Spatial Dependence in the Persistence of Segregation and Poverty in the U.S. Urban South: the Houston case-study

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Abstract

Concentrated poverty in highly segregated neighborhoods within U.S. metropolitan areas is a long debated academic issue. Studied in isolation, the usual statistical indicators may fail to locate accurately the most distressed neighborhoods and assess the exact relationship between places, race and poverty. This paper investigates the persistent linkage between the poverty rate at the neighborhood level and the spatial distribution of African-American and Hispanic communities by using spatially autoregressive correlation analysis and bivariate local spatial statistics. Empirical analysis of geospatial data of 153 metropolitan areas of the U.S. South in 1970 and 2010 suggests that spatial dependence is a major explanatory factor of the linkage between segregation and poverty. By using data sets aggregated by census tracts at two periods, 1970 and 2010, this study confirms the persistent relevance of this issue, despite significant progress toward better integration of minorities in the American society.

Key Words

Urban segregation, poverty, USA, spatial analysis, Houston, persistence

"Everything is related to everything else, but near things are more related than distant things." (Tobler, 1970, p. 236). This definition of spatial dependence has been touted as the "first law of geography". Whereas social scientists focus mostly on historical processes and causal research, geographers are putting the emphasis on the importance of spillover effects in social patterns. This paper discusses the importance of spatial dependence in the persistent linkage of minority and poverty segregation in metropolitan areas despite the major changes that have occurred in urban race and class geography in the U.S. South from 1970 to 2010. It is common for social scientists to direct their attention to emerging issues. Meanwhile, perennial problems receive less attention. Emergence and persistence are the opposite faces of the same coin. The persistence of concentrated poverty in highly segregated neighborhoods within U.S. metropolitan areas is a long debated academic issue

(Davis & Donaldson, 1975). As such, it tends to be overlooked while emerging changes, that is "Black flight" to the suburbs and residential integration of minorities, attract researchers' attention (Frazier & Tettey-Fio, 2006). This paper aims to highlight the persistent relevance of this question in U.S. metropolitan areas, and the importance of place, vicinity and spillover effects in this issue.

Race and class are major issues in American society (Myrdal, 1944; "Kerner Report", 1968; Massey & Denton, 1993). They have been tied since the very beginning of the Colonial Era, when English and French colonists alike enrolled African slave labor in their Southern plantations. Racial prejudice survived Emancipation (1865) and translated from the countryside into cities as African American moved away from plantations to settle into cities during the 20th Century (Aiken, 2003; Davis & Donaldson, 1975; Gregory, 2005; Meinig, 2004). As a result, American cities have a long history of racial segregation (Taeuber & Taeuber, 1965; Massey & Denton, 1988, 1993). Urban geography offers an indirect but unbiased statistical measure of persisting racial discrimination on the housing market (Blank & al., 2004). The African-American minority has suffered lingering discrimination on the housing market that resulted in its concentration into inner city "ghettos" of concentrated poverty (Rose, 1970). The loan mechanisms developed by the Federal Housing Administration during the Great Depression not only promoted urban sprawl, but also favored White households over African Americans. The resulting "White flight" to the suburbs reinforced residential segregation in the Post-war period (Jackson, 1965). The concept of poverty concentration refers to the skewed statistical distribution of poverty across neighborhoods (Jargowski, 1997). Like segregation, concentration is an attribute of the entire metropolitan area (Acevedo-Garcia & Lochner, 2003).

Because of spillover effects between neighboring tracts, spatial dependence may be a significant explanatory factor of the linkage between segregation and poverty. There is a general agreement that housing is a non fungible good. Two housing units with similar intrinsic characteristics may have highly different market values because of neighborhood effects. Assuming a lack of fungibility could explain why housing benefits have such a strong effect on market rents as shown by Susin (2002). It is also commonly admitted that residential segregation may result either from discrimination or preference (Acevedo-Garcia & Lochner, 2003). Overall discrimination in housing and mortgage markets and prejudice has shaped African American segregation on the long run before the enactment of the *Fair Housing Act of 1968* (Yinger, 1995). Afterwards, illegal red lining practices persisted in the private market (Dingemans, 1979; Massey & Denton, 1993) and indirect policies have encouraged segregation. Density zoning is a common tool that allows local governments to "select" their population by class according to the maximum density allowed by its building permits (Rothwell & Massey, 2009). As class and race are correlated in the U.S., such local land-use zoning practices have a significant segmenting effect on the urban social geography. Furthermore, research on environmental justice has highlighted that disadvantaged minority neighborhoods were disproportionately affected by locally unwanted land uses (Bullard, 2000; Colten, 2005, p. 109-125; Bullard, 2007). For these reasons, neighborhood effects have to be taken specifically into account in the linkage between segregation and poverty, and quantitative analysis must include spatial analysis.

Minorities are disproportionately struck by poverty in the United States of America. According to the 2012 5-year American Community Survey, the official poverty rate

was 15% in the U.S.. Poverty is unequally distributed across ethnic groups. Only 9.7% of the Non Hispanic White majority is below the official poverty line. The same rate is 11.7% for Asians. Conversely, 25.7% of the African American population lived below the poverty line. Poverty also disproportionately affects African Americans, Native American Indians (25%) and Hispanics (23.7%). We will focus only on the African-American and the Hispanic communities, both strongly present in the U.S. South, where American Indians constitute only 0.7% of the total metropolitan population. An earlier generation of studies highlighted the political consequences of the divide in poverty between suburbs and central cities within metropolitan areas (Rusk, 1993). Racial segregation, "White flight" to the suburbs and the clustering of people of color into inner city neighborhoods of concentrated poverty has been considered a critical aspect of the urban crisis during the second half of the 20th century (McDonald, 2008). A more recent generation of study has emphasized instead the shifting geography of minorities moving to the suburbs. The "suburbanization" of minorities and poverty is considered of foremost importance by Brookings Institution analysts (Berube, 2007; Frey, 2011a, 2011b; Berube, Kneebone & Williams, 2013). As a consequence, segregation decreases and urban problems initially contained within struggling central cities spill over to older suburbs (Orfield, 2002). For the first time in history, a majority of African Americans (51%) now reside in suburbs, but this has to be compared to 69% of the total metropolitan population (Frey 2011a, 2011b). However important the "Black flight" to suburbs is, we have to keep in mind that urban poverty and minorities remain disproportionately concentrated in dilapidated inner city neighborhoods. As segregation recedes on average, there is evidence that segregation by class is increasing (Abramson, Tobin & Vandergoot, 1995; Jargowski, 1996; Darden & Bagaka's, 1997). Nationwide, the incidence of poverty is still higher in central cities (19.7% in 2012) than it is in suburbs (11.2% in 2012) (Gabe, 2013).

Concentrated urban poverty is still an important issue because it creates a self-reinforcing and vicious cycle. Academic research agrees that populations living in neighborhoods with concentrated poverty tend to receive limited services (Franzini & al., 2005). Residents of these areas face disproportionate exposure to crime and have poor employment opportunities (Waller & al., 2007; Holzer, 1991; Li, Campbell & Fernandez, 2013). Conditions in impoverished neighborhoods also chronically deprive residents are of good education for their children, which diminishes their opportunities of upward social mobility. The middle class -- including the minority middle class itself -- moves away of undesirable neighborhoods, where the remaining community lacks the adequate resources for renewal. Few businesses invest in neighborhoods with low spending power and plagued by crime. Impoverished central cities and older suburbs lack the substantial funding required to redevelop these inner city neighborhoods (Massey & Denton, 1993, Jargowski, 1997, Orfield, 2002, Berube, 2007).

Southern U.S. states are characterized by a persistently high poverty rate, 16.5% in 2012. This is nothing new. Southern poverty was deep and widespread before WW2 (Davis & Donaldson, 1975; Meinig, 2004). In the long run, the South's economic condition has steadily improved since WW2, but it remains on the low side of the "continental divide" in terms of poverty (Holt, 2007). The relative importance of minorities is another characteristic feature of the U.S. South: 19% African-American (table 1) and 16% Hispanic (table 2) according to the 2010 census. Among these two minorities, one person in four is living below the poverty line in the Urban South,

respectively 24.4% and 24% on average during the 2008-2012 period in the 153 metropolitan areas of the South. African-Americans have long been discriminated against in Southern states. Despite the *1865 Act of Emancipation*, Southern states deprived Blacks of their civil rights with "*Jim Crow*" laws after the end of the Reconstruction Era (1865-1877). Southern states enforced school segregation until 1954 and tried to resist integration in the following years. As a consequence, "White flight" to the suburbs restored school segregation *de facto* (Frey, 1979; Lewis, 2003, p. 126). At the time of the Civil Rights movement (1960s), poverty and racial discrimination was much more widespread in the South than it is today. The 1970 Census presents a demographic portrait shortly after the end of the Civil Rights movement and newly enforced anti-discrimination laws (e.g. *Fair Housing act of 1968*). It illustrates how these new policies had produced negligible impacts at the time. Poverty still affected African American families disproportionately: 31% versus an average of 12% in the urban South, and a national average of 8.6%.

Racial segregation tracks back to the Antebellum period, but it used to be slightly less severe in the urban South before school integration encouraged "White flight" to the suburbs in the 1960s than it used to be in Northern industrial metropolises (table 1) (Goldfield, 1997).

Table 1: Relative Importance and Segregation of African-Americans in the Urban South 1970-2010

African American	Urban South (153 CBSA in 2010)	Houston	Nationwide
Population share 1970	18.7%	19.5%	11.1%
Population share 2010	19.8%	17.2%	12.6%
Dissimilarity Index 1970	75.6%	77.0%	80.5%
Dissimilarity Index 2010	54.9%	47.8%	61.2%

As measured by the dissimilarity index (Massey & Denton, 1988), African Americans are still highly segregated in 2010. More than half of the total African American population would have to move from high percentage Black census tracts to low percentage tracts to equalize the total population distribution across Southern metropolitan areas. However, racial segregation was much less severe in 2010 than in 1970. This trend toward more integration of the African American minority into the total population is most visible in the large and successful Southern metropolis of Houston, Texas, which we will use to exemplify spatial analysis results in this paper.

The rise of the Hispanic minority brought major changes to Southern metropolises between 1970 and 2010 (table 2). Hispanics were mostly absent in Southern metropolises in 1970 except in Florida and Texas, where the influx of Cuban and Mexican immigrants respectively had begun earlier in the 20th century.

Table 2: Relative Importance and Segregation of Hispanics in the Urban South 1970-2010

African American	Urban South (153 CBSA in 2010)	Houston	Nationwide
Population share 1970	5.5%	9.3%	4.7%
Population share 2010	17.8%	35.3%	16.3%
Dissimilarity Index 1970	68.3%	46.8%	67.6%
Dissimilarity Index 2010	56.1%	41.6%	57.4%

Houston is a good example of a Texan metropolis, where Hispanics currently constitute the largest minority. A sizeable number of Hispanics was already present in 1970, but more than 1 Houstonian in 3 self identifies with the various communities of Latin American origin. Compared to African Americans, Hispanics have always been less segregated in the U.S. (Frey & Farley 1996, Iceland 2004, Frey, 2010). The decreasing dissimilarity index from 1970 to 2010 indicates that this community is also progressing toward a better integration in the American metropolitan regions.

Table 1 and 2 indicate that Houston is significantly less segregated than the average Southern metropolitan area, with the major exception of the African Americans in 1970. Houston is the affluent, large and expanding "Energy Metropolis" of the "New South" (Melosi & Pratt, 2007). It attracts a sustained influx of immigrants, both domestic and from abroad. Its multicultural population has become a highly diverse miniature of the world (Klineberg 2013). It tends to diverge from less affluent "Deep South" metropolises where attitudes toward minorities are less relaxed, and segregation of both African Americans and Hispanics is stronger.

Methodology

Fifty years ago, President Lyndon B. Johnson inaugurated the "*War on poverty*" as part of his "Great Society" project. Orshansky provided a formal poverty threshold definition in 1963 (Gabe, 2013), and consequently, the 1970 decennial census enabled new research questions about family income. Additionally, in response to the Civil Rights movement, the 1970 decennial census inaugurated another important innovation: racial identification shifted from an imposed definition to self-identification. This broad categorization has remained stable in the intervening years. Using the classification, scholars have directed special attention to neighborhood-level urban segregation. From 1960 onward, publicly collected census data enabled scientific research and public debate at the census tract level, a census-delimited scale providing a convenient proxy of neighborhood for mapping and statistical analysis purposes at metropolitan-wide study. Affirmative Action advocates considered the use of census data central in demonstrating discrimination and documenting progress resulting from the newly enforced anti-discrimination policies.

Unfortunately, the 2010 census dropped the controversial "long form" that included the questions about income that were used to calculate the poverty status of families and individuals. The Census long form has been replaced by the American

Community Survey since 2004. Every year, the ACS questions a sample of approximately 3 million housing units and group quarters in the United States. This technique implies very small local sample size at the census tract level. The Census Bureau releases tract level data only every five years. The so-called "2012 5-years" ACS data contains data collected from 2008 to 2012. In this paper, we consider the "2012 5-years" ACS data as representative of the central year 2010. Though ethnicity is still included in the 2010 decennial census, the combination of poverty and minority status in this study derives only from the 2012 5-years ACS estimates in order to ensure data consistency.

Some scholars have criticized the official definition of the poverty line (Gabe, 2013). However, the main goal of our paper is to emphasize the importance of spatial patterns, neighborhood and spillover effects, and their persistence over time. From this perspective the stable statistical definitions from 1970 to 2010 are of critical importance, whatever the accuracy of the empirical data *per se*.

Multiple indexes have helped measure racial segregation and poverty in urban contexts (Massey & Denton, 1988, Jargowski, 1997, Iceland, Weinberg & Steinmetz, 2002). The Dissimilarity Index has become the usual measure of the phenomenon (Frey, 2010, 2011a, 2011b). The dissimilarity index used in this paper is that of Massey and Denton (1988).

$$D^M = \sum_{i=1}^n \frac{p_i \left| x_i^m - X \right|}{2PX(1-X)}$$, **M** is the minority group, **P** is the total population, $x_i^m = \frac{p_i^m}{p_i}$ is the share of the minority group in the total population of the "**i**" neighborhood.

However these multiple indexes have been criticized for not catching the spatial dimension of the topic (Wong, 1993, Reardon & O'Sullivan, 2004). As discussed in the previous section, spatial patterns of segregation and concentrated poverty are obviously larger than census tracts because of spillover effects. As Morrill demonstrated in the 1960s (1965), spatial pattern is important in understanding the expansion and the containment of ghettoes in metropolitan areas. Creating atlases with multiple maps of the different indicators is a convenient way to catch these geographical patterns, but visual data mining is lengthy and maps can also be misleading (Monmonnier, 1996). If we want to test the significance of local data, we have to rely on statistical spatial analysis.

Based on Jargowski's findings (1997), our first hypothesis assumes that the relative concentration of African-Americans and Hispanics in some neighborhoods is an accurate predictor of the location of clusters of concentrated poverty. In other terms, to what extent localized poverty rates are related to the relative concentration of "visible" minorities? The second hypothesis to be tested is that the U.S. Urban South is slowly moving toward a more effective integration of minorities. For this reason, two models are produced in a 40 years interval of time. The first model is based on the 1970 decennial census, the second one on the 2010 decennial census and the associated 2008-2012 5-years American Community Survey. Evolving models coefficient and changing quality of fit will measure the progress realized toward better integration since the 1960s. We make a two-step spatial analysis, starting with the hot spot analysis of segregation and concentrated poverty in the Houston metropolitan area prior to creating spatial autoregressive models that helps interpret the statistical correlation between these three indicators, the poverty rate being the endogenous variable of the model, and the respective proportions of

African Americans and Hispanics in the total population being the independent predictors.

Identification of spatial patterns starts with the calculation of simple univariate spatial autocorrelation indexes. We rely on the Moran Index (1948). Calculating the ratio between the local covariance and the global variance of the variable **X**, the Moran index is a cross-product statistic similar to the Pearson correlation coefficient (Holt, 2007). Its interpretation is similar to the Pearson correlation coefficient. The Moran index varies in the [-1 ; +1] interval. A value close to 0 indicates an absence of autocorrelation. A negative value indicates an unusual negative autocorrelation; neighboring units are more different than distant ones. Conversely, positive values measure spatial clustering, neighboring tracts are more similar than distant ones (Tobler, 1970). We define the spatial weight matrix in the simplest way, based on boundaries between census tracts (queen contiguity) as Moran did initially. This choice is preferred to a distance-based spatial weight matrix because census tracts vary in shape and size according to unequal population density. The Moran index can be broken down in its local components (Anselin, 1995). *Local Indicators of Spatial Association* (*LISA*) are decision-support tools that helps interpreting maps by detecting significant clusters of "hot spots" of concentrated high and low values. Moran LISA helps drawing maps that display significant clusters of concentrated Poverty, African-American ghettoes and Hispanic "barrios" as well.

These univariate exploratory spatial statistics have become familiar to many spatial analysts (see, Cressie, 1993, Anselin, 1995). Integrating spatial analysis and bivariate analysis of interactions between two variables is less usual, though it has provided a theoretical foundation for spatial econometrics for years (Anselin, 1988). We use the bivariate Moran LISA created by Lee (2001) to capture the geographical pattern of the statistical association between two continuous variables, in other words, the bivariate spatial dependence. The bivariate Moran index captures both numerical covariance and spatial clustering at the same time (Lee, 2001, p. 370). Statistical test of the bivariate LISA helps drawing maps of significant clusters of joint high or low values of both variables. It is the best way to explore the geography of combined racial segregation and concentrated poverty (fig. 2 to 5).

Since Moran's Index and Pearson's correlation coefficient are both variants of Mantel's cross-product statistics (Mantel, 1967), Lee proposes a bivariate Moran coefficient in the following form:

$$L_{X,Y} = \frac{n}{\sum_i \left(\sum_j w_{ij} \right)^2} \cdot \frac{\sum_i \left[\left(\sum_j w_{ij} (x_j - \bar{x}) \right) \left(\sum_j w_{ij} (y_j - \bar{y}) \right) \right]}{\sqrt{\sum_i (x_i - \bar{x})^2} \cdot \sqrt{\sum_i (y_i - \bar{y})^2}}$$ (Lee, 2001, p. 377) where **X**

is the independent variable, **Y** is the endogenous variable, **I≠J** are two different observations and **w_{ij}** is the associated element of the spatial weight matrix **W**. By extending the Mantel's generalized significance testing, Lee has proposed the associated statistical significance test of his bivariate Moran index (Lee, 2001, p. 381). Lee further breaks down the bivariate Moran index in its local components, creating a bivariate LISA in the following form:

$$L_i = \frac{n.\left[\left(\sum_j w_{ij}(x_j - \bar{x})\right)\left(\sum_j w_{ij}(y_j - \bar{y})\right)\right]}{\sqrt{\sum_i (x_i - \bar{x})^2} . \sqrt{\sum_i (y_i - \bar{y})^2}}$$ (Lee, 2001, p. 383).

The second step of spatial analysis investigates the relationship between the poverty rate at the neighborhood level and the spatial distribution of African-American and Hispanic communities by using spatially autoregressive (SAR) correlation analysis. Conventional Ordinary Least Square (OLS) regression models suggest a statistically significant relationship between Poverty rate and Minorities, but two basic hypothesis of OLS regression are violated. First, model residuals are heteroskedastic; second, model residuals display a strong spatial dependence. For this reason, we use SAR models in the spatial-lag model form (Paelinck & Klaasen, 1979, Anselin, 1988). Among SAR models, we prefer the spatial-lag model to the spatial-error model primarily for theoretical reasons. As we already discussed, considering neighborhood effects as an independent explanatory factor in the combination of segregation and poverty in specific locations is our first hypothesis to be tested, not a error-term to be discarded from the model of "pure" econometric linkage. Following Ward & Gleditsch (2007), the spatial-lag model's matrix notation is

$$Y = \rho WY + X\beta + \mathrm{E}$$, where **Y** is the vector of the endogenous (dependant) variable (here, the Poverty rate), **X** is the matrix of independent variables (two independent variables are introduced in the model only, Percentage of African-American and percentage of Hispanics), **W** is a spatial weight matrix based on the topology of dataset (data is available by census tracts), E is the vector of error terms, part of the variance of **Y** that is not correlated to the **X** independent variables. β is a vector of model coefficients that capture the form and intensity of the correlation and ρ is the spatial-lag coefficient, which measures the average strength of the spatial dependence in the dependant variable. A comparison of the spatial-lag model with the spatial-error model shows both models are equivalent in this study. The spatial-error model has a slight advantage of quality of fit (**R²** statistics), but its residuals display a slight deviation to the normal distribution condition. Conversely, the spatial-lag model residual's expected value is zero and their distribution is perfectly normal.

Results will be discussed on the basis of statistical testing and comparison of the ρ and β factors of the 1970 and 2010 models.

Concentrated poverty in the U.S. South and in the Houston metropolitan area

Following the methodology proposed by Jargowsky (1997), only 5% of the total metropolitan population resides in 1,313 concentrated-poverty census tracts where the poverty rate is estimated over 40% in 2010 in the U.S. South. But, these distressed neighborhoods concentrate 9% of the total southern Hispanic minority and 10% of the African Americans. Together, these two communities form, on average, 73% of the population residing in Southern neighborhoods with concentrated poverty versus an average share of 38% of the Southern total population residing in metropolitan areas.

Enlarging the scope to "high-poverty" tracts where the poverty rate is estimated at over 20%, 6,298 high-poverty census tracts (30%) contain over 25.1 million

residents. Of the total metropolitan area population of the U.S. South, 27% resides in these disadvantaged neighborhoods. Minorities are disproportionately concentrated in high-poverty neighborhoods. These tracts concentrate 44% of the total southern Hispanic minority and 45% of the African Americans. Together, these two communities form, on average, 61% of the population residing in Southern high-poverty neighborhoods.

Dissimilarity indexes reveal that levels of racial segregation remain higher than levels of economic segregation in the Houston metropolitan area (table 3), but the univariate Moran index, which measures spatial clustering of distressed neighborhoods is significantly high in this area (table 3). The Moran index is an important complement of the Dissimilarity index. As the latter measures the uneven distribution within tracts whatever their location, the Moran index measures the degree of resemblance between neighboring tracts.

Table 3: Relative Concentration and Spatial Clustering of Poverty and Segregation of African Americans and Hispanics in the Urban South and in Houston CBSA 2010

Index	Urban South (153 CBSA in 2010)	Houston CBSA
Poverty concentration 2010 – Dissimilarity Index	34.8%	36.6%
Segregation of African-Americans 2010 – Dissimilarity Index	54.9%	47.8%
Segregation of Hispanics 2010 – Dissimilarity Index	56.1%	41.6%
Clustering of Poverty 2010 – Moran Index	0.508	0.499
Clustering of African-Americans 2010 – Moran Index	0.764	0.651
Clustering of Hispanics 2010 – Moran Index	0.869	0.700

A total of 386 "high-poverty" census tracts (poverty rate is estimated over 20%) concentrate 31% of the total resident population in the Houston metropolitan area. These disadvantaged neighborhoods concentrate 48% of the Hispanic minority and 43% of the region's African American community. Together, these two communities form, on average, 79% of the population residing in Houston's area neighborhoods of high poverty, 55% Hispanics and 24% African American.

We use the Houston metropolitan area to exemplify our findings. The landmarks we cite in this paper can be located on the orientation map (fig. 1).

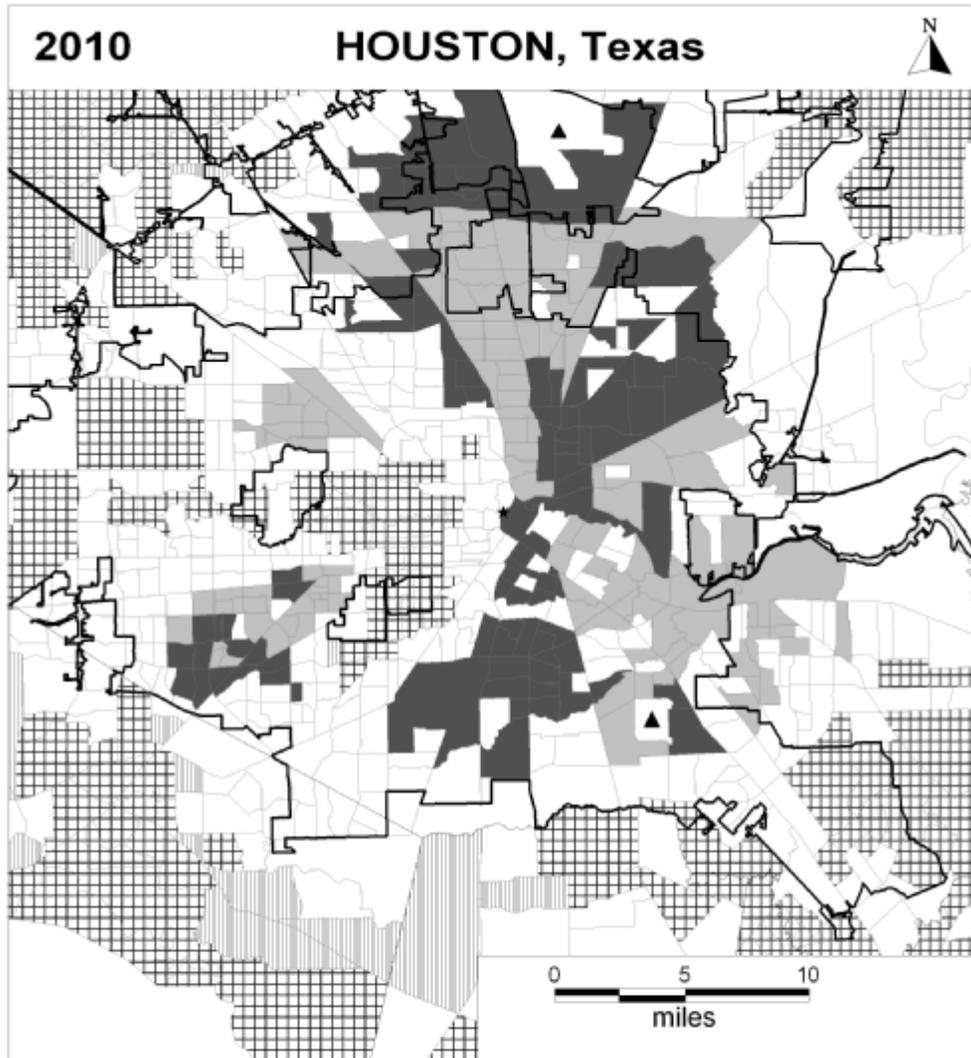*Figure 1. Houston city and vicinity, orientation map*
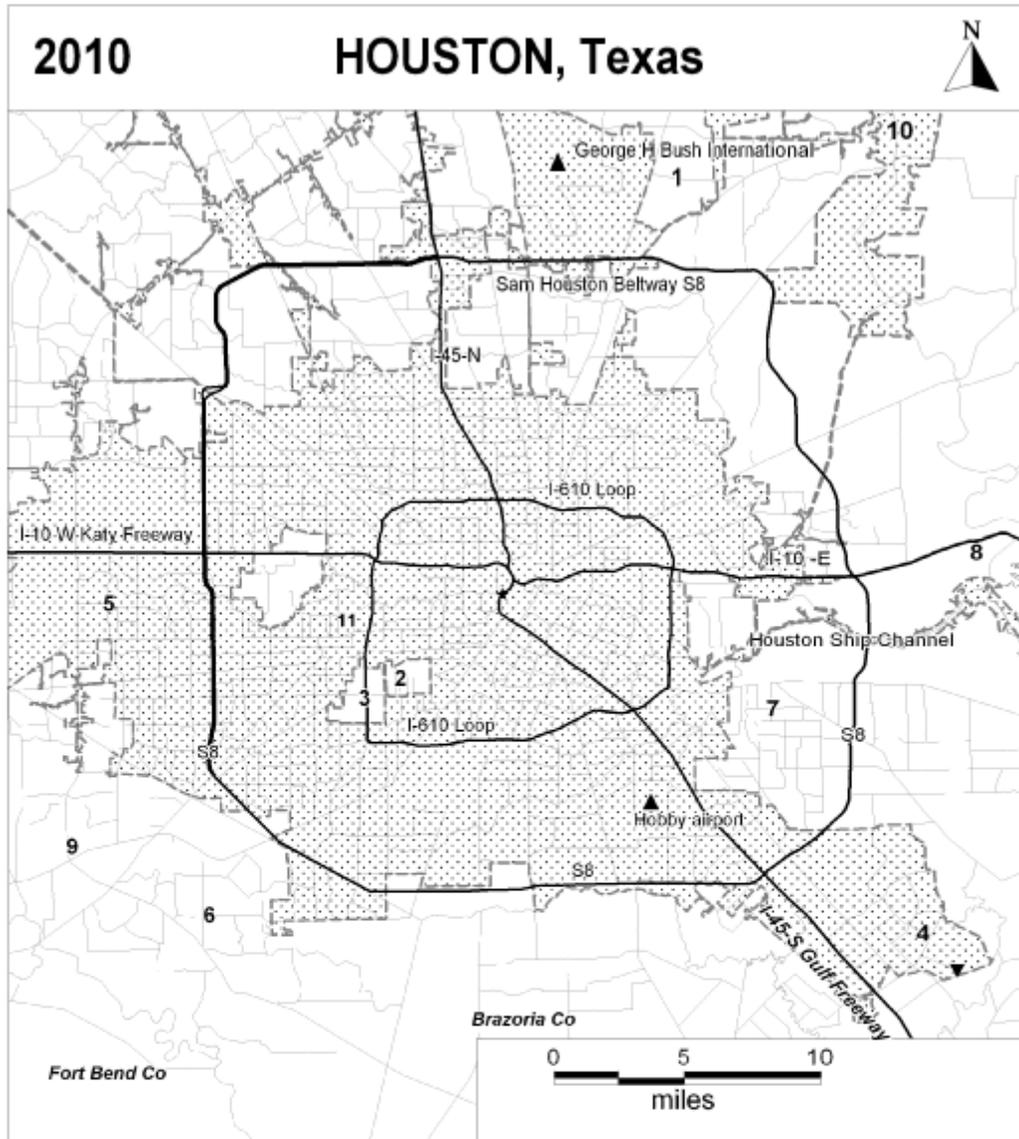
Figure 2. Clustering African Americans and Poverty Houston city and vicinity 2010

2010 **HOUSTON, Texas** N

Black - Poverty bivariate LISA clusters
95% confidence interval

☐ No significant cluster
■ High-High cluster
⊞ Low-Low cluster
▨ Low-High cluster
▥ High-Low cluster

▲ Airport
▱ County limit
▱ Central city
★ City hall

0   5   10
miles

Houston Metropolitan Area Pop. 2010 5,920,416 (census 2010)

incl. 15.8% below the Poverty line (US average 15%)
17% African-American population (U.S. avg. 12%)

Houston Metropolitan Area African-American Poverty rate
2010 estimate 21.9% (US. avg. 27.2%)

Source: American Community Survey
2012 5-years estimate

Exploratory spatial analysis: the Houston case-study

Bivariate LISA analysis identify the location of "hot spots" of African American segregation and poverty in the Houston metropolitan area with a statistical significance test at the confidence interval of 95% (fig. 2). Houston's social geography is strikingly similar to the urban sector model, which suggests that specialized zones expand from the CBD along transportations corridors (Hoyt, 1939; Zaninetti, 2009, p. 158).

A majority of census tracts (617/1073) is not significantly different from the metropolitan average. However, in a region where African Americans form 17% of the total population and 16% of this population lives below the poverty line, 100 tracts can be considered ghettos of concentrated African American poverty. The population of these distressed neighborhoods is 50% African American, and 38% of the neighborhood's total population is below the poverty threshold. Stretching from Downtown to the Sam Houston Beltway, two sectors contain these neighborhoods. To the north-east and to the south. Another cluster of Black poverty is visible around the George H. Bush Intercontinental Airport, straddling the city boundary between Houston and Humble. Though an indispensable infrastructure for a major metropolis, an international airport is typically a locally unwanted land use that generates major environmental nuisances, devaluating the surrounding neighborhoods.

Opposite to this situation, a majority of low-low clusters are located in the exurbs, and are not visible on figure 2. But there is a major cluster of affluent White neighborhoods around the West Loop of Interstate 610 in Uptown Houston and the incorporated places of West University Place and Bellaire. Another cluster of affluent White neighborhoods can be seen on this map to the south-east of Houston city, in the Clear Lake area around the NASA Johnson Space Centre. West Houston is another hot spot of exclusive White neighborhoods. On average, the population of these privileged neighborhoods is only 7% African American, and 6% of its residents are living below the poverty threshold.

African Americans are not the only visible minority living in neighborhoods of concentrated poverty. A pattern of low African American population (7%) combined with high poverty (30%) exists in 126 tracts.. These neighborhoods are mainly located to the north and east of Downtown. These neighborhoods are actually "*Barrios*" of Hispanic population, as shown on figure 3.

Last but not least, there is a minority of neighborhoods that African American middle class residents prefer. A majority of these 14 tracts are located to the south-west in Fort Bend and Brazoria County. A place like Missouri City is a good example of this kind of affluent Black suburb where 31% of the resident population is African American, and only 7% is below the poverty line.

Similarly, bivariate LISA analysis identifies the location of "hot spots" of Hispanic segregation and poverty in the Houston metropolitan area too (fig. 3).

Figure 3. Clustering Hispanics and Poverty Houston city and vicinity 2010
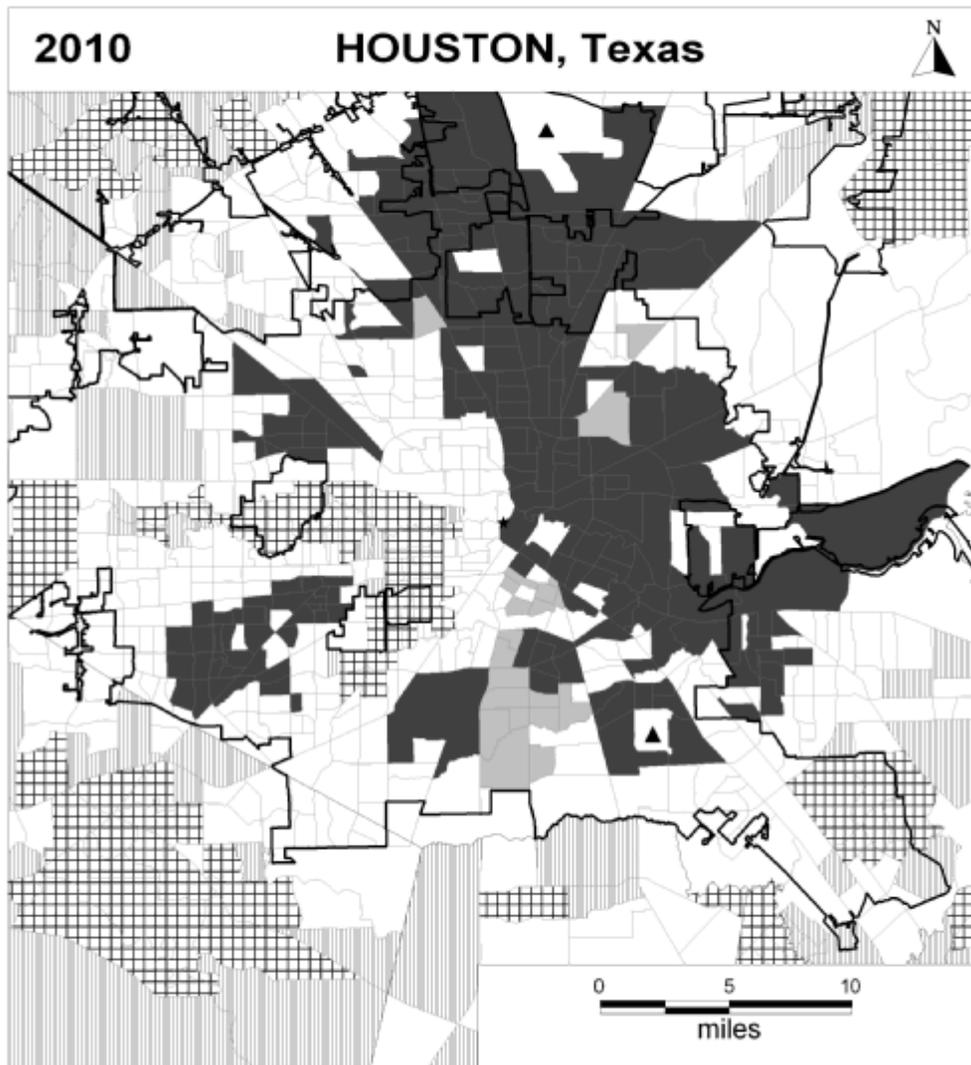
Hispanic - Poverty bivariate LISA cluster
95% confidence interval

☐ No significant cluster
■ High-High cluster
⊞ Low-Low cluster
▨ Low-High cluster
▥ High-Low cluster

▲ Airport
⬠ County limit
⬡ Central city
★ City hall

Houston Metropolitan Area Pop. 2010 5,920,416 (census 2010)

incl. 15.8% below the Poverty line (US average 15%)
35% Hispanic or Latino population (US. avg. 16%)

Houston Metropolitan Area Hispanic Poverty rate
2010 estimate 23.9% (US. avg. 25.6%)

Source: American Community Survey
2012 5-years estimate

Hispanics form an overwhelming minority in the Houston metropolitan area, with a population of 2.1 million according to the 2010 decennial census. A majority of census tracts (621/1073) is not significantly different from the metropolitan average of 35% Hispanics residents and 16% people in poverty. "Barrios" of concentrated Hispanic poverty exist in 201 census tracts, with a population 64% Hispanic or Latino, and 30% of the total population below the poverty threshold on average. This reflects the fact that there are twice the number of Hispanics in the Houston area. Most of the Black "ghettoes" (figure 2) actually are embedded into Hispanic "barrios" (figure 3). A fairly large super "barrio" is visible to the north and east of Downtown, including the George H. Bush Intercontinental Airport area and the industrial sector along the Houston Ship Channel of Pasadena and Channelview. This sector expands to the south-east and includes part of South Houston around the older Hobby Airport. Secondary clusters are evident to the south-west. Another smaller "hot spot" of Hispanic poverty exists to the northwest.

As Hispanic "barrios" and African American "ghettoes" tend to share the same sections of the urban region, the location of the 124 tracts of low Hispanic (11%) – low poverty (4%) clusters can be compared to the 216 low African-American – low poverty clusters visible on figure 2 within the Sam Houston beltway loop. The inner city enclave of White affluence in Uptown Houston is strikingly visible on both maps. However, the situation is very different beyond the beltway line. Outer suburbs are divided in two groups. Some segregated Non Hispanic White "Anglo" enclaves persist (e.g. Sugar Land to the southwest, Kingwood and Lake Houston to the northeast), but many other suburban tracts fall into the high Hispanic (25%) – low Poverty (8%) cluster class of 107 census tracts. This pattern is very different from the situation of the African American minority. This evidence demonstrates that the fairly large Hispanic minority is integrating better into the Anglo middle class residential areas, and this helps explain why the dissimilarity index is lower for Hispanics than for African Americans. Old prejudices lingering from the segregation era, along with the anxieties created among the White middle class during the Civil Rights movement persist, and African American are much more segregated than Hispanics.

The Houston – Galveston metropolitan area has undergone tremendous changes from 1970 to 2010. Houston and Galveston combined metropolitan area hosted only 2.18 million inhabitants in 1970, including 425,000 African Americans (19.5%) and 200,000 Hispanics or Latinos (9.3%). As the region's population has nearly tripled in 40 years, the Hispanic community has expanded tenfold and the African-American minority grew only 2.5 fold. As a consequence, Houston turned from a classic southern racial Black and Anglo White mix in 1970 to a multicultural urban complex including a sizeable Asian minority (7%). Segregation was at its maximum in 1970 (table 4).

Table 4: Relative Concentration and Spatial Clustering of Poverty and Segregation of African Americans and Hispanics in the Urban South and in Houston-Galveston combined MSA 1970

| Index	Urban South (88 SBSA in 1970)	Houston – Galveston combined MSA
Poverty concentration 1970 – Dissimilarity Index	38.3%	38.9%
Segregation of African-Americans 1970 – Dissimilarity Index	75.6%	77.0%
Segregation of Hispanics 1970 – Dissimilarity Index	68.3%	46.8%
Clustering of Poverty 1970 – Moran Index	0.514	0.408
Clustering of African-Americans 1970 – Moran Index	0.528	0.447
Clustering of Hispanics 1970 – Moran Index	0.454	0.407

A comparison of tables 3 and 4 illustrates that racial segregation was much higher in 1970 than in 2010, particularly for African Americans. Hispanics were already less segregated than blacks in the urban South, but this was much more obvious in the Houston area, where a sizeable Hispanic minority had already settled before 1970 (table 2). Residential segregation by class was much lower than racial segregation, and it was a little bit higher in 1970 than in 2010. Spatial clustering was already perceptible at the tract level in 1970. Minorities concentrated in a few inner city census tracts and suburbs had more homogenous White middle class populations. The Houston case-study exemplifies this pattern (fig. 4 and 5).

Bivariate LISA analysis identify the location of "hot spots" of African American segregation and poverty in the Houston metropolitan area in 1970 (fig. 4).

A majority of census tracts (263/400) is not significantly different from the metropolitan average of 1970, where African Americans form 20% of the total population, and 10% of the families are living below the poverty line. The map displays a stark contrast between the suburbs and a handful of inner-city tracts.

A modest number of 19 highly segregated tracts cluster to the north and to the south of Downtown, the largest Black "ghetto" is located to the north-east of Downtown Houston (Bullard, 2007). On average, these neighborhoods are 78% African American and 29% of the resident families are below the poverty line. Conversely, 101 suburban tracts have, on average, no more than 1% African Americans in their population, and only 4% of the resident families in poverty. West Houston was already a privileged section of the metropolitan area in 1970.

Figure 4. Clustering African Americans and Poverty Houston city and vicinity 1970
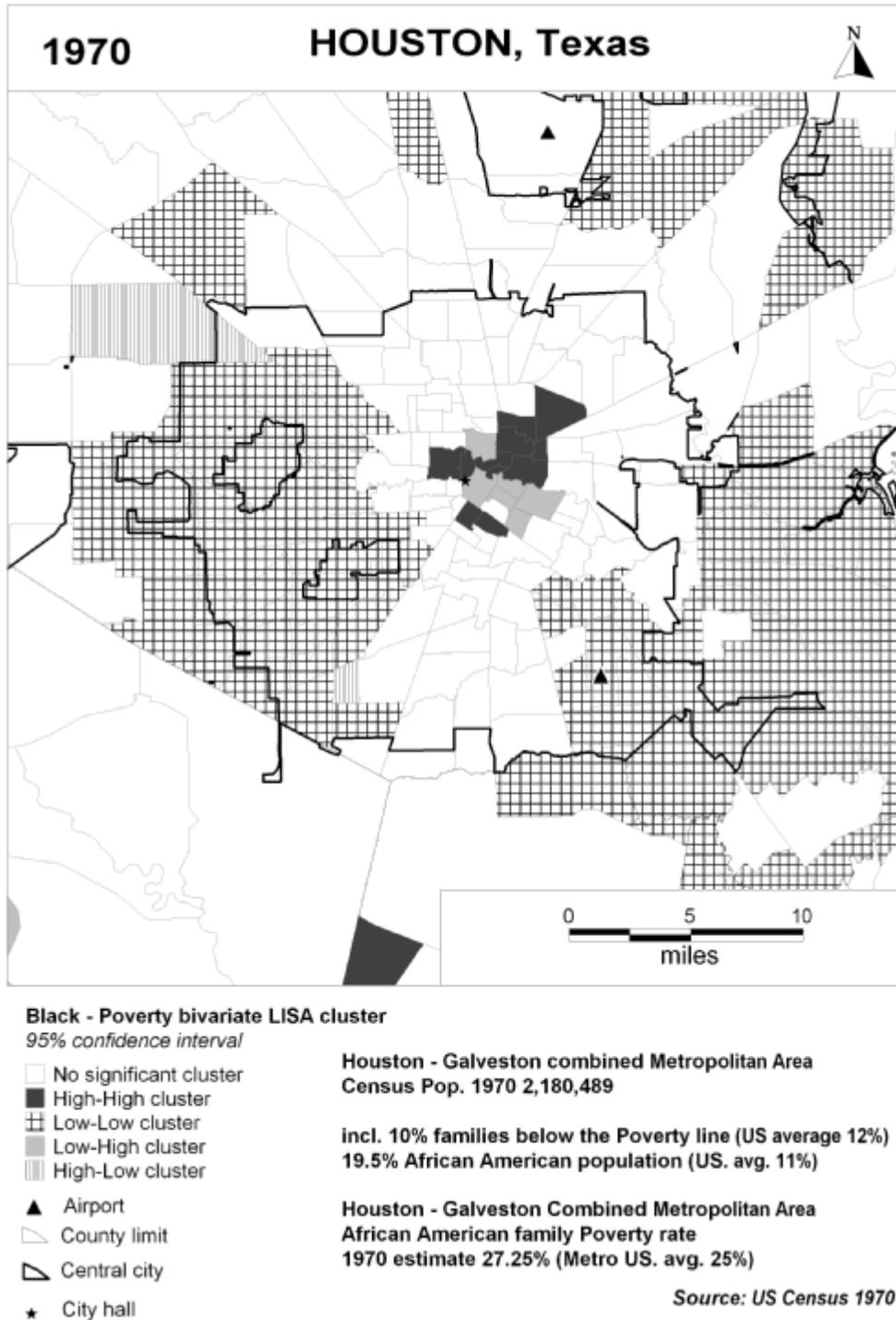
High poverty (19%) exists in 13 inner-city tracts, notably east of Downtown, but they do not constitute Black ghettos (only 7% of the total population). Compared to figure 5 reveals the area is actually the heart of Houston's Mexican "barrio". Opposite

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that, few tracts (4) a high proportion of African-American residents (35%) and a low family poverty rate (11%). This residential pattern reflects discrimination against African Americans in Texas during the 1960s (Barr, 1996, Bullard, 2007).

Comparing figures 2 and 4 reveals the shifting geography of racial segregation and concentrated poverty in the Houston area from 1970 to 2010. Clusters of low African American population and low poverty are located on the urban fringe. As Houston has grown and expanded its territory, privileged White neighborhoods have moved farther away from Downtown, except for the most privileged area of Uptown Houston. Meanwhile, the African American "ghetto" has expanded outward from its original base around Downtown to the north-east and to the south. We note a few tracts to the north-west of Downtown that were highly segregated in 1970 and have turned mixed race and mixed income in 2010, undergoing a partial "gentrification" process. Meanwhile, the Northwestern Black "ghetto" has moved away from Downtown. The comparison between figure 3 and 5 displays another important social change in the tracts surrounding the George H Bush International airport, 23 miles to the north of Downtown. Inaugurated in 1969 on tracts annexed by Houston city in 1965, the new airport was located in affluent White exurbs. By 2010, all these neighborhoods had become high minority – high poverty clusters a function of the disamenities of the airport. This change represents convincing evidence of the importance of spillover effects and spatial dependence in the evolving social landscape of a metropolitan region. A locally unwanted land use (LULU) like a major airport devalues its entire vicinity through the nuisances it generates. Path dependency is important. The fact that the airport development precedes the impoverishment of its vicinity undermines the argument that LULUs are intentionally located in high minority clusters.

Similarly to African Americans, bivariate LISA analysis identify the location of "hot spots" of Hispanic segregation and poverty in the Houston metropolitan area too (fig. 5).

The Houston area housed a sizeable Hispanic minority by 1970. A majority of census tracts (261/400) is not significantly different from the metropolitan average of 1970, where Hispanics or Latino form 9% of the total population, and 10% of the families are living below the poverty line. As in figure 4, this map displays a stark contrast between the suburbs and a handful of inner-city tracts.

A handful of 21 highly segregated tracts are clustered to the north and east of Downtown, the largest "barrio" is stretched to the north-east of Downtown. On average, these neighborhoods are 30% Hispanic and 25% of the resident families are below the poverty line. Conversely, 65 suburban tracts including West Houston have, on average, no more than 2% Hispanic in their population, and only 3% of the resident families in poverty in 1970.

Ten inner-city tracts of high poverty (31%) form the heart of the African American ghetto, where only 2% of the total population is Hispanic or Latino to the south and east of Downtown. Opposite to that, 43 suburban tracts are characterized by a relatively high proportion of Hispanic population (10%) and a low family poverty rate (4%). Hispanics were already better integrated in the Texan society during the 1960s than their African American counterparts.

Figure 5. Clustering Hispanics and Poverty Houston city and vicinity 1970
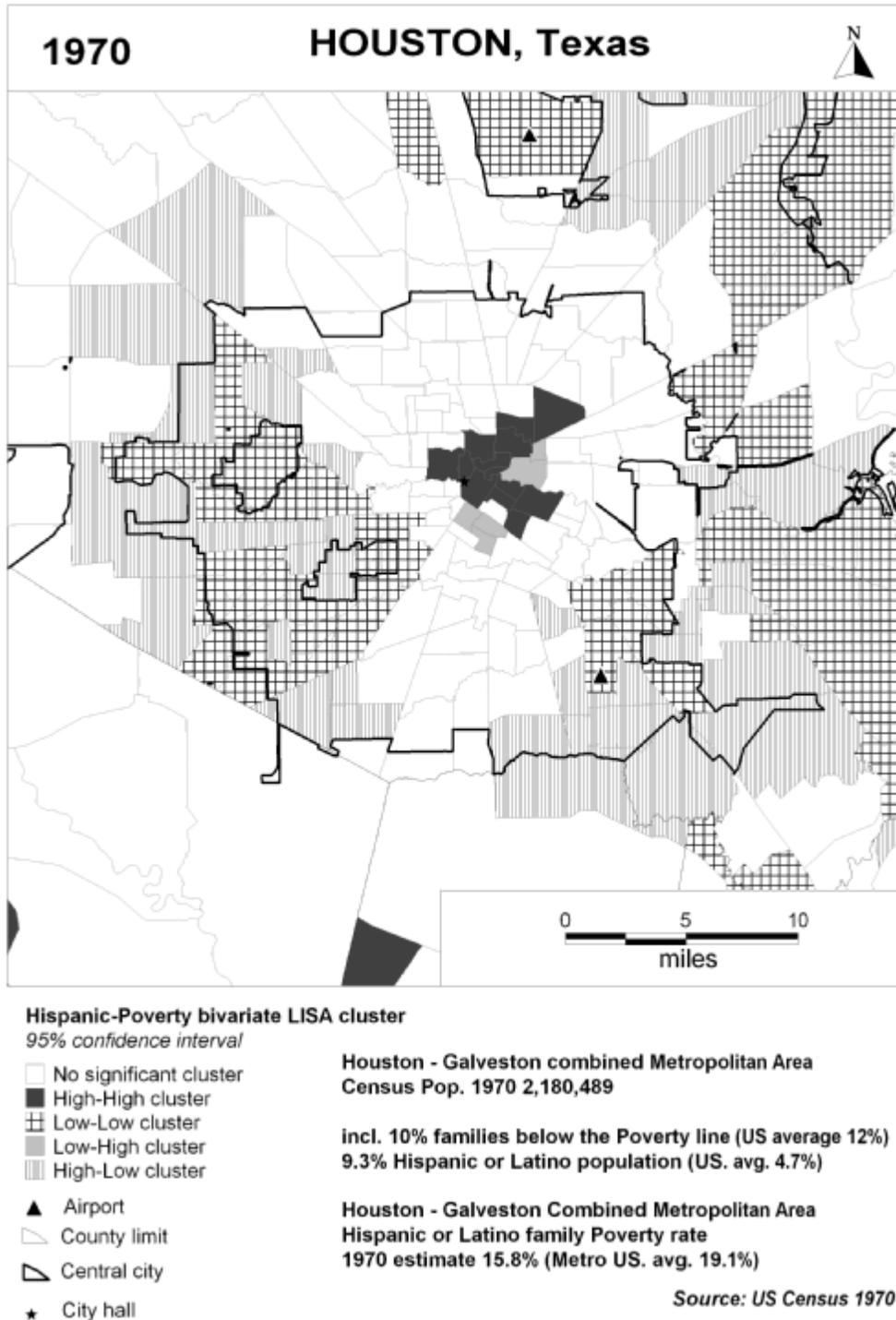
The comparison of figures 3 and 5 displays the shifting geography of Hispanic segregation and concentrated poverty in the Houston area from 1970 to 2010. As noted for African Americans, clusters with low Hispanic population and low poverty

exist on the city's fringe. These privileged "Anglo" White neighborhoods have moved farther away from Downtown, except for the most privileged area of Uptown Houston. Meanwhile, the Hispanic "barrio" has greatly expanded outward from its existing base around Downtown to the north and to the east as a Hispanic community grew rapidly. The same few tracts to the north-west of Downtown that were highly segregated with a majority African American and Hispanic population in 1970 have become mixed race and mixed income in 2010 as a result of partial "gentrification."

As the Houston area exemplifies, residential integration of Hispanics and African Americans has improved, but, African Americans remain disproportionately segregated. If spatial analysis supports Klineberg's argument based on a survey about a positive generational shift in attitudes toward ethnic diversity (2013), there is also convincing evidence that the correlation of segregation and poverty is still a major issue embedded in the urban fabric.

Modeling the correlation between poverty and minority concentration with SAR spatial-lag models

Exploratory spatial analysis with bivariate LISA displays strong evidence of the importance to take spatial dependence into account in analyzing residential segregation and concentrated poverty in urban regions. The Houston case-study proved useful in making the issue visible and relating it to history factors of urban planning and growth. However we still need to assess the evolving intensity of the general relationship between these phenomena with spatial econometrics.

Table 5 summarizes a diachronic analysis with two spatially-lagged autoregressive correlation models of the entire urban South at the census tract level.

Table 5: Spatial Lag Regression model of Segregation and Poverty in the U.S. urban South 1970-2010

Model indicator	1970	2010
African-American - Poverty Bivariate OLS model quality of fit R²	0.375	0.189
Hispanic - Poverty Bivariate OLS model quality of fit R²	0.045	0.061
African-American - Hispanic Bivariate OLS model quality of fit R²	0.000	0.037
[African-American - Hispanic] - Poverty OLS model quality of fit R²	**0.425**	**0.301**
[African-American - Hispanic] - Poverty OLS model multicollinearity diagnostic Jarque-Bera test (p-value)	*0.000%*	*0.007%*
[African-American - Hispanic] - Poverty OLS model heteroskedasticity (Obs-Res R²)	0.575	0.699
[African-American - Hispanic] - Poverty OLS model residuals Moran Index	0.425	0.447
[African-American - Hispanic] - Poverty SAR Spatial Lag model quality of fit R²	**0.614**	**0.520**

[African-American - Hispanic] - Poverty SAR Spatial Lag model heteroskedasticity (Obs-Res R²)	0.452	0.570
[African-American - Hispanic] - Poverty SAR Spatial Lag model residual normality (Shapiro-Wilks test) p-value >n	*0.010*	*0.010*
[African-American - Hispanic] - Poverty SAR Spatial Lag model heteroskedasticity (Breusch-Pagan test) p-value >n	*0.010*	*0.010*
[African-American - Hispanic] - Poverty SAR Spatial Lag model residual Moran	0.046	0.030
[African-American - Hispanic] - Poverty SAR Spatial Lag model Residual spatial dependence (Likelihood Ratio test) p-value >n	*0.010*	*0.010*
[African-American - Hispanic] - Poverty SAR Spatial Lag model Rho	0.568	0.596
[African-American - Hispanic] - Poverty SAR Spatial Lag model Intercept	2.021	1.666
[African-American - Hispanic] - Poverty SAR Spatial Lag model African-American coefficient	0.175	0.151
[African-American - Hispanic] - Poverty SAR Spatial Lag model Hispanic coefficient	0.095	0.115

Bivariate OLS correlation R^2 coefficients show that there is no relation between the concentration of African American and Hispanic in the resident population at tract level in the urban South. Both minorities can be combined in a single regression model. The Jarque-Bera test or the OLS confirms that there is no multicollinearity between the two independent variables. Ordinary OLS models show that African American and Poverty have the higher bivariate Pearson index value at both periods, +0.61 in 1970 and +0.43 in 2010. Statistically significant, this a-spatial correlation coefficient displays a weakening linkage between the two variables. Nonetheless, integrating the Hispanic minority in the model improves the quality of fit of the OLS model, taking into account 42% of the variance of poverty rates in 1970 and 30% in 2010. Other statistical tests demonstrate that the OLS model is biased. The model residuals are highly heteroskedastic and display a strong spatial dependence, very similar to the endogenous variable spatial dependence. The residual Moran is +0.425 in 1970 where the Poverty rate Moran is +0.528. Similarly, the residual Moran is +0.447 in 2010 where the Poverty rate Moran is +0.508, indicating an ever stronger spatial dependence in 2010 than it was already in 1970.

Substituting a spatial-lag model to the usual OLS model improves the quality of fit of the model. The spatial-lag model quality of fit jumps from 42% of the variance of tract-level poverty rates in 1970 with the OLS model to 61% with the SAR model. In 2010, the gain is even larger, jumping from 30% of the variance of tract-level poverty rates with the OLS model to 52% with the SAR model. Two lessons can be drawn from this simple statistic. First, integrating explicitly the spatial dependence in the

model creates a much better adjustment with no additional independent variable. Second, the weakening linkage from 1970 to 2010 is still highly perceptible with the SAR model. Model residuals are normally distributed, but they are still strongly heteroskedastic, even though the correlation coefficient between observed poverty rates and model residuals is lower for the SAR model than for the OLS model. This means that other explanatory factors are required to better explain the actual level of poverty in urban neighborhoods, but this extends beyond the scope of this paper. Despite this later fact, the relative concentration of the African American and Hispanic minorities is a good predictor of the relative wealth of a neighborhood's resident population.

On average, the model coefficients indicate an increasing correlation between Hispanics and poverty, and a decreasing correlation for African Americans from 1970 to 2010, even though the African American percentage is a better "predictor" of poverty than its Hispanic counterpart. This shift is related to the growing importance of Hispanic communities within Southern U.S. metropolitan areas. The arrival of numerous recent immigrants in regions that had negligible Hispanic population in 1970 helps explain this change. Recent immigrants occupying the lower rungs of the social ladder tend to settle in ethnic enclaves to ease their adjustment in American society (Fernandez-Kelly & Schauffler, 1996). The Hispanic minority will soon be larger than the African American minority in the urban South. This is already true in Texas, as we illustrated with the Houston case-study. Despite this major trend, African Americans are still struggling to fully integrate into the middle class in comparison with the Hispanics.

The growing importance of spatial dependence in the linkage between segregation and concentrated poverty is another important lesson from the SAR model. The ρ coefficient, which measures the average spatial dependence in the endogenous variable, is higher in 2010 than in 1970, and the model intercept is lower, despite the rise of the poverty level from 1970 to 2010 (Gabe, 2013).

Discussion

The results of the exploratory bivariate LISA spatial analysis of the Houston metropolitan area and the general spatial-lag SAR model of the entire urban South converge. Statistical tests confirm our hypotheses.

First, concentrated poverty in highly segregated neighborhoods persists within U.S. metropolitan areas. It is still a major issue to the American society, particularly in the South.

Second, spatial dependence is a major explanatory factor in the social geography of segregation and poverty in metropolitan areas. This means that census tracts are smaller than the actual scale at which significant neighborhood effects are perceptible. Substituting a simple SAR model to the usual OLS model causes a major gain in the model quality of fit. The geography of urban poverty is closely tied to the location of visible minorities, both African Americans and Hispanics. However, heteroskedastic residuals involve the need to further improve the model with the addition of others independent variables to better fit with the geography of poverty. Nevertheless, the increasing importance of spatial dependence from 1970 to 2010 suggests that place-based policies are meaningful (Orfield, 2002). This implies for instance that urban planning tools like Community Development Corporations imagined in the wake of the Civil Rights movement may be key ingredients in the

recipe of the continuing "war on poverty" (Keating, Rasey & Krumholz, 1990, Green & Haynes, 2012).

Third, there is statistical evidence that integration improved from 1970 to 2010. Hispanics are less segregated than African Americans, and persistent high levels of poverty may be mostly the result of continued immigration. The Houston case-study makes a convincing example of integration of the Hispanic middle class in the outer suburbs. In contrast, there is striking evidence that African American progress is painfully slow. At the 1970-2010 average rate of desegregation, the Black community would not be fully integrated in 2050! Though based on empirical evidence, the Brookings Institution's optimistic vision of integration through middle-class "Black flight" to the suburbs has its limits in Houston (Frey, 2011b). The "ghetto" persists and a disproportionate number of African Americans are still trapped there. Change for the best may happen more easily in the future because American metropolises are moving toward multiculturalism as they transform into "majority minority" societies and memories of old prejudice fade. Perhaps the generational shift in attitudes toward diversity will reduce the traditional polarization of the American urban social landscape along ethnic lines. Our findings suggest that major "New South" metropolises like Houston are frontrunners in this direction.

Acknowledgments

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