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**Measuring Residential
Segregation in Urban Mexico:
Levels and Patterns**

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Measuring Residential Segregation in Urban Mexico: Levels and Patterns

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Abstract

Changing patterns of urban development in Latin America have drawn increasing attention to residential segregation, yet systematic quantitative analysis remains limited. Using data from the Mexican census of 2000, this paper describes spatial patterns and levels of segregation by ethnicity and socioeconomic status in over 100 cities. Findings confirm many recognized patterns; low-income and informally employed households tend to live in peripheral areas of the city, while high-income and formally employed households are more centrally concentrated. High-income areas are more socioeconomically diverse and densely developed than low-income areas. Indigenous people experience similar patterns of segregation at higher levels than do low-income households. The difference in levels of segregation by income in cities of different sizes is statistically significant; larger cities are more segregated. Regional differences in patterns of segregation are also statistically significant and large, demonstrating the importance of both historical periods of urban development and levels of regional economic development.

Keywords: Segregation; Urban Spatial Structure; Latin America; Mexico.

1. Introduction

The residential segregation of different socio-economic groups and indigenous people in the urban areas of Latin America is a recognized and much discussed phenomenon, but is only recently being documented empirically, due to the difficulty of gaining access to necessary data. Understanding segregation in Latin American cities is important. The region has some of the highest levels of income inequality in the world, a majority urban population, and pronounced social divisions by race and class, and the spatial location of these different groups has major implications for social outcomes and governance (Roberts and Wilson, 2009).

The present study measures the level and patterns of the residential segregation of informally employed workers, indigenous people, and high- and low-income households in Mexican cities, using four of the five dimensions of segregation outlined by Massey and Denton (1988); evenness, clustering, centralization and concentration. In spite of recent developments in the spatial measurement of segregation that show evenness and clustering to be the same measure at two scales (Reardon and Sullivan, 2004), the use of multiple measures continues to be useful given the limitations of the data (tract level rather than block level) and because they are conventional and thus allow comparison. Further, centralization and concentration measures describe the spatial location and relative residential density of different groups, which is important to describe spatial patterns and compare them with other countries.

The study is the first analysis of segregation that covers the entire urban system of a Latin American country, an important contribution given the tendency to focus on large metropolitan areas (Roberts and Wilson, 2009) and the increasing proportion of population that lives in medium-sized and smaller cities (Portes and Roberts, 2005). Moreover, a national analysis

ensures that the spatial structure of some cities does not get generalized to the whole country. Finally, comparison of segregation levels and patterns in different types of cities allows for the formulation of some hypotheses regarding their determinants.

Mexico makes a good case study for several reasons. It has a large number of cities. Secondly, it has one of the highest levels of GDP per capita in Latin America (World Bank, 2008) and an above average level of income inequality in the region (Gasparini, 2003). Mexico also has a substantial indigenous population and in spite of nationalist politics promoting the concept of *mestizaje*, or racial mixing, discrimination based on skin color remains clearly evident in social and employment outcomes and media representation. Finally, gated communities, urban slums and illegal housing developments; visual symbols of residential segregation, are characteristic of the urban areas in the country.

The study's findings confirm and quantify some of the generally accepted patterns of residential segregation in Latin American cities; the more central location of high-income households vis-à-vis low-income households and the greater income heterogeneity of high-income neighborhoods compared with low-income ones. Additionally, the measurement of segregation patterns provides a nuanced understanding of the settlement of low-income households at in urban peripheries. Although low-income households tend to reside in more peripheral locations than households of higher-incomes and peripheral areas have high percentages of low-income households, these households are actually relatively well dispersed across Mexican cities.

A surprising result of the study is evidence that most low-income households in urban Mexico live in relatively low density areas of the city, in sharp contrast to the stereotypical image of dense urban slums, one which exists in part because of the tendency of urban researchers to focus on large metropolitan areas. In fact, high-income households in Mexican cities live at a higher density than low-income households. This is logical, given their tendency to live in central parts of the city and the higher intensity of development on more centrally located land.

Segregation of indigenous people follows patterns similar to those of low-income households and informally employed workers; not surprising because of the large degree of overlap between these three groups. Nevertheless, segregation levels of indigenous people are higher and patterns are more extreme, reflecting further evidence of discrimination (Floréz et al., 2001). Indigenous people occupy much less space per household and live more peripherally than either low-income households or the informally employed.

In addition to evidence from country-wide averages, the study analyzes averages across cities of different size categories and in different regions. Variation in levels of segregation by income, as measured by the dissimilarity and entropy index, is statistically significant between cities of different sizes. This fits predictions of standard urban economic theory; greater differentiation of land markets and neighborhoods in larger cities leads to higher levels of separation of different income groups (Mills and Hamilton, 1994; White, 1986). However, the same is not true for households with informally employed workers and indigenous people, suggesting that there are forces other than income determining the residential location patterns of these two groups.

The difference in large scale patterns of segregation – clustering, centralization and concentration – across cities of different sizes is not statistically significant, although in general, across cities in different regions it is. This suggests that increasing land values and differentiation in land markets does not determine these large scale patterns of residential location, and raises questions about what does. Possible explanations are the different historical periods of urban development in the different regions of Mexico and the difference in regional economies.

The paper is organized as follows. The following section is a review of empirical literature on residential segregation in Latin America, with a focus on recent studies using comparable methods. The third section presents the four sets of segregation measures. Next, the city of Mérida, Yucatán, is used to visually illustrate the patterns of segregation in Mexico. The paper concludes with a brief summary.

2. Literature Review

Latin America has a history of systematic residential segregation in urban areas dating back to the colonial period. A set of Spanish laws, which began as the *Laws of Burgos* in 1512 and was later expanded as the *Compilation of the Laws of the Kingdom of the Indies* in 1680, set strict guidelines about almost every aspect of city planning. These laws sought to regulate interactions between Spanish colonists and indigenous people, forbidding the residence of indigenous groups in areas inhabited by the Spanish and the “residence of mulattoes, *mestizos* and Negroes in company of Indians” (Mörner and Gibson, 1962:561).

In spite of continued discrimination based on skin color (Flórez et al., 2001); contemporary discussion of urban segregation in Latin America generally refers to socio-economic segregation, with the notable exception of Brazil (Telles, 1992). This lack of focus on racial segregation stems principally from the politics of miscegenation, or racial mixing, which tends to dominate the discourse on racial identity in the region and prevent open debate about racism (Telles, 2007). This is especially true in Mexico.

While the debate over the connection between race and class in the United States has persisted for decades (Wilson, 1978; Massey and Denton, 1993), in Mexico it is only beginning to surface. The spatial connection between race, class, and poverty in Mexico is also different. The mismatch between the location of low-income housing and jobs in the United States (Ihlanfeldt and Sjoquist, 1998) is inverted. Housing for low-income groups is found mostly in the periphery of cities, but many formal jobs have not yet suburbanized (Suárez-Lastra and Delgado-Campos, 2007).

Unlike the United States, where growth in incomes during the second half of the twentieth century, combined with car based suburban development and land-use regulation in suburban areas confined the poor and ethnic minorities to residence in central cities (Mieszkowski and Mills, 1993), in Latin America, the rapid urbanization of the latter half of the twentieth century led to the proliferation of informal housing settlements at the periphery of cities and their gradual incorporation into the urban area (Mangin, 1967; Ford, 1996; Ward, 2001).

The spatial structure of Latin American cities has been traditionally recognized to have three characteristics: lower-income groups occupy low-density, peripheral and poorly-serviced areas; high-income groups cluster in one area of the city, generally with an apex in the historical center and moving outward in one direction; and a greater socio-economic homogeneity in lower-income neighborhoods (Griffin and Ford, 1980; Sabatini, 2003). Recently, however, the rise of gated communities and commercial developments in the urban periphery has engendered a discussion of Latin American suburbanization and fragmentation of urban space (Ford, 1996; Borsdorf, 2003). Nevertheless, the majority of peri-urban space continues to be inhabited primarily by low-income groups.

Academic attention to residential segregation in Latin American cities has grown in recent years due to these changes and expanded access to higher quality geographic census data (Roberts and Wilson, 2009). Some scholars argue that new urban growth patterns are exacerbating social disparity and changing the scale of segregation in Latin American cities, from large-scale patterns to smaller, unevenly distributed pockets of segregation (Sabatini et al., 2001; Libertun, 2006). This debate over scale makes consistent and robust measures more important than ever.

The growth in the use of quantitative methods in research on segregation in Latin America is exemplified by a recent edited volume (Roberts and Wilson 2009), which is application of new methods of spatial analysis, such as the Local Indicator of Spatial Association described later in the present paper, using newly available georeferenced data. Like other recent work (Rodríguez and Arriagada 2004; Skop et al. 2006; Peters and Skop 2007) it is a detailed examination of segregation in several case study cities; Santiago, Chile, Mexico City, Montevideo, São Paulo

Brazil, Lima, Peru, and Austin, Texas. These single city case studies are important in the understanding of the phenomenon, but lack some external validity and comparative power.

In Mexico, a review by Schteingart (2001) of the literature on the social division of urban space explains that, apart from research based in methodologies of the Chicago School (Park et al., 1925), urban research in Mexico has traditionally emphasized theories of marginality and critiques of said theories, rather than ideas of social exclusion. Schteingart also points out that quantitative analysis of segregation in Mexico was limited until the 1990s because adequate data were not available. Since then, a number of quantitative research papers on social exclusion in Mexico have been published (Alegría, 1994; Ariza and Solis, 2009; Duhau, 2003; Garza, 1999a; Gonzalez Arrellano and Villeneuve, 2006; Hernández Gómez, 2001; Rubalcava and Schteingart, 2000a; Rubalcava and Schteingart, 2000b). With one exception, however, none of these studies uses measures of segregation common in the international literature, relying instead on such aspatial techniques as factor analysis. Furthermore, they are limited in their extent, studying only the five largest cities in Mexico – Mexico City, Guadalajara, Monterrey, Puebla, and Tijuana.

The paper most relevant to the present study uses Massey and Denton's (1988) five dimensions of segregation to examine four aspects of socio-economic status (income, occupation, migration status, and level of education) in the three largest cities in Mexico - Mexico City, Guadalajara, and Monterrey (Ariza and Solis, 2009). The authors provide some evidence for the previously assumed spatial patterns of segregation in Mexico. However, the paper does not present patterns visually, nor does it examine the segregation of low-income households. The measure of income

used by Ariza and Solis restricts (2009) their analysis to a comparison of the very highest income households to the all the rest, yielding an incomplete picture of segregation in these cities.

The one exception to the prevalence of case studies of segregation in large metropolitan areas in Latin America is the work by Telles on Brazil from the 1990s (Telles, 1992; Telles, 1995). Telles' two studies of socioeconomic and racial segregation in Brazilian cities are the only in Latin America that measure segregation quantitatively in a large number of cities. Although it is the most robust analysis of segregation in Latin America to date, Telles' work does not examine the clustering dimension of segregation, nor does it assess spatial patterns using measures of centralization or concentration.

3. Measuring Segregation in Mexican Cities

The present study measures the segregation of informally employed workers, indigenous people, and high- and low-income households across four of the five dimensions of segregation proposed by Massey and Denton (1988) - evenness, clustering, centralization and concentration - in the 128 urban areas in Mexico with a population of more than 50,000 in the year 2000. Data come from the Mexican census of population and housing for 2000 (Instituto Nacional de Estadísticas y Geografía, 2000a) and the digital urban cartography of the same year (Instituto Nacional de Estadísticas y Geografía, 2000b). Data tabulations are made by the author at the level of the *basic geo-statistical area* (AGEB), which is similar to the census tract. AGEBs can be larger than census tracts in the United States – more than 10,000 people in some cases – but are mostly similar in size, with 2,500 people in each on average. Unlike US census tracts, AGEBs are only defined for urban areas and towns.

The 128 urban areas or cities covered by this study are also referred to as Metropolitan Statistical Areas (MSAs). In Mexico, the term metropolitan area has recently been defined officially (Secretaría de Desarrollo Social et al., 2004) as cities that encompass more than one municipality. However, this definition excludes many large cities which lie within one municipal boundary. Thus, for the present study MSAs are defined for Mexico using the MSA definition from the United States; the urban area that lies within a commute shed around an urban core of 50,000 or more people.

The study employs proxy variables for informal employment and ethnicity. The proxy for informal employment is based on the existing understanding of informal work (Castells and Portes, 1989; AlSayyad, 2004; Biles, 2007) and made up of three variables from the census; health insurance status, occupation, and industry of employment (Suárez-Lastra, 2007). Health insurance status indicates formal employment, as all salaried employees and their families are guaranteed health insurance from the Mexican Institute for Social Security by law (Diario Oficial de la Federación, 2006a and 2006b). Occupation and industry of employment are also good indicators; professionals are considered to be formally employed, as are those who work in healthcare, education, finance, telecommunications, or other government-run industries. While there are limitations to this definition of informal employment, it is the state of the art and captures the dimensions of the phenomenon to a large extent (Suárez-Lastra, 2007).

The proxy for ethnicity is whether a person speaks an indigenous language. Although it is also an imperfect measure, excluding a large number of people who suffer from discrimination based on skin color, it is also the only one available (Telles, 2007).

Income data are at the household level. Income in Mexico is often measured in multiples of minimum wages earned and reported categorically. In the year 2000, one minimum wage was defined as between 32.7 to 37.9 Mexican pesos, or 4.13 to 4.79 U.S. dollars, per day, the variation due to regional differences. In the present study, high-income households are defined as those that earned more than five minimum wages and low-income households those that earned one minimum wage or less. This classification is that used by the Mexican Census Bureau when reporting tabulations at the tract level. The 5 minimum wage cut off for high-income groups is not a very high income; however, it represents roughly the highest income decile - 11.5 percent of households - in an average city.

The summary data and segregation measures reported here are presented as averages for all cities, for small, medium, and large cities, and for cities in six different regions of Mexico; the northwest, northeast, center, the Mexico City region, the south and the Pacific. Figure 1 is a map of Mexico, which indicates the outlines of the six regions and the location of small, medium and large cities. As can be observed on Figure 1, the southern region has no large cities, while the Mexico City and Northwestern regions have three each.

Table 1 presents summary data for the variables for which segregation is measured. These averages provide an initial idea of how drastically income distribution in Mexico differs from the

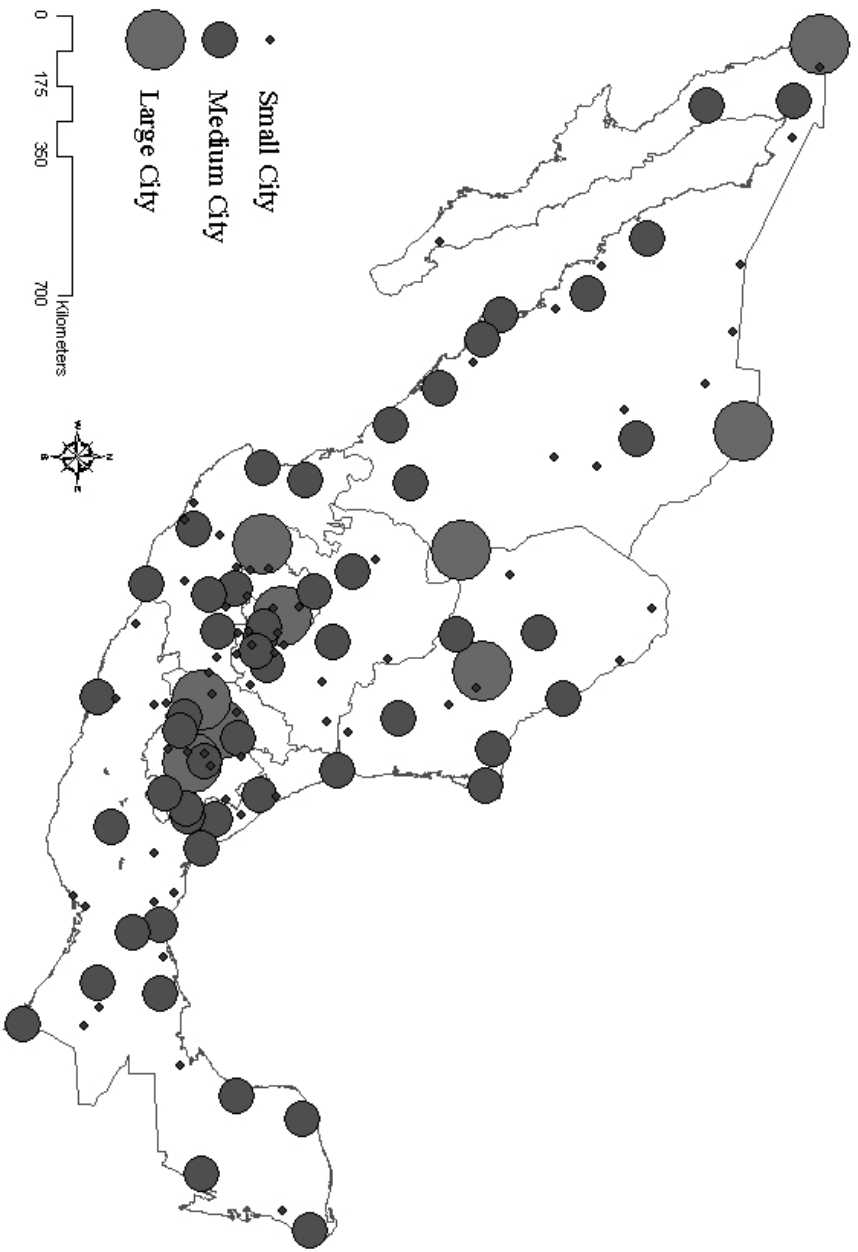


Figure 1. Map of Mexico, with Regional Boundaries and Cities by Size Category
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

Table 1

Share of Population Informally Employed, Indigenous, High-, and Low-income in 128 Cities, by City Size and Region

City Category	Number of Cities	Percent Informal	Percent Indigenous	Percent High-Income	Percent Low-Income
All Cities	128	46.8	4.1	11.5	32.9
Large Cities	9	41.4	1.6	17.0	23.5
Medium Cities	52	42.1	3.6	12.3	31.2
Small Cities	67	51.1	4.8	9.5	35.7
F-statistic (2, 125)	NA	8.1**	0.4	20.3**	8.3**
Northwest	24	36.3	1.2	15.2	25.0
Northeast	15	32.6	0.6	13.6	26.9
Center	19	51.1	0.6	10.6	33.0
Mexico City Region	18	54.0	5.7	11.4	37.5
South	32	50.5	10.9	9.2	39.3
Pacific	20	53.6	1.4	9.4	30.8
F-statistic (5, 122)	NA	13.9**	4.7**	3.9**	9.2**

Notes: Large cities have more than one million residents, medium-sized cities have between 200,000 and one million residents, and small cities have fewer than 200,000 residents. The northwest includes the states of Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa, and Sonora; the northeast, Coahuila, Nuevo Leon, and Tamaulipas; the center, Aguascalientes, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas; the Mexico City region, the Federal District, Hidalgo, the state of Mexico, Morelos, Puebla and Tlaxcala; the south, Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán; and the Pacific, Colima, Jalisco, Michoacán, and Nayarit. * and ** indicate significance at the 0.05 and 0.01 levels. NA indicates not applicable. Source: Instituto Nacional de Estadísticas y Geografía 2000a.

United States or European countries. Low-income households outnumber high-income households in almost every city and by two to one or more on average in smaller cities. This will naturally alter the idea of socio-economic segregation, as it is traditionally conceived of as the isolation of a small low-income population.

There are clear and statistically significant differences between larger and smaller cities on all variables other than the share of the population that is indigenous. A one-way ANOVA was used to test for differences and all were significant (F statistics reported in the table) other than the share of population that is indigenous. The variation in income is especially high – larger cities have an almost twice as large a share of high-income households than small cities on average.

Similarly, regional variation is wide and the differences on all variables are statistically significant. There are higher proportions of high-income households and formally employed workers in the cities in the north of the country, while the cities in the south have a larger share of indigenous people, and are poorer. This fits with general regional development trends in Mexico; early- and mid-century industrial development of cities in the center of the country, the recent industrialization of northern cities, and persistent poverty in the south (Garza, 1999b).

3.1 Evenness

The dissimilarity and entropy indexes are used to measure evenness, the most commonly measured dimension of segregation, which is the difference in the distribution of groups over subunits of a city. The index of dissimilarity is used because it is the most common measure of

evenness. It can be understood as the percent of a given group that would need to move in order to achieve an even distribution of groups.¹

The entropy index has recently been shown to be the most appropriate index of evenness (Reardon and Firebaugh, 2002). It indicates the extent to which the composition of tracts deviates from the citywide composition of a given variable and can be interpreted as the percent difference between the existing distribution of given groups and a completely even distribution. Additionally, unlike the dissimilarity index, the entropy index can be used to calculate segregation between many groups, in this case five income categories of households. Values for the dissimilarity and entropy index in Mexican cities are presented in Table 2.

Although some cities in Mexico have high levels of segregation of indigenous people, the average value for the dissimilarity index, 0.32, is lower than levels found in the United States for African-Americans or Latinos, which were 0.64 and 0.51 in the year 2000 (Iceland, Weinberg, and Steinmetz, 2002), and lower than in most European cities for which comparable data are available (Musterd, 2005).

High-income households have a much higher value of both the dissimilarity and entropy index than do informally employed and low-income households. The low values for the latter two groups indicate that they are relatively evenly distributed across census tracts, in part because they make up significant shares of the population. The average value of segregation levels of low-income households in Mexico is similar to the United Kingdom or Holland, whose values range between 0.15 and 0.25 (Musterd, 2005). It is less than that of other cities in Latin America

¹ Mathematical definitions for all segregation measures can be found in the appendix.

Table 2
Dissimilarity and Entropy Index Values in 128 Cities, by City Size and Region

City Category	Dissimilarity Index				Entropy Index				
	Informal	Indigenous	High-Income	Low-Income	Informal	Indigenous	High-Income	Low-Income	Income categories)
All Cities	0.19	0.32	0.31	0.17	0.04	0.10	0.09	0.03	0.04
Large Cities	0.19	0.41	0.35	0.18	0.05	0.15	0.13	0.04	0.06
Medium Cities	0.20	0.34	0.34	0.17	0.05	0.11	0.11	0.04	0.05
Small Cities	0.19	0.32	0.29	0.16	0.05	0.09	0.07	0.04	0.04
F-statistic (2, 125)	0.95	0.56	13.17**	3.44*	0.25	1.02	29.06**	0.28	31.91**
Northwest	0.16	0.32	0.31	0.17	0.03	0.08	0.09	0.03	0.05
Northeast	0.16	0.37	0.33	0.16	0.03	0.08	0.11	0.03	0.05
Center	0.20	0.29	0.30	0.17	0.05	0.05	0.09	0.04	0.04
Mexico City Region	0.22	0.42	0.34	0.18	0.06	0.19	0.10	0.04	0.04
South	0.21	0.30	0.33	0.18	0.06	0.11	0.10	0.04	0.05
Pacific	0.19	0.37	0.28	0.14	0.05	0.11	0.07	0.03	0.03
F-statistic (5, 122)	9.08**	0.73	2.41*	3.04*	9.21**	3.07*	2.17	3.59**	2.31*

Notes: Large cities have more than one million residents, medium-sized cities have between 200,000 and one million residents, and small cities have fewer than 200,000 residents. The northwest includes the states of Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa, and Sonora; the northeast, Coahuila, Nuevo Leon, and Tamaulipas; the center, Aguascalientes, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas; the Mexico City region, the Federal District, Hidalgo, the state of Mexico, Morelos, Puebla and Tlaxcala; the south, Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán; and the Pacific, Colima, Jalisco, Michoacán, and Nayarit. * and ** indicate significance at the 0.05 and 0.01 levels.

Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

for which data are available. Santiago de Chile, for example, had a dissimilarity index of between 0.30 and 0.47 (Rodriguez and Arriagada, 2004), and Lima, Peru, had an aggregate dissimilarity index of socio-economic segregation of 0.52 (Peters and Skop, 2007). In the United States the average dissimilarity index for low-income households in 100 cities was 0.36, more than double that of Mexico (Musterd, 2005).

Table 2 also reports the F statistic from a one-way ANOVA used to test of the significance in the difference between dissimilarity and entropy indexes for different city size categories and regions. The statistical significance of the differences between levels of segregation by income is much stronger over cities of different sizes than in different regions. This is logical given the predictions of urban economic theory presented in the introduction. Larger cities have higher levels of dissimilarity of both high-income and low-income households, and of the 5 income group entropy index. The situation is completely different for informally employed and indigenous households. There is no significant difference in levels of segregation of informally employed households in cities of different sizes and that of indigenous households are minimal.

3.2 Clustering

Clustering refers to the tendency of subunits of a city with high proportions of a group to adjoin another. As mentioned previously, this can also be conceived of as an extension of the evenness measure on a larger scale. Due to the limitations of data, a separate measure is used here. The global Moran's I is a test of spatial autocorrelation that indicates whether tracts with high proportions of a group are located next to other tracts with high proportions of that group (Moran, 1950). In this case, it is used to measure both whether there is a statistically significant

degree of clustering in a city, and at what level. The Moran's I is the most commonly used measure of clustering in research on segregation in Latin America (Roberts and Wilson, 2009).

Moran's I values for all cities in Mexico that have a statistically significant level of clustering are presented in columns two to five of Table 3, and the percent of cities that have a significant level of clustering is reported in columns six to nine. Larger values of the Moran's I indicate a greater degree of spatial autocorrelation, with negative one indicating spatial independence and positive one indicating perfect spatial autocorrelation.

Table 3 also reports the F statistics for a one-way ANOVA used to test whether the differences between average values of the Moran's I are statistically significant in cities of different sizes and in different regions. The variation in the value of the Moran's I by city size is not statistically significant for any of the variables measured, in spite of large differences in average values in some cases. Regional differences are statistically significant.

An average value of clustering measured with the Moran's I test is not available for the metropolitan areas of another country, though Martin's (1991) analysis of several cities suggests that clustering by income is slightly higher in the United States (around 0.40) and clustering by race can be much higher (as high as 0.80 in Oklahoma City). There is limited evidence that other Latin American cities also have high levels of clustering; Lima, Peru, had a Moran's I of 0.70 for socio-economic status (Peters and Skop, 2007), higher than the vast majority of cities in Mexico.

Table 3
Moran's I Values in 128 Cities, by City Size and Region

City Category	Moran's I Values				Share of Cities with Significant Values			
	Informal	Indigenous	High-Income	Low-Income	Informal	Indigenous	High-Income	Low-Income
All Cities	0.48	0.34	0.38	0.38	0.80	0.38	0.65	0.79
Large Cities	0.53	0.23	0.47	0.32	1.00	0.78	0.89	0.89
Medium Cities	0.45	0.28	0.37	0.34	0.60	0.35	0.54	0.60
Small Cities	0.41	0.28	0.31	0.39	0.94	0.34	0.70	0.93
F-statistic (2, 125)	2.23	1.06	0.33	1.65	NA	NA	NA	NA
Northwest	0.47	0.17	0.36	0.25	0.79	0.17	0.58	0.88
Northeast	0.30	0.50	0.39	0.22	0.80	0.40	0.67	0.87
Center	0.41	0.16	0.31	0.48	0.63	0.26	0.58	0.63
Mexico City Region	0.77	0.51	0.65	0.69	0.83	0.44	0.61	0.72
South	0.46	0.31	0.33	0.43	0.94	0.63	0.84	0.91
Pacific	0.44	0.31	0.30	0.33	0.70	0.20	0.45	0.60
F-statistic (5, 122)	3.74**	0.78	2.77*	3.22**	NA	NA	NA	NA

Notes: Large cities have more than one million residents, medium-sized cities have between 200,000 and one million residents, and small cities have fewer than 200,000 residents. The northwest includes the states of Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa, and Sonora; the northeast, Coahuila, Nuevo Leon, and Tamaulipas; the center, Aguascalientes, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas; the Mexico City region, the Federal District, Hidalgo, the state of Mexico, Morelos, Puebla and Tlaxcala; the south, Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán; and the Pacific, Colima, Jalisco, Michoacán, and Nayarit. * and ** indicate significance at the 0.05 and 0.01 levels. NA indicates not applicable.

Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

3.3 Centralization

An absolute centralization index (ACI) is calculated to measure the degree to which different groups live near the center of the city. ACI values range from negative one to one, with higher values indicating a greater level of centralization. A value of negative one indicates extreme decentralization, with all of a group members located in peripheral tracts, a value of zero means that all members are evenly distributed from the center to the periphery, and a value of one that all members of that group live in the central polygon.

The ACI values for all cities in Mexico are reported in Table 4, as are the F statistics for a one-way ANOVA used to test the differences in average values in cities of different sizes and in different regions. The mean ACI of informally employed people is 0.21 and that of low-income groups is 0.20. By comparing these values to that of the population overall, which is 0.25, it is clear that informally employed and low-income populations are more likely to live in peripheral areas. In contrast, high-income households have an average ACI of 0.37, which indicates that they live much more centrally than the population overall. Another way to consider this contrast is that on average in the 128 cities considered in this study, almost 70 percent of high-income households live in the inner 10 percent of a city's area, while only 55 percent of low-income households do.

There is little variation in the ACI in cities of different sizes and it is not statistically significant. This consistency suggests that centralization does not respond to changes in land values, a result that suggests a surprising homogeneity in the urban development process in Mexico. Regionally, however, there are significant differences in ACI values, especially between cities in the

Table 4
Absolute Centralization Index and Delta Values in 128 Cities, by City Size and Region

City Category	Absolute Centralization Index				Delta			
	Informal	Indigenous	High-income	Low-income	Informal	Indigenous	High-income	Low-income
All Cities	0.21	0.18	0.37	0.20	0.37	0.46	0.48	0.37
Large Cities	0.21	0.16	0.38	0.22	0.38	0.49	0.50	0.39
Medium Cities	0.18	0.17	0.35	0.19	0.36	0.47	0.48	0.37
Small Cities	0.23	0.19	0.39	0.21	0.37	0.44	0.47	0.36
F-statistic (2, 125)	1.74	0.17	0.83	0.76	0.12	1.58	0.49	0.43
Northwest	0.12	0.06	0.21	0.13	0.32	0.41	0.39	0.34
Northeast	0.25	0.28	0.40	0.24	0.42	0.52	0.50	0.43
Center	0.25	0.29	0.38	0.24	0.37	0.44	0.47	0.37
Mexico City Region	0.21	0.13	0.50	0.21	0.37	0.49	0.56	0.37
South	0.21	0.17	0.41	0.20	0.36	0.44	0.50	0.36
Pacific	0.24	0.19	0.39	0.22	0.39	0.48	0.47	0.37
F-statistic (2, 125)	3.99***	2.94*	13.94***	2.86*	4.79***	3.47***	10.38***	2.86*

Notes: Large cities have more than one million residents, medium-sized cities have between 200,000 and one million residents, and small cities have fewer than 200,000 residents. The northwest includes the states of Baja California, Baja California Sur, Chihuahua, Durango, Sinaloa, and Sonora; the northeast, Coahuila, Nuevo Leon, and Tamaulipas; the center, Aguascalientes, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas; the Mexico City region, the Federal District, Hidalgo, the state of Mexico, Morelos, Puebla and Tlaxcala; the south, Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán; and the Pacific, Colima, Jalisco, Michoacán, and Nayarit. * and ** indicate significance at the 0.05 and 0.01 levels.

Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

Northwest and Northeast. This could be a result of the more recent development of cities in the Northwest and the difference in urban structure as a result (Alegría, 1994; Garza, 1999b).

3.4 Concentration

In order to measure the land area or residential density of areas occupied by different groups in Mexican cities, the delta index is used. Delta can be interpreted in a similar fashion to dissimilarity, the percent of people from a group that would have to shift units in order to achieve uniform density. Thus, the higher the delta, the less land area a group occupies. Values of delta are presented in Table 4. On average, informally employed and low-income households are slightly less concentrated than the overall population, while high-income households and indigenous people are much more concentrated than the population overall. That indigenous people have such high delta values is surprising, given that on other indexes they tend to have values similar to those of low-income households.

The fact that the informally employed and low-income groups seem to occupy more land than their formally employed and high-income counterparts does not mean they occupy larger living spaces; rather, it simply indicates that they inhabit areas with lower density on average.

Frequently, these areas are of low density because they are on hillsides, or other areas where high-density development is not possible, or because they are recently settled areas that as yet have not urbanized completely.

As with the measures of clustering and centralization, the difference in Delta values in cities of different sizes is not significant, while regional differences are. The cities in northwestern Mexico stand out as having unusually low values on the Delta index, indicating lower densities and lower levels of concentration for all groups, though the relative differences between groups is similar. City structure in Mexico seems to depend more on regional differences than size.

4. Visualizing Segregation Patterns

In this section, a visual representation of a city that exemplifies spatial patterns of segregation in Mexico is presented. Mérida, Yucatán, is one of Mexico's growing medium-sized metropolitan areas, consisting of five municipalities with a total population of almost 900,000 in 2005. The compound annual growth rate of Mérida, and the average of all 20 cities with between 500,000 and one million residents in Mexico was 2.4 percent between 2000 and 2005; much higher than the overall urban population growth rate in Mexico of 1.6 percent.

Mérida was chosen as a reference city for two reasons. Firstly, it is a highly segregated city and the observed patterns of segregation in Mérida clearly illustrate trends across cities in Mexico. This assertion is based not only on the on comparison of numerical measures of segregation in Mérida to averages, but also upon visual review by the author of choropleths for all cities' segregation measures. Secondly, Mérida has a sizable indigenous population; roughly 30 percent of residents speak an indigenous language. Thus, trends in the spatial distribution of indigenous people are clearly visible. Figures 2 – 6 show the spatial distribution of informal employment, indigenous people, income diversity,² and high- and low-income households. In addition, the

² Income diversity is measured with the entropy of income.

figures present a second choropleth that indicates AGEBs that have statistically significant spatial autocorrelation according to the local Moran's I test. The local Moran's I provides a nuanced perspective of clustering by testing whether the spatial autocorrelation between a tract and its neighborhood is statistically significant (Anselin, 1995). Tracts that form clusters can be identified on a map and provide a useful visual representation of segregation patterns.

Mérida has a global Moran's I of 0.32 for informal employment, slightly below average.

However, the city stands out in terms of segregation by ethnicity and income. The indigenous population is highly clustered, its Moran's I score is in the top 10 percent of cities. Mérida is also the second most clustered city for high-income households (Moran's I of 0.67) and in the top quarter of cities in the clustering of low-income households (Moran's I of 0.42).

The city of Mérida exemplifies the three most notable patterns of segregation in Latin America. First, low-income households and informal workers are fairly evenly dispersed throughout the city, slightly more peripherally located than the overall population, while high-income households and formally employed workers are more centrally located (ACI of 0.41) and concentrated (Delta of 0.54). Informally employed workers and low-income households have ACI values of 0.27 and 0.30 compared to the city's overall ACI of 0.32. People that speak an indigenous language, who have an ACI of 0.15, live much more peripherally than other groups.

Figures 2, 3, and 6 illustrate the higher shares of low-income, informally employed and indigenous people in peripheral tracts.

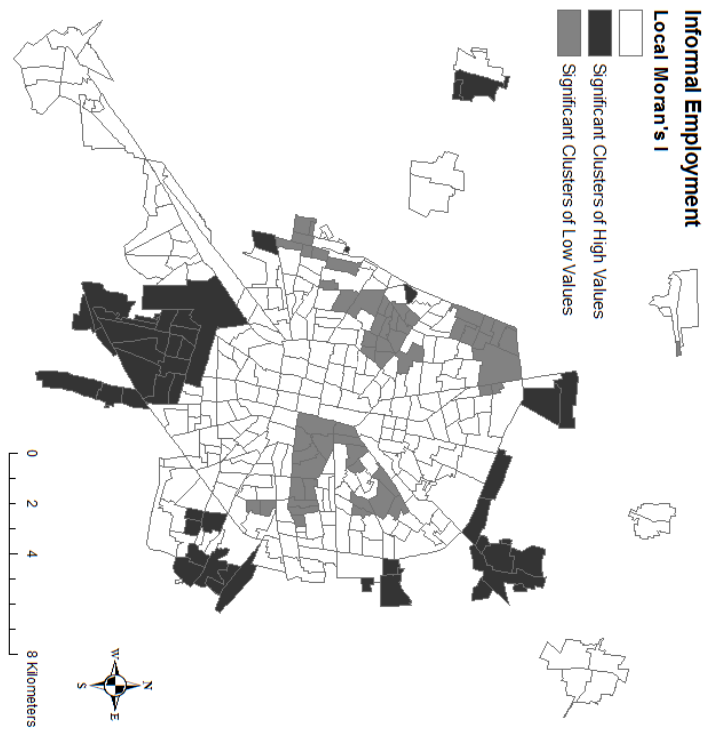
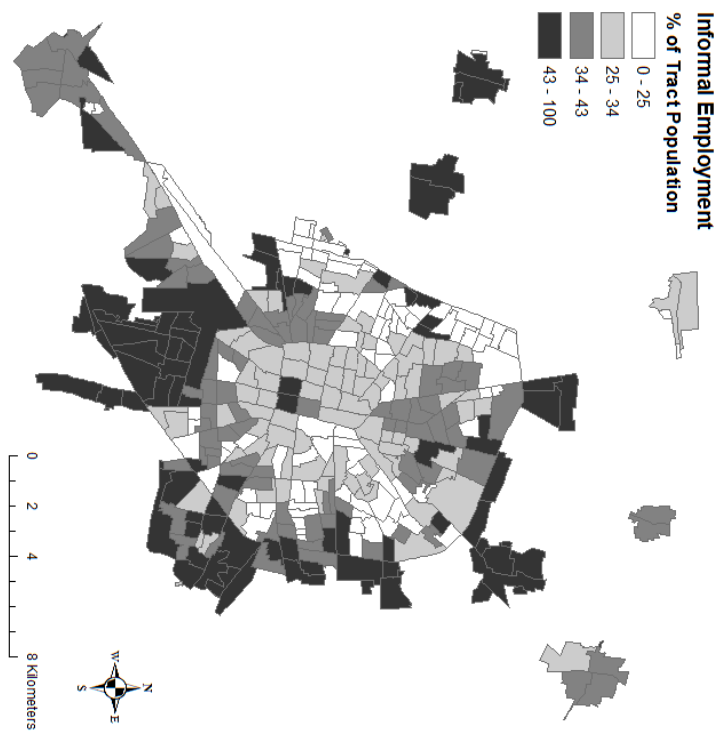


Figure 2. Distribution and significant clusters of informally employed workers in Mérida, Yucatán, 2000
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

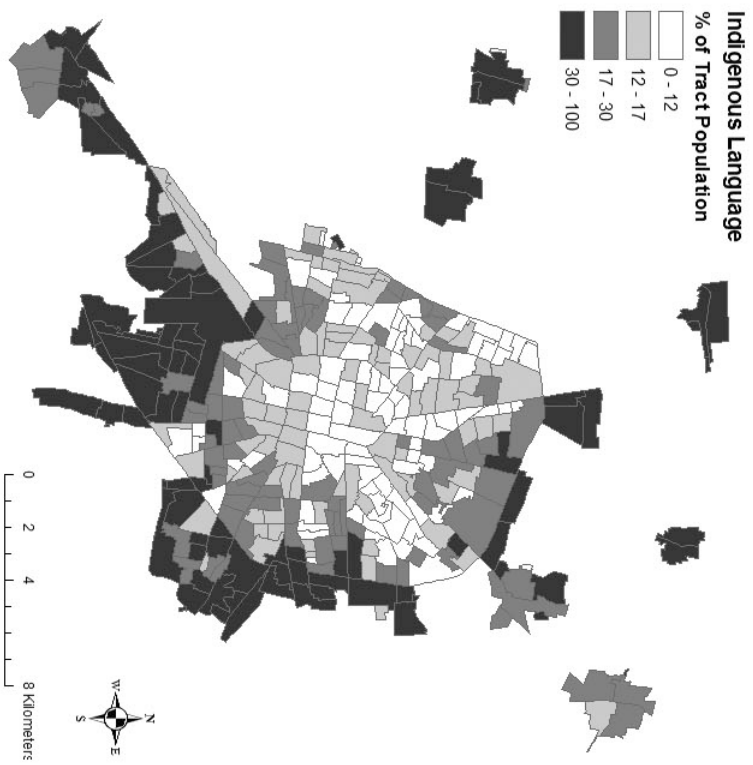


Figure 3. Distribution and significant clusters of people that speak an indigenous language in Mérida, Yucatán, 2000
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.



Figure 4. Distribution and significant clusters of census tracts by level of income diversity (entropy) in Mérida, Yucatán, 2000
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

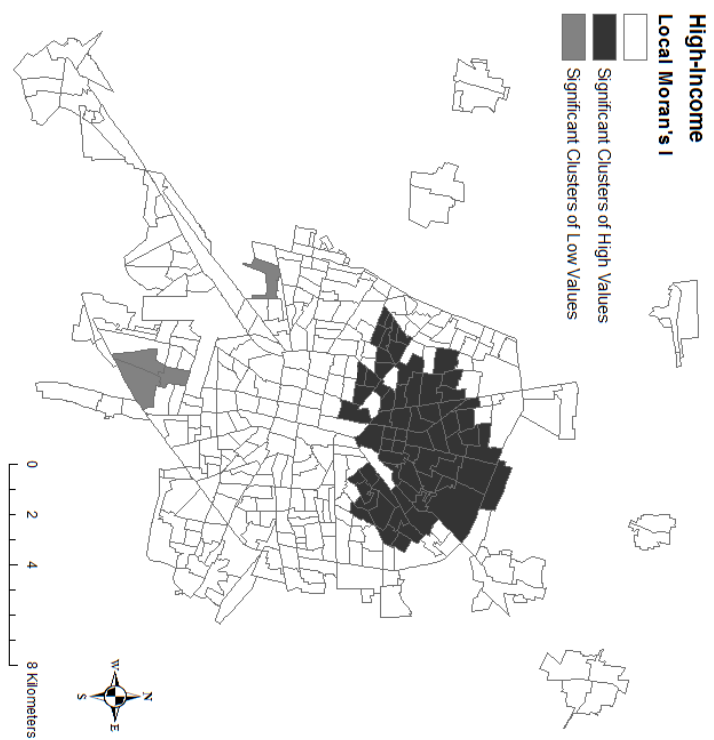


Figure 5. Distribution and significant clusters of high-income households in Mérida, Yucatán, 2000
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.



Figure 6. Distribution and significant clusters of low-income households in Mérida, Yucatán, 2000
 Source: Author's calculation with Instituto Nacional de Estadísticas y Geografía 2000a and 2000b.

The second pattern illustrated by Figures 2 – 6 is the tendency of informally employed workers and low-income households to be grouped in small and fragmented clusters, whereas formally employed workers and high-income households are clustered in one large group. In Mérida, for example, there is only one significant cluster of high-income households, while there are seven separate clusters of low-income households.

Finally, a juxtaposition of Figures 4 and 5 visually demonstrates the third pattern of segregation; high-income areas tend to have greater income heterogeneity. Using the local Moran's I, it is possible to statistically test this pattern by comparing the income diversity in a tract as measured by the entropy. The average entropy of income in high-income neighborhoods in the 101 cities that have significant clusters of both high- and low-income groups is 1.55, whereas that of low-income areas is 1.22. Higher entropy values indicate greater levels of diversity. The entropy of the high-income neighborhoods exceeds that of low-income by 0.33, roughly 20 percent of their combined entropies and a difference that is statistically significant at the 0.01 level according to a two sample t-test with unequal variances ($t = 8.89$).

5. Conclusion

The present study provides the first comprehensive analysis of residential segregation in the urban system of a Latin American country. The segregation of informally employed workers, indigenous people, and high- and low-income households is measured in the 128 metropolitan areas of Mexico. Magnitudes and spatial patterns of segregation are analyzed with measures of four dimensions of segregation and the visual reference of a highly segregated city; Mérida, Yucatán. The paper provides concrete evidence for two of the segregation trends that

characterize cities in Latin America; the clustering of high-income groups in a central zone and the greater income heterogeneity of high-income areas as compared to those of low-income residents. Additionally, a nuanced understanding of a third commonly assumed trend - the dispersal of low-income groups throughout peripheral areas - is developed. Finally, the paper shows that levels of segregation of low-income households and ethnic minorities are not high in Mexico compared with those of the United States or Europe.

The relatively low levels of socio-economic segregation in Mexico are likely to be explained by a combination of factors, including land and housing markets conditions, the structure of local government, and the nature of land-use regulation and its (lack of) enforcement. Until recently, the majority of households in Mexico accessed housing through an incremental construction process, in which families build houses slowly over time. This process leads to a large share of low-income households on the urban periphery. Both the limited speculative development of suburban housing and the inability of suburban developments to incorporate as cities reduce the possibility of middle- and high-income suburbanization, and minimal enforcement of land-use and building regulation means that households often improve their current house rather than move to a new one. Thus, segregation levels remain relatively low.

The importance of urban land markets and land use in segregation outcomes has only recently become a topic of empirical research in the United States (Galster and Cutsinger 2007). Yet the nature of access to housing, which depends heavily on urban development characteristics, is especially important in the study of socio-economic segregation. The fact that the variation in segregation levels of different income groups is significant over cities of different sizes in

Mexico fits with the predictions of standard urban economic theory. A similarly significant variation in segregation patterns over cities of different sizes was expected but not found.

The significant levels of regional variation in segregation patterns greater supports the notion that historical urban development processes – the way in which housing is built and accessed by households in different regions at different times – are more important determinants of segregation patterns than universal land market factors. Clearly this explanation needs further development before a strong conclusion can be reached.

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APPENDIX

Evenness

Dissimilarity

The index of dissimilarity is defined as:

$$D = \frac{1}{2} \sum_{i=1}^n \left| \frac{x_i}{X} - \frac{y_i}{Y} \right|$$

Where x_i is the number of people of group X in tract i ; X is the total number of people in group X ; y_i is the number of people of group Y in tract i ; and Y is the total number of people in group Y .

Entropy

A tract's entropy is defined as:

$$H_i = -(x_i) \log \left[\frac{x_i}{X} \right] + (1 - x_i) \log \left[\frac{1 - x_i}{1 - x_i} \right]$$

Where H_i is the entropy of tract i and x_i is the proportion of population group in tract i .

The entropy index, H , is the sum of the entropy of each tract, weighted by the proportion of the population in that tract. For example, an entropy index of income with six groups $H(Y)$ is calculated as follows:

$$H(Y) = \sum_{t=1}^n w_t \left[\sum_{Y=1}^6 p_{Yt} \log \left[\frac{1}{p_{Yt}} \right] \right]$$

Where w_t is the proportion of the population in tract t , and p_{Yt} is the proportion of households in tract t in income group y . The maximum entropy of the city is calculated based on the city-wide proportions of households in each income bracket.

$$H(Y) = \sum_{Y=1}^6 p_Y \log \left[\frac{1}{p_Y} \right]$$

Thus, the entropy index, S , is calculated as the reduction in entropy that occurs based on the unequal distribution of income groups across tracts.

$$S = \frac{(H(Y) - H(Y))}{H(Y)}$$

Clustering

The local Moran's I is a decomposition of the global Moran's I, defined as:

$$I_i = \frac{nZ_i}{\sum_{i=1}^n Z_i^2} \sum_{j=1}^n W_{ij} Z_j$$

Where Z_i is the deviation of X from its mean, and W_{ij} is a matrix of spatial weights.

The global Moran's I is defined as:

$$I = \frac{N}{\sum_i \sum_j W_{ij}} \frac{\sum_i \sum_j W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\sum_i (X_i - \bar{X})^2}$$

Where N is the number of spatial units indexed by i and j , X is the variable of interest, \bar{X} is the mean of X , and W_{ij} is a matrix of spatial weights.

Centralization

The Absolute Centralization Index (ACI) is defined as:

$$ACI = \left(\sum_{i=1}^n X_{i-1} A_i \right) - \left(\sum_{i=1}^n X_i A_{i-1} \right)$$

Where the census tracts are ordered by distance from the center of the city, A_i is the cumulative proportion of land area through unit i . X_i is the cumulative proportion of population group X in tract i .

Concentration

Delta is defined as:

$$DEL = \frac{1}{2} \sum_{i=1}^n \left| \frac{x_i}{X} - \frac{a_i}{A} \right|$$

Where x_i and X are defined as before, a_i is the land area of unit i and A is the total land area in the city.