to the 2000s in Guangzhou, and became concentrated in some new industry parks, thus resulting in the restructuring and upgrading of industry. In addition, with the development of higher education, science and technology industries, some new districts of land use in the city suburbs developed due to the pleasant environment and relatively abundant land resources, such as the Guangzhou Higher Education Mega Centre and Science and Technology Park. These places finally formed a concentration of high-end jobs and attracted some technical and professional groups. Generally, it became the place for high-income groups' out-of-home activity clustering. Zone 3 in Fig. 5 shows the significant area, which is the high employment activity meeting place shaped by the process of urban employment-oriented suburbanisation.

The spatial and temporal clustering zones of low-income groups

Low living costs and institutional factors are the main driving forces of the activity clustering of low-income groups. The varied, cheap and highly accessible opportunities in the traditional city centre attract low income groups' clustering. At the same time, the supply of government led low-income housing and the urban villages formed under the dual urban–rural system have also been places for the low income groups' clustering.

Clustering zone in traditional city centre of low-cost living space

The diverse and low-cost activity opportunities supplied by the traditional city centre are sufficient to meet the low-income group's activity demands and payment ability, which gradually shaped the spatiotemporal clustering place for low-income groups.

Zone 4 in Fig. 5 is a significant place in traditional city centre with poor living conditions but relatively low rent close to multiple job opportunities. It is the place that attracts the low income migrant population to rent housing as work is nearby. In addition, there is a large proportion of native residents in inherited housing with poor conditions in the old city centre who cannot afford to move out, most of whom are low-income, poorly educated, elderly or unemployed people, attached to social networks and the close daily social interaction that the city centre provides. The traditional city centre is also the main jobs centre offering low-end commerce, wholesale, retail-based consumption services job opportunities that attract local low-income groups who prefer the low cost of commuting. In terms of living and entertainment activities, the traditional city centre with matching public services and living facilities can supply more daily shopping and other leisure activities to maintain the low-income groups' basic and low-cost living demands. Since the low-income groups living in this area are mostly engaged in the service industries, working longer hours, and having less and fragmented spare time, the varied spatially concentrated activity opportunities meet the low-income groups' needs for limited activities during their personal time. That is, the plentiful, cheaper activity opportunities in the traditional city centre help to make up for the time limitation on the low-income groups' personal activities. Therefore, the traditional city centre has become the place that supplies low-income groups' daily out-of-home activities.

Clustering zone around low-income housing supplied by traditional state-owned enterprises and local government

Another proportion of the low-income groups came from the low-income housing supplied during the transformation era. There are two sub-groups; employees in state-owned enterprises (SOEs) established before the transformation era or relocated and employees from the *danwei* compounds (*danwei da yuan*) or workers-communities (*gong ren sheng huo qu*) set up by the SOEs. The second sub-group comprises low-income earners living in low income social housing supplied by the local government. Zone 5 in Fig. 5 shows a significant spatiotemporal out-of-home activities clustering place near to the low-income housing supplied by the SOE or local government.

The historical path-dependence of the *danwei* system and the reform of the SOE somehow generated the sub-low-income group. In the former planning system, some SOEs constructed *danwei* compounds or worker-communities to address their employees' working and daily living conditions under the principle of 'favorable production and convenient living' (*Xian sheng chan, hou sheng huo*). The construction quality and environment are relatively poor. Under the reformation and relocation of SOEs in the city, some large factories closed or relocated outside the central city, leaving the laid-off former SOE workers in places such as Zone 5. They became the low-income group under the transformation. In addition, previous social relationships link these laid-off workers to the original work units-system. Most of them were colleagues. Housing was allocated by their *danwei*. Since the living space is adjacent to the housing, the inertia of social activities and social contacts was maintained prompting the laid-off or retired workers to become more socially connection with each other. Therefore, Zone 5 is the major area for SOE laid-off or retired low-income groups' daily activities, and became one of the out-of-home activity clustering places for low-income groups.

The other type of low-income settlement district is dominated by government-led affordable housing: social housing to solve the housing problems of low-income groups by local government after the transformation of the housing allocation system. Due to statutory protection objectives, only the city's native low-income residents are eligible to apply for affordable housing. Therefore, it

becomes a typical low-income group's residential district. Under the pursuit of profits and driven by market forces, favourable locations are often occupied by commercial properties, and the affordable housing has to be built in suburbs away from the inner city, forming a marginalised and isolated living space. The inadequate supply of public transport services further lessens accessibility, thus long distances and higher travel costs make this low-income groups' daily activities limited to around their jobs and housing places.

Clustering zone around urban villages mostly for the floating population under the binary system and rapid urbanisation background

With rapid urbanisation and industrialisation in the coastal areas of China, a large number of migrant workers pour into cities like Guangzhou, generating a massive demand for housing. Most of this 'floating population' (the new migrant workers) cannot afford high-priced commercial housing. At the same time, the threshold of household registration (or *hukou*) excludes this external population from the social housing allocation system. The city government is so far still only concerned about the housing needs of native residents. Urban housing policy does not cover temporary housing demands. A huge gap therefore exists between the housing supply and the external low-income group's housing demand. Urban villages with their low rental prices, and mostly excellent geographic location, convenient transportation and rich informal job opportunities, become the external low-income group's first stop when entering the city. Urban villages play an important role in providing low-rent housing to solve the housing problems of migrants. Zone 6 in Fig. 5 is a significant out-of-home activity clustering place near to urban villages. It is close to the new CBD of the city where there is a large proportion of high-end employment, consumption, leisure and entertainment opportunities, configured with a series of mega-shopping malls and luxury shopping places. All these activity opportunities and places are purely for high-income earners, and the low-income groups, who are mainly the floating population such as employees and waiters in the service sectors of the CBD are excluded. They prefer to live in places with low housing rental prices, short commuting distances, and low living costs. The urban village in Zone 6 attracts groups comprising the low income floating population and at the same time, it offers informal job opportunities with low work thresholds and living costs that attract low income groups to work and live here. The rough but cheap informal services reduce living costs to lower

the migrant population's living expenses and alleviate economic pressure. Therefore, it has become one of the main out-of-home activity clustering districts for the floating low-income population.

Personal space–time constraints and social segregation of out-of-home activities

The analysis above shows that there is considerable social isolation or segregation for both high-income and low-income groups. The formation of these concentrated areas is a result of various factors with different levels of influence. China's unique historic path of the *danwei* system and the series of policy reforms during the period of economic transformation are the invisible hand reshaping both the built environment and social space in urban China and deeply impact on individuals' out-of-home activities. Furthermore, personal space–time accessibility and constraints of high- and low-income residents are other factors impacting on out-of-home activity clustering diversity. These factors encompass personal financial status and mobility, housing relocation options and the ability of workers to access jobs appropriate to their educational status.

With regard to workers being able to relocate their jobs and housing together, as discussed above, high-income earners are able to 'actively' search for jobs and housing whilst low-income earners are more constrained to 'passive' search, which gives rise to the groups' differing out-of-home activities. When changing their jobs, most of the high-income groups consider more 'active' factors such as their personal promotion and a better salary, whilst the low-income groups face more 'passive' issues such as being laid off. This is similar to the factors considered when selecting housing: most of the high-income groups consider more 'active' personal factors such as a better living environment and local facilities whilst the low-income groups face more 'passive' factors such as demolition resettlement and government welfare housing distribution. Tables 1 and 2 show the relative importance of these factors in percentages for each income group. The total percentage for each factor over the two income groups gives an indication of which factors are most important overall: better salaries for a change of job and commuting convenience and price for housing relocation.

The constraints applying to jobs and housing relocation impact on out-of-home activity spaces. That is, low income individuals' out-of-home activities cluster near to their living spaces whilst high income clusters are away from their living places (Table 3).

Table 1
The percentage importance given to factors considered when changing jobs.

Personal monthly incomes (RMB)	Transfer and relocation of work units	Children's schooling	Being laid-off	Better personal promotion	Better salary	Too far away from housing	Others
Less than 2000	3.49	0.39	27.13	14.34	32.95	9.69	12.02
2000–5000	6.13	0.47	9.43	25.94	41.51	5.66	10.86
5000–8000	0.00	0.00	0.00	31.58	57.89	5.26	5.26
More than 8000	0.00	0.00	0.00	30.00	50.00	0.00	20
Mean	4.41	0.40	18.04	20.24	37.88	7.62	11.42

Table 2
The percentage importance given to factors considered when changing housing.

Personal monthly incomes (RMB)	Commuting convenience	Lower prices	Demolition resettlement	Housing welfare	Better living environment and facilities	Others
Less than 2000	27.7	25.76	7.58	9.74	3.25	25.97
2000–5000	26.12	32.33	4.07	14.13	10.07	13.28
5000–8000	30.18	22.64	0.00	22.64	24.53	0
More than 8000	31.82	27.27	0.00	9.09	31.82	0
Mean	27.19	28.69	5.38	12.45	8.17	18.13

Table 3

The distance between residential areas and out-of-home activities.

Distance (m)	All out-of-home activities	Work	Daily living		Recreation and shopping		
		Commuting	Buying foods	Picking up child	Visiting friends	Recreation	Shopping
High-income	4094	8139	3439	908	759	5144	6198
Low-income	1433	3124	343	587	461	1325	2456
Mean	3669	4581	543	862	2910	2563	3835

Conclusion and discussion

Based on the transformation of China's social and economic system and the dual urban–rural administration system, social diversity has emerged not only in the residential sector, as a lot of literature refers to, but also in people's out-of-home activities. Firstly, the *danwei* system inherited from the planning system still has an important influence on related groups' daily living spaces. This organisation of living spaces close to employment and production gives rise to related groups' gathering places. The structural transition produces two types of 'unit person': high-income groups engaged in monopolistic economic sectors or public service industries; and low-income groups laid-off from state-owned enterprises. The different employment sectors correspond to different daily out-of-home activity clustering zones. Secondly, under the market-oriented transformation, the job–housing relationship has been gradually reshaped from the original 'unified living and job' in the age of the *danwei* system to the separation of jobs and housing under market-led conditions. With the enhanced role of the market for resource allocation and more intense competition between individuals for resources and opportunities, individual ability often determines the quantity, quality, and geographical distribution of resources and opportunities they are able to access, thus forming a series of high/low income group activity clustering in space–time. Thirdly, The urban–rural dual structure is the main driving force shaping the floating low-income population's daily out-of-home activity clustering. The urban villages generated by the dual system are the main places of China's huge floating population's spatial and temporal clustering.

The spatial and temporal pattern of both high and low income groups are explored using the standardised autocorrelation index of N_{Gi} , N_{Ti} and GT_i . The results show that the clustering of high and low values is much more significant with N_{Ti} indexes than N_{Gi} ones. The distribution of high incomes' out-of-home activities is the most unequal, following with the low incomes'. The residents' daily out-of-home activity clustering is close to employment and living spaces. Studies have shown a clear differentiation between the clustering behaviours of different income groups. High-income groups concentrate in the high-end and professional activity opportunity places (for employment, recreation, etc.), which match their high end activities demands. Low-income groups mainly concentrate in typical low income neighbourhoods for their leisure activities. There thus exists certain activity differentiation processes resulting in differing activity clusters. Indeed, three kinds of high-income out-of-home activity clustering zones could include: (i) around the education and scientific research *danweis*; (ii) the CBD; and (iii) the suburbanised advanced and scientific industrial park area and the Higher Education Mega Centre. Similarly, three kinds of low-income workers out-of-home activities clustering zones could include: (i) the traditional old city centre; (ii) around the traditional workers' *danwei* compounds; and (iii) social housing districts and urban villages.

The formation mechanisms of high- and low-income groups vary according to the socio-economic and personal capacities of their members. High/low income groups showed diversity in factors affecting the spatial characteristics of the activities. The

gains and losses of both the high- and low-income groups' activity opportunities are subject to space–time factors. Low income individuals' out-of-home activities cluster nearer to their living spaces than the high income ones.

This study provides support for further guiding the equitable distribution of urban resources to create sufficient, convenient and appropriate activity opportunities for different income/social groups. The historical path dependence of transformation still plays its role on people's daily activities and needs to be considered seriously for public administration. In order to decrease the social isolation or segregation for both high and low groups, mixed land use and the equality of public service are encouraged.

As a large sample survey covering the whole city would have been difficult to carry out, there are certain limitations in the sample distribution and sample size in this paper, and the results may thus provide some deviation. Under the premise of a sufficient sample size and a relatively balanced sample distribution, future scientific research topics as following could be also interesting. Firstly, it is meaningful to discuss the social exclusion issues based on the analysis of people's daily activities. Secondly, it is also interesting to discuss the space–time diversity of activities based on age groups, genders, occupation categories, and Hukou types, etc. Thirdly, the space–time constrain between the different members in a family would be also interesting.

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