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Paavo Monkkonen and Xiaohu Zhang
Department of Urban Planning and Design
The University of Hong Kong

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Paavo Monkkonen
Department of Urban Planning and Design
The University of Hong Kong

Xiaohu Zhang
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The spatial distribution of households of different income groups in urban areas has drawn longstanding attention from scholars and policy makers as residential location patterns have important implications for social outcomes and the economic efficiency of cities. Recent research on the measurement of socioeconomic segregation has led to the development of an index that is explicitly spatial and accounts for the ordinal nature of income data. The index allows for a disaggregation of segregation levels by scale and income. This paper applies these new measurement techniques to Hong Kong, an ideal case study due to its high population density, high level of income inequality, and the large share of the population that lives in public housing. Findings show that levels of socioeconomic segregation in Hong Kong are high, similar to those found in the United States. However, the shape of the segregation profile across the income distribution is found to be quite different from the United States, with high-income households much more isolated than low-income households. Explanations for this include the mountainous and island geography of Hong Kong, as well as the importance of public housing in the city.

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1. Introduction

Hong Kong is one of the most densely populated cities on the planet, with roughly 7 million people inhabiting 1,000 kilometers of land, of which only about one fifth is actually urbanized. The urban landscape is characterized by high-rise residential buildings, many of which reach up to 50 floors, even in areas far from the city center. Additionally, the city has a highly unequal income distribution, data from the most recent population census yield a Gini coefficient of 0.53 in 2006 (Census & Statistics Department 2007).

However, little is known about the spatial nature of socioeconomic inequality in Hong Kong and how spatial segregation is affected by the high-density of the city. In fact, the connection between population density and the separation of different income groups across space is understudied generally. On the one hand, high population density levels should lead to more socioeconomic heterogeneity within a given area simply due to the presence of larger numbers of people. However, urban economic theory predicts cities with high population density will have more competitive land markets, thus should exhibit greater differentiation between neighborhoods and more spatial separation of different income groups.

The motivation for research on spatial patterns of segregation in Hong Kong is not only academic. Policy questions related to the spatial distribution of different socioeconomic groups have become increasingly important in recent years. Hong Kong has undergone several dramatic spatial and economic changes, including the decentralization of large numbers of people into its peri-urban areas and deindustrialization. This has led to an association between a spatial concentration of low-income households and social problems, something new to the city. Tin Shui Wai, a new town developed with large numbers of public housing estates in the peri-urban area of Hong Kong, became notorious for crime, abuse, and suicides.

This paper explores the spatial dimension of economic inequality in Hong Kong using recently developed measurement techniques that allow for an explicit analysis and disaggregation of segregation at different spatial scales and across the income distribution. Small area census data with income reported over more than 10 categories are analyzed over a 15 year period. The spatial, ordinal indexes employed have thus far been applied only in the United States, and the implementation in Hong Kong provides an important point of comparison. Hong Kong is a highly unequal society and extremely high density; the population density was roughly 14 times higher than that of the San Francisco Bay Area in the year 2000. However, a strong public housing program

In spite of its high density, Hong Kong is found to have a similar level of segregation as cities in the United States when using the most aggregated form of the new indexes. Yet this similarity belies significant differences in the way across households are segregated across space and the income distribution. The most significant difference is that when calculated using a rank-order index, segregation levels are found to increase consistently with income. Households in the 90th percentile of the income distribution are roughly 2.5

times more segregated than households in the 10th percentile. This pattern is in sharp contrast to those found in the United States where segregation levels form a U-shape when mapped across the income distribution, and low-income households experience similar levels of segregation to high-income households.

Additionally, segregation levels in Hong Kong are significantly higher at smaller geographic scales; the ratio between large and small scale segregation levels is less than half that found in the United States. This pattern might be expected due to the high-density environment, but also reflects the fragmentation of urban space in Hong Kong, with pockets of high-income housing found scattered across the city. Finally, it is found that while inequality increased consistently in Hong Kong, segregation did not. Segregation levels in 2006 were actually lower than in 1991, though they fluctuated in 1996 and 2001. This is in contrast to a long, relatively consistent trend in the United States of increases in both inequality and socioeconomic segregation.

After a brief review of literature on socioeconomic segregation, recent advances in its measurement and the urban context of Hong Kong, the geographic and census data used in the analysis are presented and contrasted with equivalent data in the United States. Then, segregation levels are analyzed, followed by a discussion of the drivers of segregation patterns and the reasons for their volatility.

2. Literature on Socioeconomic Segregation

The uneven distribution of different groups within urban areas has long been studied by sociologists (Park 1957; Wilson 1987; Massey and Denton 1993) and urban economists (Tiebout 1954; Schelling 1978). Research among the former group tends to refer to the phenomenon as segregation, while among the latter it is known as sorting. Sociologists have tended to focus on the structural forces that separate people of different races or income groups, be they racial discrimination (Galster and Godfrey 2005), the structure of public housing policy (Massey and Kanaiaupuni 1993), patterns of urban immigration and assimilation (Park 1957), or localized land-use controls (Jargowsky 2002).

Urban economists, on the other hand, generally emphasize the way individual decisions influence where people live through land and housing markets (Tiebout 1954). One important contribution from urban economics is the theoretical insight is that residential location is determined through a competitive bidding process on land for housing, and thus land markets play the most important role in deciding the distribution of different groups (Mills and Hamilton 1994). This implies that as cities grow, land values become increasingly differentiated due to increases in commuting costs and increasing differences in the mix of public services and natural amenities in different locations. Land value differences then lead to a greater differentiation of residents between neighborhoods and a ‘natural’ separation of different income groups occurs.

Another avenue of research has attempted to ascertain the determinants of segregation more generally by using statistical analysis across a large number of cities within a country (Telles 1995; Pendall and Carruthers 2003; Monkkonen 2011). These studies assess the relationship of a number of factors with levels of segregation at the city level, using statistical controls to estimate the relative impact of each. In Mexico, for example, cities with more well developed housing markets are more segregated (Monkkonen, 2011). Population density, for example was found to have a quadratic relationship with segregation; cities with very low and very high population densities had higher levels of segregation (Pendall and Carruthers 2003). Bigger cities are consistently found to be more segregated, presumably because more competitive land markets leading to greater neighborhood differentiation.

2.1 Advances in the Measurement of Segregation

Any analysis of segregation is only as good as the measurement of the phenomenon, which has been an active area among sociologists and social scientists since the 1960s (Taeuber and Taeuber 1965). A seminal review of the large number of segregation indexes by Massey and Denton (1988) saw their classification into five dimensions of segregation. Later, however, it was rightly observed that three of these dimensions; evenness, exposure, and clustering, were actually one so-called super dimension referred to as separation and the reason for three separate measures was the inadequacy of the techniques themselves (Johnston, Poulsen, and Forrest 2007). The reliance of researchers on census tract data led to two approaches to measuring the separation of groups; a non-spatial measurement of their distribution across tracts (the evenness or exposure component) and a spatial measure of adjacent tracts similarity (the clustering component).

Recently, there have been major advances in the measurement of this dimension of separation, as well as in the measurement of socioeconomic separation. An index known as the spatial rank-order information theory index (Reardon et al. 2006; Reardon and Bischoff, forthcoming) allows for explicit consideration of geographic scale in measuring segregation, as well as analysis of socioeconomic segregation across the income distribution.

The first step towards this index was the development of a multi-group index of segregation, as traditional measures such as the dissimilarity index only allowed for measurement of the separation between two groups (Reardon and Firebaugh 2002). This index is based on Theil's information theory index, also known as the entropy index (Theil 1972). The entropy index is the difference between the heterogeneity of the city for the variable of interest, and a weighted average of the heterogeneity calculated for each sub-unit of a city. The deficiency of the multi-group index for measuring socioeconomic segregation or the separation of different income groups, however, is that it fails to capture the ordinal nature of the data. The difference between a low-income household and a high-income household is greater than the difference between a low-income household and a middle-income household. Yet it is possible to adapt the measure to ordinal data by using the entropy index and cumulative categories of income groups (Reardon 2009).

The main limitation of the ordinal entropy index calculated using cumulative income groups is that its value will be influenced by the way in which income data are categorized. However, it is possible to overcome this problem to some extent by estimating what is referred to as a rank order entropy index (Reardon et al. 2006; Reardon and Bischoff forthcoming). A 2-group entropy index is calculated for each cumulative category of income, and rather than taking a weighted average of these measures, a polynomial function is estimated to represent the curve of segregation values across the income distribution, and an index is calculated based on this curve. This smoothing effect reduces the bias created by the income categories for which data are reported. A graphical illustration for the Hong Kong case will be presented in Figure 5 below. The method also allows researchers to easily visualize segregation levels across the income distribution.

The rank order entropy index then can also be thought of as the variation of cumulative incomes of different subunits of the city around the mean, i.e. the city's cumulative income distribution (Reardon et al. 2006). A visualization of rank-order segregation is presented in Figure 1, which shows the cumulative percentage of households across the income distribution for one-quarter (400) of the geographic subunits of Hong Kong. The 45 degree line is the cumulative income distribution for the city as a whole, and each thin line represents the cumulative distribution of income for a subunit. The greater distance between the thin lines and the 45 degree indicates more segregation.

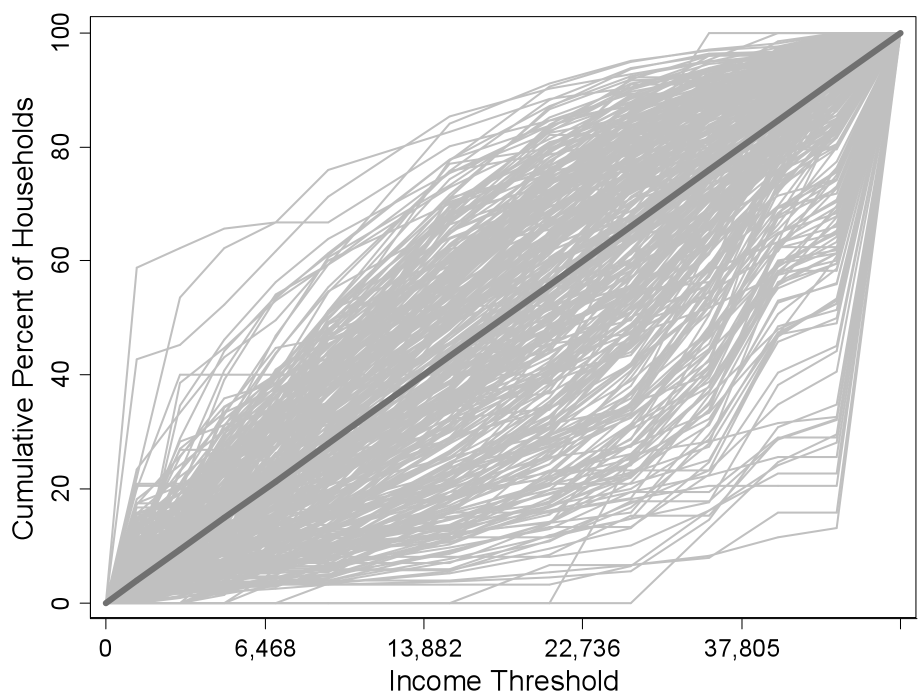

Figure 1. Cumulative Distribution of Household Income in 400 LSBGs, 2006
Source: Authors' calculation with Census and Statistics Department 2006.

In addition to the advances in measuring ordinal segregation and segregation of different income groups, new spatial measures of segregation have also been developed that effectively combine the dimensions of evenness and clustering mentioned previously. The conceptual innovation was to start from the idea of measuring segregation within sizes of 'local environment' from every point across a city (Reardon and O'Sullivan 2004). Ideally, these points would be households and thus segregation would be measured at different distance thresholds from each household. In practice, data from small geographic areas such as blocks or block groups are used. A grid (of 50 meter by 50 meter cells) is superimposed on the map, and the density of different income groups is estimated and smoothed for each cell across this grid. Details of the procedures can be found in (Reardon and O'Sullivan 2004; Reardon et al. 2008; Lee, et al. 2008)

Measuring segregation at different sizes of local environment allows for comparison of segregation at larger and smaller scales, providing insight as to the spatial nature of segregation in a city. In fact, the common census tract measures of segregation can be thought of as one specific spatial scale of segregation, albeit with irregular sizes across the city (Reardon and O'Sullivan 2004). Moreover, by smoothing data across a grid, the more drastic differences at the edges of geographic subunits are lessened, reducing the impact of the data tabulation at this level.

2.2 The Hong Kong Context

Beyond the major political change Hong Kong experienced in 1997 when it returned to China, the city underwent two significant transitions during the end of the 20th century; a shift from manufacturing dominated economy to services and a significant expansion of the population into a peri-urban region to the north of the city known as the New Territories (Monkkonen and Fan 2011; Sui 1995; Hui and Lam 2005). The extent to which these changes have altered the spatial distribution of households according to incomes is not yet clear.

The economic impact is more straightforward. The shift in the economy from manufacturing to producer and financial services led to an overall increase in GDP, and an increase in average incomes. Figure 2 is a graph of the income distribution in Hong Kong in 1986 and 2006.[1] It is clear that there were major changes in the distribution of household incomes over these two decades. There was a large drop in the share of households at the lower end of the distribution and a significant increase in the share of households at the highest end.

[1] Nominal incomes in 1986 are adjusted to 2006 levels using the consumer price index (CPI) available from the Census and Statistics Department online at www.censtatd.gov.hk/ (last accessed March 11th, 2011).

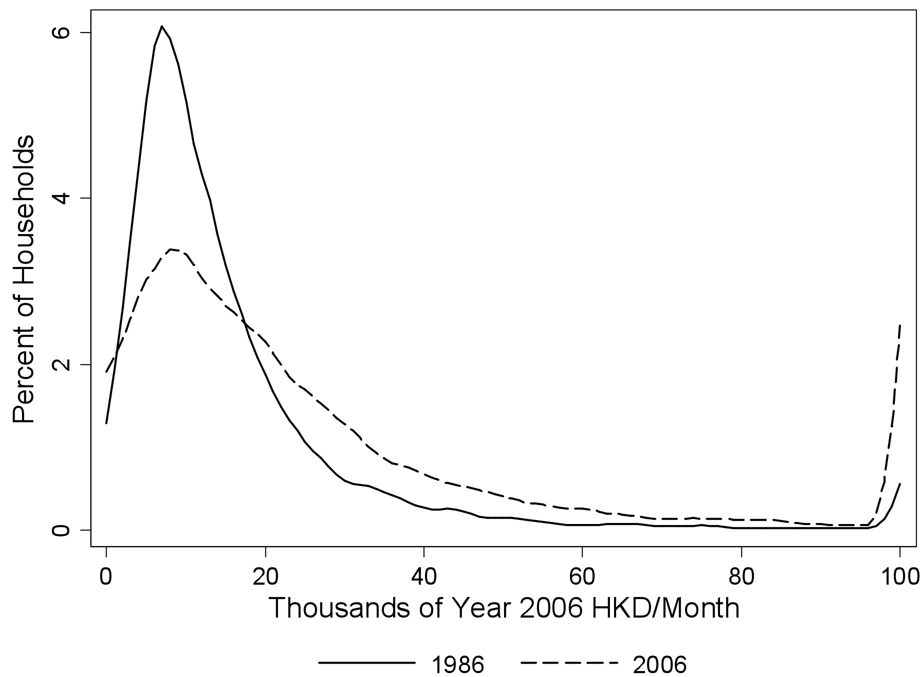

Figure 2. Distribution of Household Income in Hong Kong, 1986 and 2006[2]
Source: Census and Statistics Department 1986 and 2006.

Notwithstanding the drop in the share of lowest income households, income inequality actually *increased* during this time period. The actual levels of the Gini coefficient differ depending on the way it is calculated but all calculations find it to have grown (Census and Statistics Department 2007; Lui 2011). By the estimation of the authors using household incomes, it increased from 0.44 in 1986 to 0.49 in 2006.[3] Given the changes in the distribution of incomes demonstrated in Figure 2, it seems the increase in the earnings of high-income households dominated the decrease in low-income households in the overall measure of inequality.

Yet, very little research has addressed the socio-spatial distribution of Hong Kong's population, and none at the necessary geographic scale, although several studies have examined trends of population suburbanization, residential movement and the development of new towns (Sui 1995; Hui and Lam 2005; Lui and Suen 2010). One example is a study of employment and the concentration of low-income households in a new town, Tin Shui Wai, which focuses on how the city's recent development generates a certain spatial distribution of people (Lau 2010).

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[2] Incomes were categorized and line was drawn with locally weighted scatterplot smoothing.
[3] Calculated using Donaldson-Weymark relative S-Gini and the 1% sample, excluding households for which data were not available. The Gini coefficient reported by the Census and Statistics Department (2007) for 1996 was 0.51 and for 2006 was 0.53. Those reported by Lui (2011) for the working population were 0.39 in 1986 and to 0.43 in 2006.

The impact of population decentralization into the New Territories on the overall socio-spatial structure of Hong Kong is less clear than the changes in the income distribution. Monkkonen and Fan (2011) explore neighborhood change in the city from 1986 to 2006, and find that income heterogeneity has been consistently higher in central parts of the city, but increased to a greater degree in the growing areas of the New Territories. Although the central parts of the city are more economically diverse at a large scale, they are more segregated at a small scale.

Forrest, La Grange, and Yip (2004) do explicitly treat the question of the socio-spatial structure of Hong Kong, framing the topic in terms of the global city literature. They argue that the high income inequality in Hong Kong is not reflected in levels of spatial segregation; however, the quantitative analysis they use to demonstrate this is conducted at what in Hong Kong is a large geographic scale. Tertiary Planning Units (TPUs) contain roughly 30,000 people, six times more than census tracts in the United States, the most commonly used geographical unit of analysis. Not only does the scale of analysis introduce bias into the results, Forrest and his colleagues use only two-group measures such as the dissimilarity index, and do not measure separation by income.

Nonetheless, the importance of the question of scale is not lost on Forrest, La Grange, and Yip, who in previous work (2002) have explored the meaning and importance of neighborhood in the high-density Hong Kong context. They found that in many cases, interviewees did have a strong connection to their neighborhood, and that these neighborhoods were often defined as a relatively small area. For example, several respondents mentioned their residential estate Tai Koo Shing, which covers roughly 2.1 square kilometers, and one respondent said "from Centre Street to Water Street", a distance of about 300 meters (Forrest La Grange, and Yip, 2002: 225-226).

In discussing the new spatial segregation measure, Reardon et al. (2008) propose that a circle of 500 meters in radius is an appropriate size for measuring a neighborhood, as it covers a comfortable walking distance. They begin the analysis of segregation at this scale and expand to larger areas. Given the high density and mixed-use nature of Hong Kong's urban areas, we begin with a local environment of 100 meters. Many residential buildings in the urban areas of Hong Kong have shops in their ground floor, thus it is not unusual in Hong Kong to find all neighborhood necessities within one hundred meters. Moreover, the median size of the aerial units for which census data is tabulated in Hong Kong is 0.05 square kilometers, which corresponds to a circle of 120 meters radius.

4. Data

In order to calculate the various measures of segregation, data on household income are obtained for the years 1991, 1996, 2001, and 2006. Income is reported 11 categories in 1991 and 12 categories in 1996-2006. Data are tabulated according to the smallest geographic area for which census data are available in Hong Kong, the Large Street Block Group (LSBG). These geographic units are defined by the Planning Department of the Hong Kong Government and used by the census for reporting data tabulations. There were about 1,500 LSBGs in 2001. Figure 3 is an image that shows the boundaries of LSBGs in the central urban area of Kowloon, along with an example of the concentric rings of 100, 200, 500, 1,000, 2,000, and 4,000 meters that are used in estimating spatial segregation indexes.

Figure 3. Boundaries of Large Street Block Groups in 2001, and Circles of Radius 100, 200, 500, 1000, 2000 and 4000 meters, Kowloon
Source: Authors' calculation and Census and Statistics Department 2002.

Given the extremely high density of Hong Kong, the implication of this for the calculation of segregation measures, and because methods used in this paper were developed in the United States and have only been used there until now, it is important to understand how data reporting differs from the United States. Thus, census data tabulation areas for Hong Kong are compared to United States census tracts, specifically those of the San Francisco Combined Statistical Area (hereafter referred to as the San Francisco metropolitan area), which covers 9 counties. The San Francisco metropolitan area is chosen because it has a similar population – roughly 7 million people in 2000 - and physical geography to Hong Kong. Both cities have a large proportion of their areas made undevelopable by water (the center of San Francisco is the tip of a peninsula and that of Hong Kong is on an island) and a mountainous terrain.

However, Hong Kong is about 14 times as densely populated as San Francisco. The San Francisco metropolitan area has about 130 households per square kilometer whereas Hong Kong has about 1,800. Table 1 reports descriptive statistics of LSBGs in Hong Kong and Census tracts in the United States. The LSBG in Hong Kong is comparable to the census tract in terms of households, with slightly fewer on average but greater variation. There were 1,400 census tracts in the San Francisco metropolitan area in the year 2000 and 1,595 LSBGs in Hong Kong. Census tracts are much larger in terms of land area than LSBG.

Table 1. Comparison of census geographic tabulation areas in Hong Kong and the San Francisco CSA, 2001/2000

	Households (thousands)			Area (km2)		
Geographic Area	**Mean**	**Median**	**SD**	**Mean**	**Median**	**SD**
Large Street Block Group (Hong Kong)	1.29	0.67	1.55	0.70	0.05	3.58
Block Group (San Francisco)						
Census Tract (San Francisco)	1.77	1.67	0.78	13.20	1.66	69.24

Source: Census and Statistics Department 2001; US Census Bureau 2000.

Given that the number of households is similar on average, the non-spatial measures calculated without any consideration of neighboring tracts are comparable. However, when calculating the spatial segregation indexes using radii of a certain number of meters, it is expected that segregation should decline much faster in the high density environment of Hong Kong. The same land area will include more people thus increasing the possibility of heterogeneity.

5. Analysis

In order to accurately measure levels of socioeconomic segregation in Hong Kong, a series of spatial segregation indexes are calculated; a simple multi-group entropy index, an ordinal entropy index, and a rank order index. Non-spatial values of these indexes are also reported for comparison purposes. The formulas used for the calculation of these indexes can be found in the Appendix.

Table 2 contains values for the six indexes in the four time periods. The spatial versions of the index are reported for a local environment of a 100 meter radius circle in this table, values for other sizes are shown in Figure 4 below. As expected, the ordinal index of segregation is consistently and significantly larger than the multi-group index, roughly 50 percent in most years. This reflects the fact that the multi-group treats all income categories as equal, which does not reflect the ordinal nature of income groups.

Table 2. Non-spatial and Spatial (100 m) Indexes of Segregation, 1991 - 2006

	Non-Spatial Indexes			Spatial Indexes (100 m radii)		
Year	Multi-Group	Ordinal	Rank Order	Multi-Group	Ordinal	Rank Order
1991	0.100	0.159	0.142	0.087	0.143	0.126
1996	0.096	0.145	0.141	0.081	0.129	0.126
2001	0.101	0.151	0.158	0.085	0.132	0.138
2006	0.095	0.138	0.142	0.080	0.121	0.125

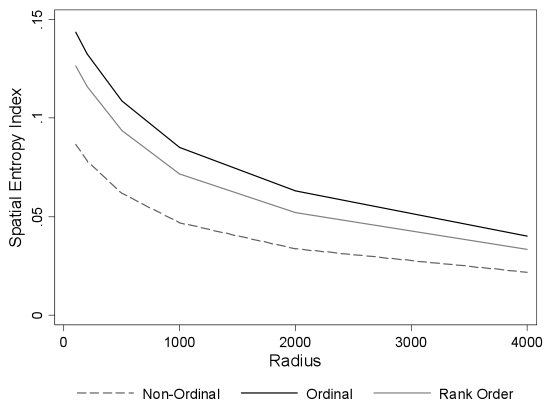
Source: Authors' calculation with Census and Statistics Department 1992; 1997; 2002; and 2007a.

Yet the sharp, and arbitrary cut-offs between categories of income used to calculate the ordinal segregation index mean the measure can be improved upon. When these categories are smoothed and an index is calculated by integrating over the function of segregation levels along the income distribution (the 3rd index described in the Appendix), it is more accurate. This rank-order segregation index is slightly lower than the ordinal measure in 1991 and 1996, but higher in 2001 and 2006.

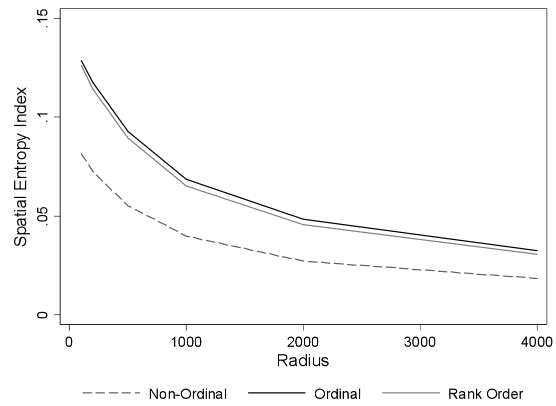
Most of the indexes of segregation for Hong Kong presented above are slightly below the average value reported for 100 US metropolitan areas. The non-spatial rank order index of segregation was 0.157 in 2000 (Reardon and Bischoff, forthcoming). Thus, segregation in HK appears to be relatively high if we consider that United States cities are highly segregated, which is true at least in comparison to European cities (Musterd, 2005). One further consideration, however, is that the average level of inequality is lower in US cities, the average Gini was 0.40 in 2000 there as compared to 0.49 in Hong Kong in 2006.

The spatial indexes of segregation are reported for circles of 100 meter radius in Table 2. Examining changes in segregation levels in increasingly larger areas, however, provides important information about the spatial nature of segregation in a city. Thus, Figure 4 presents values of the three indexes for several distance bands; 100, 200, 500, 1,000, 2,000 and 4,000 meters. It is apparent that the segregation index drops rapidly, almost exponentially, as the size of the area for which it is tabulated increases.

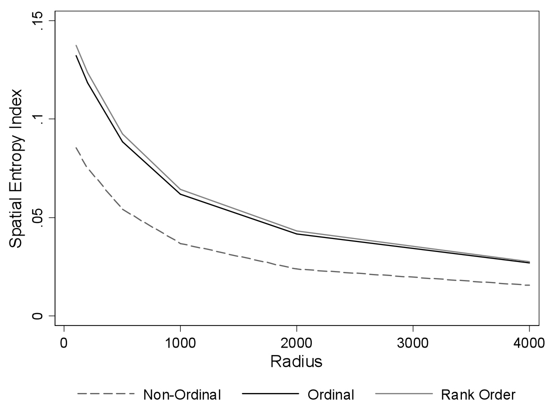
The rate at which segregation levels fall indicates whether overall levels of segregation stem from micro or macro trends. One way to measure this dynamic is a simple macro/micro ratio, obtained by dividing segregation levels for large local environments, in this case 4,000 meter radii to those of small local environments, in this case 500 meters. The macro/micro ratio is much lower in Hong Kong than it is in US cities. In 2006 it was 0.32 while the available ratios from 6 US cities ranged from 0.42 to 0.65 (Reardon et al. 2008).



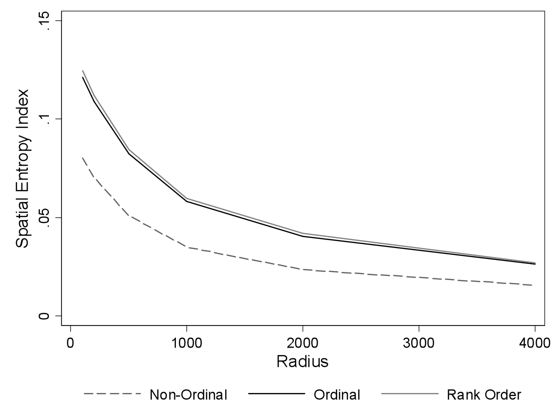
1991



1996



2001



2006

Figure 4. Non-ordinal, Ordinal and Rank Order Spatial Entropy Indexes, 1991-2006
Source: Authors' calculation with Census and Statistics Department 1992; 1997; 2002; and 2007a.

It is noteworthy that levels of segregation in Hong Kong did not increase consistently from 1991 to 2006 while income inequality did. This discrepancy could be a result of changes in relative residential locations of different income groups, or it could be due to the nature of change in income inequality. Recall the change in the income distribution presented in Figure 1. Much of the increase in inequality came from an increase in earnings at the top end of the income distribution, as the share of the population in the lower income category actually decreased. As mentioned previously, more information on this is obtained through the rank order index, which enables us to disaggregate segregation across the income distribution.

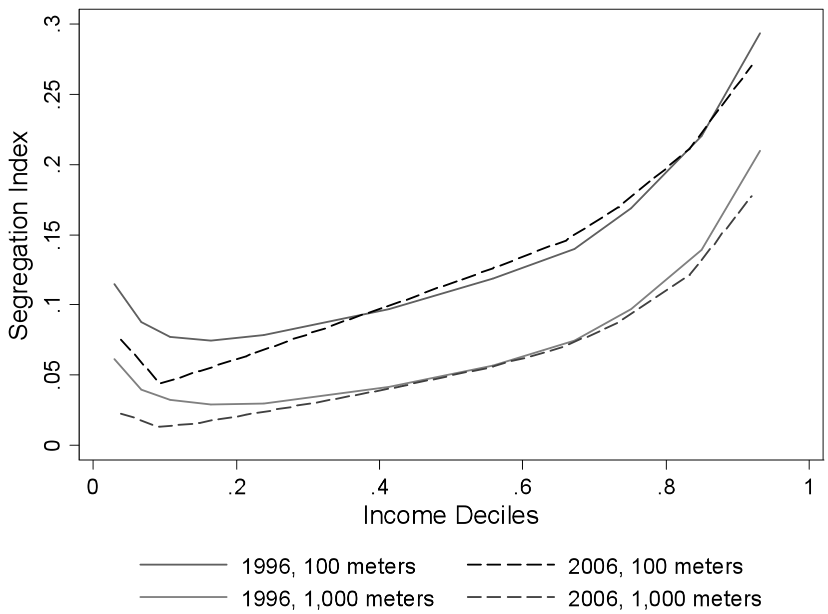


Figure 5. Spatial Segregation Index at 100 and 1,000 meters, 1991 and 2006

Figure 5 shows the levels of segregation across the income distribution for 1991 and 2006. The shape of the segregation profile across the income distribution has changed only slightly during the 15 year period, and is quite distinct from that seen in the United States. Reardon et al. (2006) present similar graphs for several US cities, all of which have a flat U-shape with less variation. Lower-income households generally experience a similar level of segregation as High-income households in the United States, and segregation levels are quite similar for the 30th to the 70th percentile. In Hong Kong, on the other hand, segregation levels are lowest for the 20th percentile and increase rapidly as incomes grow. Households in the 90th income percentile are more than twice as segregated as those in the 10th percentile!

6. Conclusion

The paper presents an analysis of segregation levels across spatial scales and the income distribution in the high-density and highly unequal city of Hong Kong. It documents distinctions from the scale and distributional nature of segregation found in US cities, and finds that in spite of a higher level of inequality, socioeconomic segregation in Hong Kong is slightly lower than the average city in the United States. Yet, the United States is considered to be a highly segregated urban landscape thus Hong Kong should be as well. Although the measures used in this paper have not yet been applied outside of the United States, a rough comparison is possible using a non-spatial dissimilarity index, which was 46 for the lowest quintile of the income distribution in the year 2001 in Hong Kong. This was higher than every city in Europe for which a measure was available (Musterd 2005).

That levels of socioeconomic segregation in Hong Kong are high is not surprising, as the city has a high level of income inequality. However, the fact that segregation did not grow over the 15 year period studied while inequality has is unexpected and merits further study, though it is partly explained by the importance of the growth of incomes among the high-income groups in the overall increase in inequality.

The shape of the segregation profile across the income distribution is also unexpected, and it is in sharp contrast to that of the United States. Segregation in Hong Kong increases almost exponentially with household income. There are several possible explanations for this feature of segregation in Hong Kong. The high population density, and high land and housing prices have created an urban landscape where distance, especially accessibility to transport, matters more than in other contexts (Tse 2002; Cervero and Murakami, 2009). Thus, there is a greater differentiation between adjacent neighborhoods. The mountainous and island geography of Hong Kong also contributes to the great differentiation among neighborhoods and actually increases their physical distance.

But possibly the most important reason for socioeconomic segregation increasing with income is that roughly one half of Hong Kong's population, mostly lower income households, lives in public housing (Census and Statistics Department 2007a). Although further research on the role of public housing in patterns of spatial segregation is merited, it is likely that the continued presence of public housing estates across the city contributes significantly to the low levels of segregation among low income groups. Additionally, piecemeal redevelopment of older urban areas by private parties has led to heterogeneity in the housing stock of many parts of the city, where lower-income households continue to inhabit old stock located near new high-rises (Ng 2002).

Yet whatever the cause, the segregation profile of Hong Kong brings an important twist into the existing literature. Other than the sorting literature that began with Tiebout (1957), the phenomenon of socioeconomic segregation has generally been approached with a concern with the concentration or segregation of the poor (Massey and Kanaiaupuni 1993; Jargowsky 2002; Liu and Wu 2006). Given findings of negative social impacts related to the concentration of poverty, the segregation profile of Hong Kong seems to be preferable, although this implication deserves investigation. Additionally, the contrast between the segregation profile in Hong Kong and US cities raises the important question of whether the difference is due to Hong Kong's high density and highly-priced housing market or is it shared by other cities around the world?

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Appendix

Income Segregation Indexes

1. Non-spatial, multi-group segregation index:

$$\mathbf{H} = \mathbf{1} - \frac{\mathbf{1}}{TE}\sum_{j=\mathbf{1}}^{J} t_j E_j$$

where
T = the total number of residents;
t_j = number of residents in block j (j indexes block);

E denotes the overall entropy:

$$\mathbf{E} = \sum_{m=\mathbf{1}}^{M} \pi_m \log_M \frac{\mathbf{1}}{\pi_m}$$

π_m = proportion in group m,
M = number of income groups, and
E_j = the entropy in block j:

$$\mathbf{E}_j = \sum_{m=\mathbf{1}}^{M} \pi_{jm} \log_M \frac{\mathbf{1}}{\pi_{jm}}$$

π_{jm} = proportion in group m, of those in block j

2. Non-spatial, ordinal segregation index:

$$\Lambda = \sum_{j=\mathbf{1}}^{J} \frac{t_j}{T} \cdot \frac{v - v_j}{v}$$

Where

$$v = -\frac{\mathbf{1}}{M-\mathbf{1}}\sum_{m=\mathbf{1}}^{M-\mathbf{1}} c_m \log_{\mathbf{2}} c_m + (1 - c_m)\log_{\mathbf{2}}(1 - c_m)$$

$$c_m = \sum_{k=\mathbf{1}}^{m} \pi_k$$

$$v_j = -\frac{\mathbf{1}}{M-\mathbf{1}}\sum_{m=\mathbf{1}}^{M-\mathbf{1}} c_{jm} \log_{\mathbf{2}} c_{jm} + (1 - c_{jm})\log_{\mathbf{2}}(1 - c_{jm})$$

$$c_{jm} = \sum_{k=\mathbf{1}}^{m} \pi_{jk}$$

3. Non-spatial, rank order segregation index

$$H_R = \int_0^1 \frac{E(p)}{\int_0^1 E(p)dp} H(p)dp = 2\ln(2)\int_0^1 E(p)H(p)dp$$

Where H(p) is a pairwise segregation index and E(p) is pairwise entropy, defined as follows:

$$H(p) = 1 - \frac{1}{TE(p)} \sum_{j=1}^{J} t_j E_j(p)$$

$$E(p) = p\log_2 \frac{1}{p} + (1-p)\log_2 \frac{1}{1-p}$$

$$E_j(p) = \pi_j(p)\log_2 \frac{1}{\pi_j(p)} + \left(1 - \pi_j(p)\right)\log_2 \frac{1}{1-\pi_j(p)}$$

The rank order index is actually calculated by first estimating the following polynomial equation using pairwise indexes:

$$\widehat{H}(p) = \widehat{\eta}_0 + \widehat{\eta}_1 p + \widehat{\eta}_2 p^2 + \cdots + \widehat{\eta}_m p^m$$

Coefficients from the model are then entered into the equation:

$$\widehat{H}_R = \widehat{\eta}_0 + \frac{1}{2}\widehat{\eta}_1 + \frac{11}{36}\widehat{\eta}_2 + \frac{5}{24}\widehat{\eta}_3 + \cdots + \frac{\left[\frac{2}{(m+2)^2} + 2\sum_{n=0}^{m}\left((-1)^{m-n}({}_mC_n)\right)\right.}{(m-n+2)^2}\widehat{\eta}_{\square}$$

4. Spatial multi-group segregation index:

$$\tilde{\mathbf{H}} = \mathbf{1} - \frac{1}{TE}\int_{p\in R} \tau_p \tilde{E}_p d\square$$

Where $\tilde{E}_p$ denotes the entropy of the local environment of point p:

$$\tilde{E}_p = \sum_{m=1}^{M} \tilde{\pi}_{pm} \log_M \frac{1}{\tilde{\pi}_{pm}}$$

$\tilde{\pi}_{pm}$ denotes the proportion of group m in local environment of point p:

$$\tilde{\pi}_{pm} = \frac{\int_{q\in R} \tau_{qm} \emptyset(p,q)dq}{\int_{q\in R} \tau_q \emptyset(p,q)dq}$$

τ_q denotes population density in p,

τ_{qm} denotes population of group m in p,

$\emptyset(p,q)$ is a distance-decay function, a biweight kernel proximity function is adopted in this research.

$$\emptyset(p,q) = \begin{cases} \left[1 - \left(\frac{d(p,q)}{r}\right)^2\right] & if\ d(p,q) < r \\ 0 & if\ d(p,q) \geq r \end{cases}$$

5. Spatial ordinal segregation index:

$$\tilde{\Lambda} = \int_{p\in R} \frac{t_p}{T} \cdot \frac{v - \tilde{v}_p}{v}$$

Where

$$\tilde{v}_p = -\frac{1}{M-1} \sum_{m=1}^{M-1} \tilde{c}_{pm} \log_2 \tilde{c}_{pm} + (1 - \tilde{c}_{pm}) \log_2 (1 - \tilde{c}_{pm})$$

$$\tilde{c}_{pm} = \sum_{k=1}^{m} \tilde{\pi}_{jk}$$

6. Spatial rank order segregation index

$$\tilde{H}_R = \int_0^1 \frac{E(p)}{\int_0^1 E(p)dp} \tilde{H}(p)dp = 2\ln(2) \int_0^1 E(p)\tilde{H}(p)d\square$$

Where

$$\tilde{H}(p) = 1 - \frac{1}{TE(p)} \sum_{j=1}^{J} t_j \tilde{E}_j(p)$$

$$\tilde{E}_j(p) = \tilde{\pi}_j(p) \log_2 \frac{1}{\tilde{\pi}_j(p)} + \left(1 - \tilde{\pi}_j(p)\right) \log_2 \frac{1}{1 - \tilde{\pi}_j(p)}$$

$$\tilde{\pi}_j(p) = \frac{\int_{q\in R} \tau(p)\emptyset(p,q)dq}{\int_{q\in R} \tau\emptyset(p,q)dq}$$