Metropolitan Growth and Neighborhood Segregation by Income

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Abstract: U.S. metropolitan neighborhoods have become increasingly segregated by income over the past thirty years. The metropolitan areas with the largest rises in income segregation include a number of distressed cities in industrial decline, as well as a subset of rapidly growing metropolitan areas. I propose a simple model based on the notion that rising income inequality creates market pressure (or "demand") for segregation by income in the housing market. Housing markets in rapidly growing areas easily respond to changing preferences, so rising inequality translates into residential segregation. On the other hand, because housing is durable and existing housing may cost less than the price of new construction, slow growth areas witness rising segregation only if the change in demand for segregated housing is sufficient to overcome construction costs.

Several implications of the model are supported empirically. First, higher levels of income inequality are associated with higher levels of residential segregation by income. Second, inequality (at the top of the distribution, but not the bottom) has a bigger effect on segregation in rapidly growing areas than in slowly growing areas. Third, large increases in segregation are coupled with higher than expected housing construction in slow-growth areas but not rapid-growth areas. Finally, income segregation levels are persistent, and the persistence is more pronounced in cities with older housing stocks. The model helps to explain the U-shaped relationship between residential segregation by income and metropolitan area growth.

Metropolitan Growth and Neighborhood Segregation by Income

I. Introduction

Between 1970 and 2000, residential segregation by income has become an increasingly important feature of the metropolitan landscape in the United States. About two-thirds of American metropolitan areas witnessed increasing segregation of the rich from the poor over the last three decades. Over 85 percent of the metropolitan population lives in an area that was more segregated by income in 2000 than in 1970.

The metropolitan areas with the largest rises in segregation include a number of distressed cities in industrial decline, such as Buffalo and Trenton. There is a sizable literature examining the flight of white, middle-class residents from the central cities of declining metropolitan areas and the consequent residential isolation of the minority poor (e.g. Wilson, 1987.) Less well-studied, however, is the rising income segregation of a subset of booming metropolitan areas. For example, Tuscon and Reno saw increases in segregation over the past three decades that were comparable in magnitude to those in Buffalo and Trenton. The relationship between segregation growth and population growth is U-shaped, with both rapidly growing and stagnating metropolitan areas experiencing rising income segregation (see Figure 1).

This paper investigates the relationship between metropolitan growth and neighborhood segregation by income. I propose a simple model suggesting that rising income inequality creates market pressure (or "demand") for segregation by income in the housing market. In rapidly growing metropolitan areas, changing preferences are rapidly reflected in the housing stock and in level of segregation. In stagnant metropolitan areas, however, the housing stock reflects the preferences of previous generations of residents. If housing costs less than the price of new construction or retrofitting, there is little incentive to build new housing. Rising segregation will occur in slow growth areas only if the change in demand for segregation is sufficient to overcome the costs of new construction.

Why does economic segregation matter? Income sorting affects the distribution of role models, peers, and social networks. Sociologists such as Wilson (1987) hypothesize that the lack of neighborhood exposure to mainstream middle-class role models and social networks is a major contributor to urban joblessness and social problems. A number of empirical papers also suggest that the characteristics of one's neighbors and peers in school affect outcomes (Case and Katz (1991), Cutler and Glaeser (1997), Hoxby (2000), Katz, Kling and Liebman (2001)), though the issue is far from settled (e.g., Oreopoulos, 2003). If households sort into different political jurisdictions, economic segregation affects the degree of fiscal redistribution among income groups (Glaeser, Kahn and Rappaport (2000)). Even within political units, neighborhood-level sorting may influence the average level and variance of school quality and other local public goods. Finally, the factors that motivate households to segregate by income also shape the spatial relationship between jobs and homes, in turn affecting commuting patterns and labor market decisions.

Each of these factors is amplified by the political process because economic segregation itself shapes the context in which policy decisions are made. Bjorvatn and Cappelen (2003) present a model in which income inequality generates residential sorting by income. Residential segregation, they hypothesize, reduces social attachment between groups, and rich children who grow up in segregated neighborhoods are less willing to favor redistribution as adults. In this way, income sorting may have consequences reaching beyond the current generation.

In this paper, I examine the determinants of income segregation and how they interact with metropolitan growth. Section II introduces the simple model, as described above. Section III introduces several measures of income segregation. These measures of income segregation are insensitive to a rank-preserving spread of the income distribution if residential location is unchanged, making them particularly well-suited for studying the relationship between income inequality and residential choice. Trends in residential segregation are reported as well. In Section IV, I test several implications of the model using the newly developed measures of income segregation. Section V concludes.

II. Theoretical Background

II.a. The "Demand" for Residential Segregation by Income

One tradition of modeling residential location decisions starts with a classic paper by Tiebout (1956), which suggests that household location decisions can be viewed as choices over bundles of local public goods. Households sort by income at the level of political district because income is correlated with willingness to pay for public goods. Analogously, households might sort across school districts or neighborhoods because income is correlated with willingness to pay for school quality or neighborhood quality. Sorting by income at the neighborhood level stems from divergence in willingness to pay for neighborhood attributes, including both attributes that vary across political jurisdictions (those emphasized by Tiebout) and attributes that vary within a political jurisdiction. Even within political boundaries, neighborhoods differ in their access to governmentally provided local public goods, such as proximity to public transit or reliability of trash collection, and differ in their non-governmental local public goods, such as nice neighbors or a good view.

If households of different income groups are willing to pay different amounts to live in a given neighborhood, market forces will tend to generate residential segregation by income. I refer to this phenomenon as the "demand" for residential segregation by income. Individual households need not prefer segregated neighborhoods *per se*. Rather, differences in the willingness-to-pay for various neighborhood attributes across income groups attract these groups to different neighborhoods. In a frictionless housing market, demand for segregation is observed as actual segregation – that is, rich and poor households living in different neighborhoods.

The simplest form of a Tiebout model implies that residential segregation by income should be complete. If all households have the same underlying tastes, the rich will always pay more to live in high-quality neighborhoods and complete residential segregation by income will occur (Ellickson, 1971). The model has been extended by Epple and Platt (1998) to allow variation in both tastes for neighborhood quality and income. For a given level of tastes, rich households always choose to live in a higher quality neighborhood than poor households in the model. Similarly, at a given income level, households with stronger preferences for neighborhood quality always live in higher quality neighborhoods than those with weaker preferences. Because both income and tastes vary across households, the willingness to pay for neighborhood quality is imperfectly correlated with income. In equilibrium, neighborhoods are partially but incompletely sorted by income. The prediction of the Epple and Platt model accords well with the observed patterns of residential location in American metropolitan areas.

The Epple and Platt framework suggests that observed economic segregation in American metropolitan areas depends on household preferences and the income distribution. Income inequality affects the relative willingness-to-pay of people at different income levels. There are two distinct ways in which the income sorting predicted by a Tiebout-style model could be affected by inequality. First, there is a direct effect of income inequality on willingness-to-pay.

As inequality increases, it becomes less likely that rich and poor households are willing to pay similar amounts to live in a given neighborhood. In this sense, income inequality is a primary determinant of the demand for segregation.

Other market forces are also likely to differentially affect the willingness-to-pay of the rich and poor to live in particular neighborhoods. For example, industrial change associated with declining employment of less-skilled men is empirically related to segregation trends. Idleness among men may change neighborhoods differentially and thereby affect the relative price of living in a high-quality neighborhood. To the extent that this change pushes the market towards a segregated equilibrium, it too is a factor raising "demand" for segregation.

A thought experiment helps to clarify the meaning of demand for segregation as it is used in this paper. Consider two identical metropolitan areas, each with a fixed group of families that are heterogeneous in income and tastes for neighborhood attributes. Residential markets in the two cities are in a competitive equilibrium and identical to each other. Thus, the observed level of income segregation is the same in the two cities. At some point, an exogenous force widens the distribution of income in only one city, the "treatment" city, by changing the amount of income associated with each family income percentile but preserving each family's rank in the metropolitan area income distribution. If no family moves in response to the change in the income distribution, income segregation is unchanged.

Given the scenario described above, one might like to ask the following question: if the supply of housing was perfectly elastic in the treatment city, what level of income segregation would emerge? I refer to the level of income segregation under this hypothetical costless competitive equilibrium as the "demand" for segregation. In other words, even if no family cares explicitly about the incomes of its neighbors, factors such as income inequality affect the willingness of different income groups to pay for various attributes of neighborhoods. Divergence in the valuation of neighborhood attributes across income groups leads to competitive pressure, or demand, for income segregation. Under this nomenclature, the difference in equilibrium segregation levels in the treatment and control cities in the absence of adjustment costs is the effect of inequality on the demand for segregation.

II.b. Adjustment Costs

In practice, adjustment costs in the housing market are likely to be quite important. For example, Glaeser and Gyourko (2005) develop a "bricks and mortar" model of metropolitan growth and decline. A key insight of their piece is that population is slow to fall in declining metropolitan areas because the housing stock remains after employment disappears. Residents choose declining metropolitan areas to enjoy their low housing costs, which often fall below the cost of new construction. Because of the durable nature of housing, adjustments to labor demand shocks across metropolitan areas are likely to be quite slow.

Similarly, the durable nature of housing prevents an immediate market response to changes in demand for segregation within metropolitan areas. The costs of retrofitting or building new housing indicate it may take many years to respond to a demand shock. Indeed, if the residential market evolves sufficiently slowly, there may be coordination failures that preclude the hypothetical costless equilibrium from ever being realized. An empirically observed change in the level of segregation resulting represents the effect of a change in demand for segregation, tempered by incomplete adjustment.

Rapidly growing and stagnant cities vary in their adjustment costs. Glaeser and Gyourko (2005) report that existing housing stock is priced lower than new construction in many declining cities, making it relatively costly to develop new neighborhoods. In rapidly growing cities, on the other hand, newly constructed housing stock can easily respond to current consumer preferences. Developers of new neighborhoods can also overcome coordination problems that might persist in cities with a preexisting housing stock. Holding other factors constant, income segregation in rapidly growing cities should have greater sensitivity to changes in demand for segregation because growing cities more quickly adjust to the new equilibrium.

II.c. A Simple Model

A simple model illustrates this point. Suppose that there are two neighborhoods, G and B. The good neighborhood, G, is more desirable because residency includes access to an unspecified local public good, but the two neighborhoods are otherwise identical. As the city is built, the supply of housing in each neighborhood is upward-sloping, reflecting the fact that it is more expensive to build on some lots in the neighborhood. Let $S_q(p_q)$ be a function describing the supply of housing in neighborhood of quality $q \in \{G,B\}$. Assume $S_q'(p_q) > 0$ and the supply function S_q is the same in both neighborhoods.

The willingness-to-pay for housing in each neighborhood is described by $D_q(p_q)$, where $D_q'(p_q)<0$. In neighborhood G this includes the valuation of the local public good. In equilibrium:

$$D_b(p_b) = S_b(p_b),$$
$$D_g(p_g) = S_g(p_g), \text{ and}$$
$$p_g = p_b + a^*,$$

where $a^*>0$ represents the valuation that the marginal resident assigns to the local public good. Note that $p_g > p_b$ and $S_g > S_b$ in equilibrium.

Suppose that the metropolitan area with n residents. A fraction r of these residents are rich, while $1-r$ are poor. Residents each live on a plot of land of a fixed size, but rich residents always build a big house and poor residents always build a small house. Rich and poor residents have different distributions of willingness-to-pay to live in the good neighborhood, represented by $f_r(a)$ and $f_p(a)$ respectively. The distribution $f_r(a)$ stochastically dominates the distribution $f_p(a)$.

Let a^* be the equilibrium difference in prices between the two neighborhoods, as described above. The fraction of rich residents with valuations $a>a^*$ in equilibrium is $1-F_r(a^*)$; this is therefore the fraction of rich residents who live in neighborhood G. The fraction of poor residents with valuations $a>a^*$ in equilibrium is $1-F_p(a^*)$. Assume, as in the Epple and Platt model, some residents of each type have valuations above and below a^*, so $0 < (1-F_p(a^*)) < (1-F_r(a^*)) < 1$. It follows that both neighborhoods will contain both rich and poor residents, but rich residents are disproportionately represented in neighborhood G and poor residents are disproportionately represented in neighborhood B. The housing in each neighborhood is constructed as a mix of large and small houses, reflecting the incomes of residents.

It is instructive to consider the effect of inequality on the distribution of residents across neighborhoods as the metropolitan area is built. Suppose the income of the rich is higher while the income of the poor is unchanged. The distribution of willingness of the rich to pay for the local public good, $f_r(a)$, shifts upward, while the distribution of the WTP of the poor, $f_p(a)$, remains the same. Let a^{**} represent the marginal valuation of the public good in this new scenario. In the new equilibrium $a^{**}>a^*$, $(1-F_p(a^{**}))<(1-F_p(a^*)$, and $(1-F_r(a^{**}))>(1-F_r(a^*))$. That is, with rising inequality, poor residents are less likely to live in the good neighborhood and rich residents are more likely to live in the good neighborhood. Because rich residents become increasingly concentrated in the good neighborhood, residential segregation by income increases relative to a situation in which income is distributed equally (see Figure 2).

Figure 2.

Fig 2a. Hypothetical Distributions *f(a)* Under Relative Equality

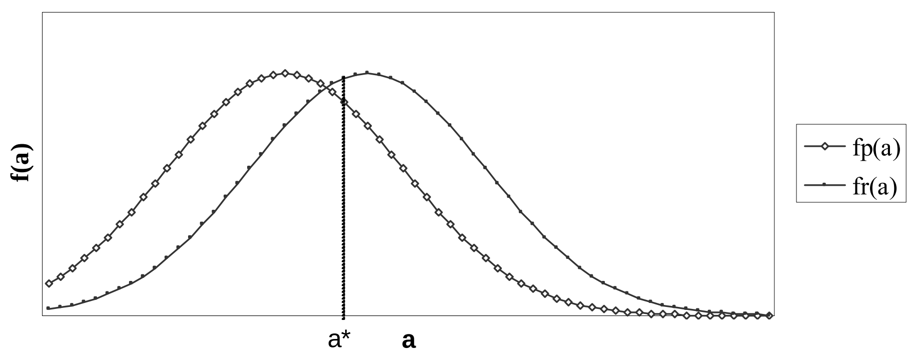
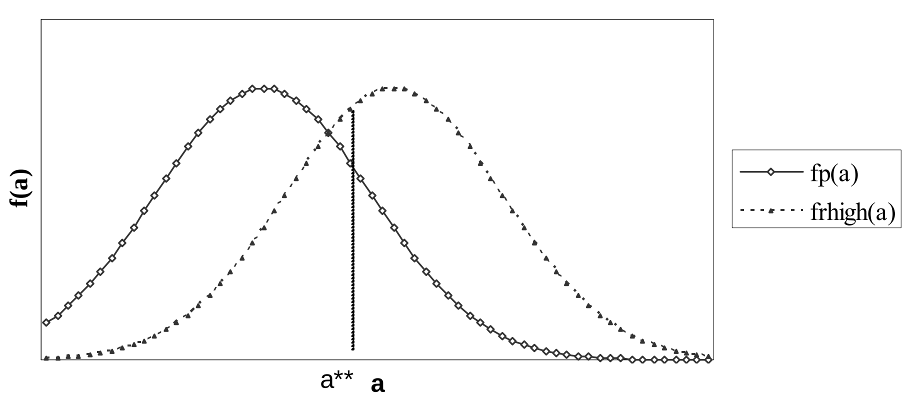


Fig 2b. Hypothetical Distributions *f(a)* Under Relative Inequality



Suppose a city is built at a time of relative equality and neighborhoods are characterized by moderate segregation, with a mix of large and small houses in each neighborhood. In equilibrium,

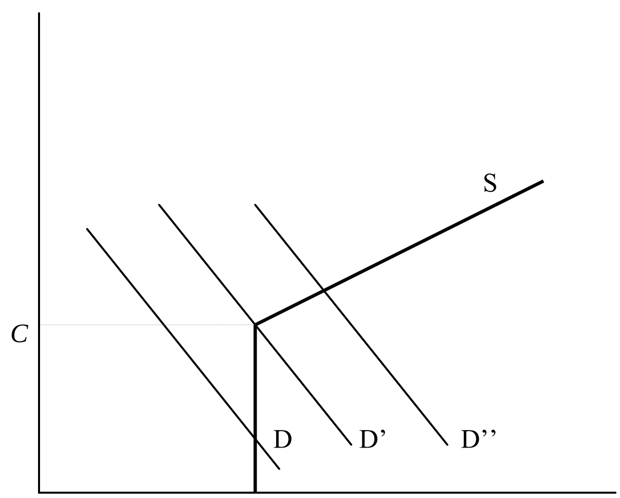
$$p_{lg} = p_{lb} + a_r^* \text{ and}$$

$$p_{sg} = p_{sb} + a_p^*$$

where l and s represent large and small houses, respectively, and a_r^* and a_p^* represent the marginal willingness-to-pay for the local public good of each type of resident. If the metropolitan area is growing, $a_r^*=a_p^*$ because both groups are simultaneously bidding on empty lots.

Eventually the hypothetical city falls into economic decline. Housing prices in both neighborhoods fall below the cost of new construction for both house types, c_l and c_s, as the metropolitan area as a whole becomes less attractive. As noted by Glaeser and Gyourko (2005), the housing supply curve becomes kinked in the scenario; it is inelastic for prices below the cost of new construction and upward sloping above the cost of new construction (see Figure 3.)

Figure 3. The Supply of Housing, Glaeser and Gyourko (2005)



Suppose an exogenous force raises incomes of the rich in the metropolitan area, increasing income inequality. This change raises the WTP of rich residents, but not poor residents. In the new equilibrium,

$$p_{lg} = p_{lb} + a_r^{***},$$

where $a_r^{***} > a_r^*$ represents the new marginal valuation of the new marginal resident. The "demand" for segregation has increased. However, if the new price $p_{lg} < c_l$, then no new houses will be built in neighborhood G. The demand shock will raise the price for large houses in neighborhood G, but the housing supply remains fixed at its historical level. Because the housing stock is tied to the income levels of residents, no rich residents move into the good neighborhood, and segregation remains constant.

On the other hand, if $p_{lg} > c_l$, then new large houses in neighborhood *G* are built and rich residents move into neighborhood *G*.[1] Thus, a sufficiently large demand shock induces new housing construction even in a stagnant metropolitan area, and leads to higher levels of residential segregation by income.[2]

To summarize, consider a hypothetical distressed metropolitan area. It is characterized by economic decline, stagnant or negative population growth, and housing prices below the cost of new construction. The durable nature of housing combined with the low market price for housing implies that the supply is fixed in the absence of a large demand shock. If there is a moderate increase in inequality, the equilibrium price of large houses in the good neighborhood rises but the quantity supplied is fixed. In other words, no new houses are built because the market price for large houses in the good neighborhood is lower than construction costs. Because rich people live only in large houses, the distribution of rich and poor residents across neighborhoods remains constant and the observed level of income segregation remains unchanged.

On the other hand, suppose economic decline is accompanied by a very large shift in demand for large houses in the good neighborhood. If the demand shock is sufficiently large, the market price will exceed the cost of new construction, and new houses will be built in the good neighborhood. The fraction of rich residents living in the good neighborhood will rise and segregation will increase. In sum, a declining metropolitan area will witness an increase in segregation and new housing construction only if the underlying demand for housing in particular neighborhoods is very high.

In contrast, consider a hypothetical rapidly growing metropolitan area. Rapid population growth means that new homes are priced above the cost of construction and housing supply is somewhat elastic for both large and small houses. If income inequality remains constant as the number of residents grows, market forces will yield a distribution of new houses that is similar to the initial

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[1] According to a strict interpretation of the model, in which it is assumed poor residents only live in small houses, rich residents leave vacant large homes in the bad neighborhood. More realistically, some poor residents would move into those vacated properties, leaving small homes vacant in neighborhood B.

[2] If the model is relaxed slightly, segregation will also increase if there is a sufficiently large drop in income for poor residents and income of rich residents stays constant. In that case, the price of small houses in the good neighborhood falls, reflecting the decline in WTP of poor residents for the public good. If the price of these houses is sufficiently low, rich residents who value the local good will purchase these homes, and incur the cost of tearing them down to build a large house. Poor residents will move into large homes vacated by rich residents. Alternatively, an increase in poverty may make neighborhood *B* a less attractive place to live. Rich residents may raise their valuation of the good neighborhood more than poor residents, and be willing to pay to finance new construction in the good neighborhood.

distribution of houses. New homes are built, but segregation remains at a constant level in this case.

Rising inequality has a large effect on the housing market in a booming metropolitan area. If inequality is rising as the population expands, the increased demand for large houses in the good neighborhood will be easily accommodated. New construction will be built to reflect the current market demand for segregation. Thus, even a minor increase in inequality will translate into rising segregation levels in a growing metropolitan area.

This simple model suggests that it is the interaction between the demand for segregation and economic growth of a city which determines a metropolitan area's level of segregation. In a rapidly growing city, the housing stock and observed segregation will reflect current preferences of residents. In a slowly growing metropolitan area, observed segregation will reflect historical preferences of residents, unless the demand shock is sufficient to induce the construction of new housing that would not have occurred otherwise.

To summarize, the model predicts the following relationship between metropolitan area growth and residential segregation by income:

Table 1. Theoretical Predictions Regarding
Relationship Between Metropolitan Area Growth and Segregation

	Booming Metro Area	Distressed Metro Area
Inequality Rising	Increase in observed segregation No extra housing construction	Increase in observed segregation only if demand shock is sufficient to induce higher than expected housing construction
Inequality Not Rising	No increase in observed segregation	No increase in observed segregation

The model generates several predictions:

1. Factors raising the relative willingness-to-pay of the rich to live in a good neighborhood, such as rising income inequality, will tend to increase segregation in a metropolitan area.

2. The extent to which observed levels of segregation reflect these demand shocks depends on the economic growth of a metropolitan area.

3. Rising segregation is accompanied by higher than expected levels of new housing construction in declining cities, but not in growing cities.

4. The housing stock of a metropolitan area will tend to reflect the underlying demand for segregation at the time it was built. Market forces generating demand for economic segregation will tend to have persistent effects on segregation levels even after the forces themselves have disappeared. Segregation levels will be more persistent in cities with a slowly evolving housing stock.

The final prediction is somewhat analogous to Glaeser and Gyourko's (2005) "bricks and mortar" view of metropolitan growth and decline, applied to residential choice within metropolitan areas. Specifically, neighborhoods are develope to reflect the heterogeneity of their expected residents in terms of desired housing attributes. Because housing is durable, segregation by income will tend to reflect the demand for segregation at the time housing is built in a metropolitan area. In declining metropolitan areas, segregation will rise only if the increased demand for segregation is sufficient to induce new housing construction that would not otherwise be expected.

III. Measurement of and Trends in Income Segregation

The consensus of the empirical literature is that neighborhood income segregation rose between 1970 and 2000.[3] Massey and Fischer (2003) report an increase in the concentration of poverty between 1970 and 2000 in large metropolitan areas, with a large rise in the 1980s and a decline in the 1990s. Using a new measure of income sorting, this paper also documents an increase in economic segregation between 1970 and 2000.

[3] Jargowsky (1995, 1996) reports that economic segregation within racial groups increased both over the 1970s and over the 1980s. Mayer (2001) finds a slight decline in overall tract-level segregation over the 1970s and a substantial rise in the 1980s. Both Mayer (2000) and Jargowsky (1995) use the Neighborhood Sorting Index (NSI), a measure of overall economic segregation developed by Jargowsky. The NSI is square root of the ratio of the between-tract income variance to the total income variance. Massey and Fischer also measure the concentration of affluence and find rising residential segregation of the rich between 1970 and 2000. Affluence is defined as four times the poverty line. Concentration of affluence declines in the 1970s and 1990s, but rises in the 1980s. When they instead use the top income quintile as a measure of affluence, there is no overall change between 1970 and 2000

The empirical analysis presented here is based on census tract level family income data from the 1970, 1980, 1990, and 2000 U.S. censuses.[4] As is common in the literature, I use the census tract – an area of roughly 4,000 people defined by the Census Bureau – as the definition of a "neighborhood."[5] Information at the tract level is used to construct indicators of income segregation and income inequality at the metropolitan area level, and to calculate several metropolitan area variables. The tract level information is supplemented with data collected by the Census at the county level, county data in the City and County Data Books, and national industrial employment trends in the Integrated Public Use Microsample (IPUMS). The metropolitan areas are based on the 2003 census county-based metropolitan area definitions, so they represent a constant geographic area over time to the extent that the counties were tracted. The sample includes 216 of the 217 metropolitan areas that had at least one tracted county in 1970.[6] Table 1 presents some basic facts about the sample.

III.a. Measures of Segregation by Income

Because the literature on income segregation faces the challenge of measuring segregation along a continuous dimension, it cannot easily borrow indices from the racial segregation literature. To address this issue, Jargowsky (1995) develops the Neighborhood Sorting Index (NSI), a measure of overall income segregation. The NSI is square root of the ratio of the between-tract income variance to the total income variance. The measure is an intuitively appealing measure of economic segregation, but it has limitations for the investigation of the relationship between inequality and segregation. An ideal measure of segregation would remain the same when the income distribution widened unless households moved neighborhoods in response to the change. Importantly, the NSI is not invariant to rank-preserving spreads of the income distribution.[7]

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[4] The tract-level family income data is provided by the Census in 15, 17, 25, and 16 income bins for 1970, 1980, 1990, and 2000 respectively. The implications of this fact are discussed at length in Appendix One.

[5] The primary disadvantage to defining a neighborhood as a census tract is that a neighborhood is a much smaller geographic unit in a dense urban area than in a sprawling suburb. It is likely that much of the true segregation in suburban areas is due to within-tract sorting and is not picked up by a tract-based measure. Because both the physical proximity and "nearest neighbors" matter (for example, a neighbor living a quarter mile away has less relevance in a dense urban area than in a suburb), the ideal measure of neighborhood segregation is unclear.

[6] Gainesville, FL is excluded from the analysis due to missing data. The definition of metropolitan areas is discussed in the Appendix Two.

[7] As a simple example, suppose there are four households. One neighborhood has households with incomes of 1 and 2, another has households with incomes of 4 and 5. The NSI is 0.95. If the richest person gets a dollar and the poor person loses a dollar, the NSI is 0.89. Thus, the NSI changes even if noone moves. It is also the cause that measurement error in the NSI tends to be correlated with measurement

To analyze the changes in residential segregation by income over time, I introduce an index of segregation that is not directly related to the shape of income distribution in a metropolitan area. The Centile Gap Index (CGI) estimates how far the average family income within a tract deviates *in percentile terms* from the median family income in the tract, compared to how far it would deviate under perfect integration. Because the Centile Gap Index is based on estimated income percentiles, it is particularly well-suited to studying the relationship between income inequality and income segregation.

The data on family income at the census tract level is presented using 15-25 income bins defined by the Census Bureau. The information can be aggregated to the metropolitan area level and, to the extent that income is accurately reported, one can determine the actual range of income percentiles in a metropolitan area represented by each income bin. This strategy eliminates the need for any assumptions about the income distribution in a metropolitan area and thereby overcomes a potential source of bias. Family income groups within a census tract are known to be within a narrow range of income percentiles, but the exact income ranks are not known.

To estimate the likelihood that a family is in a given percentile within the narrow range, I assume that families in a particular income bin in a particular tract are uniformly distributed among the percentiles represented by the bin. In Watson (2005), I discuss the uniformity assumption and argue that the bias introduced by it is small.

The formula for the Centile Gap Index of metropolitan area *m* is

$$CGI_m = (0.25 - (1/J_m) \Sigma_j |P_j - P_{medtj}|) / 0.25,$$

where CGI_m is the Centile Gap Index in metropolitan area *m*, J_m is the number of families in metropolitan area *m*, P_j is the estimated percentile in the metropolitan area m income distribution of family *j*, and P_{medtj} is the estimated income percentile of median family in the tract of family j.

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error in income inequality. The NSI requires estimating the total variance of income in a metropolitan area, a variable that is not readily available. The variance of income can be estimated for a subset of metropolitan areas using the Public Use Micro Samples, can be estimated for each state using the PUMS, or can be estimated for the full set of metropolitan areas by making assumptions about the income distribution. Mayer (2001) solves the problem by using individual level census data by state to estimate total state variance of income. Instead, Jargowsky (1995) assumes a particular income distribution and then fits the income bins to that distribution. Any measurement error in the variance of income is systematically correlated with the measurement error in the segregation index. Therefore, the Neighborhood Sorting Index may be an inappropriate measure of segregation if one is interested in studying the relationship between income inequality and income segregation.

That is, the term $|P_j - P_{medtj}|$ represents the estimated income percentile distance of a given family from the median family in their tract. If a metropolitan area were fully integrated by income, each census tract would contain the full income distribution (defined from 0 to 1), and the average centile difference between a family and the median family in the tract would be 0.25. Therefore, under perfect integration, the CGI equals 0. In contrast, a completely segregated city would consist of homogenous neighborhoods. The average percentile difference between a family and the median family in the tract would be 0, yielding a CGI of 1 under perfect segregation.[8]

The major theoretical advantage of the Centile Gap Index is an overall measure of income segregation that it is invariant to rank-preserving spreads of the income distribution. As mentioned above, the key assumption I make is that the distribution of income percentiles within an income bin within a census tract is uniform. If this assumption is correct, rising inequality with no subsequent movement of households would leave the measured Centile Gap Index unchanged.[9]

Conceptually, it is worth distinguishing between different notions of neighborhood income segregation that might be of interest. Both the neighborhood distribution of income and the neighborhood distribution of socioeconomic backgrounds are plausibly important to outcomes. The isolation of the poor, a measure of segregation used in some studies, focuses on the income distribution of the neighborhood of a typical poor family. In contrast, the Centile Gap Index is a measure of the distribution of income rank groups across neighborhoods, not of the distribution of income across neighborhoods. Thus, if neighborhoods are segregated and fixed, a rise in income inequality could make the poor worse off because average neighborhood income might fall. This effect is not captured by the CGI. Rather, a rank-preserving spread of the income distribution induces a systematic change in the Centile Gap Index only if it induces a change in the residential location choices of different income groups. For the current study, which focuses on how residential choice responds to inequality, this is an advantage of the Centile Gap Index.

[8] With a small number of income bins, perfect segregation cannot be observed. See Appendix One for a discussion.

[9] In practice, the CGI could change slightly in either direction as a result of a change in the income distribution even if families do not move because income bins rather than exact incomes are used. As discussed in Watson(2005), the boundaries of the income bins do not appear to be very important empirically with 15 or more bins.

I use an additional percentile-based segregation measure to examine segregation at different parts of the income distribution. The families in each metropolitan area into five income quintiles. The exposure of quintile *x* to quintile *y* is the fraction of quintile *y* families in a typical quintile *x* family's census tract.[10] For example, the exposure of the bottom quintile to the top quintile represents the fraction of top quintile families in a typical bottom quintile family's census tract. The exposure of an income group to itself is referred to as its "isolation".

III.b. Trends in Segregation

As shown in Table 2b, economic segregation in metropolitan areas increased between 1970 and 2000.[11] The average Centile Gap Index increased from .110 to .120 over the period, decreasing slightly over the 1970s and the 1990s and rising substantially over the 1980s. Income segregation increased earlier and more substantially in larger cities (analysis not shown).[12]

The top and bottom income groups were more isolated in 2000 than in 1970. Families in the bottom quintile of their metropolitan area family income distribution had neighborhoods that were 26.3 percent bottom quintile in 1970 and 27.6 percent bottom quintile in 2000. Top quintile families were also more likely to live with other top income quintile families. In 2000, the typical family in the bottom quintile lived in a neighborhood that was about 28 percent bottom quintile residents and 14 percent top quintile residents, while the proportions were roughly reversed for top quintile families.

This paper focuses on income segregation at the neighborhood level. However, there is a mechanical relationship between central city-suburb sorting and neighborhood sorting. The period was characterized by disproportionate suburbanization of the rich.[13] Empirically, however, income sorting between the central city and the suburbs does not explain neighborhood income segregation (see Watson, 2005). The growth in neighborhood income segregation is not

[10] The formula for the Exposure Index is reported in Appendix One.

[11] One might wonder how large these changes in economic segregation were. The answer is that they were substantial, but average segregation at its peak in 1990 was not at a level unheard of in 1970. The metropolitan area with the median Centile Gap Index in 1990 would have placed at the 64th percentile of segregation in 1970. The 1990 mean Centile Gap Index is 0.3 of a standard deviation higher than the 1970 mean Centile Gap measure (using the 1970 standard deviation).

[12] The rise in overall economic segregation is not an artifact of the segregation index I have introduced. The Neighborhood Sorting Index shows a similar trend, though the NSI rose in all three decades. In part, the difference may be due to the fact that the NSI heavily weights segregation of the extreme income groups relative to the other measures. In the 1970s, the poor grew more isolated but other income groups were fairly integrated. The NSI rose only slightly over the 1990s. The formula for the Neighborhood Sorting Index is reported in Appendix One.

[13] See Watson (2005) for more details.

due primarily to differential suburbanization rates, but rather sorting *within* the suburbs and *within* the central city.

III.c. Rapidly and Slowly Growing Metropolitan Areas

Trends in residential patterns differed by metropolitan area growth rates. For the remainder of the analysis, metropolitan areas are categorized into three groups according to the 30-year population growth rate. Slowly growing metropolitan areas, also called distressed, stagnant, or declining metropolitan areas, are those in the bottom third of population growth. Booming or rapidly growing metropolitan areas are those in the top third of the population growth distribution.

Table 3 summarizes the changes that took place in slowly growing cities between 1970 to 2000. About a third of slow-growth metropolitan areas lost population between 1970 and 2000. Slow growth areas also experienced large increases in inequality and segregation. Distressed areas faced a strong trend towards suburbanization of the rich and middle class. Residential segregation by income also increased within central cities and within suburbs. The net result was a large increase in the concentration of bottom quintile families in the central city. By the year 2000, a typical bottom quintile central city family in a distressed city lived in a neighborhood that was comprised of 55 percent bottom quintile family residents.

The pattern in booming metropolitan areas was quite different. Average segregation levels were nearly flat over the period. There was also greater variation in segregation trends in these areas; over 40 percent of rapid-growth metropolitan areas had declining segregation, while a number of other areas had large increases in segregation. Unlike distressed areas, high growth areas were not characterized by disproportionate suburbanization of the rich, even among those with rising segregation. Rising segregation in booming metropolitan areas, where it occurred, was driven by the rich becoming increasingly isolated *within* the suburbs and *within* central cities. It was the growing isolation of the rich drove segregation in a subset of rapidly growing metropolitan areas.

IV. Testing the Implications of the Model

Below I present empirical evidence regarding the four implications of the model using a panel of 216 metropolitan areas over four decennial censuses spanning thirty years. After considering the predictions of the model, I briefly discuss racial segregation. Racial segregation is not explicitly considered in the model but is clearly important for understanding residential patterns in American metropolitan areas.

IVa. The Demand for Segregation

The first implication of the model is that factors raising the relative willingness-to-pay of the rich to live in a good neighborhood will tend to increase segregation in a metropolitan area. A number of factors likely contribute to demand for segregation; this paper focuses on rising income inequality. As noted above, rising inequality is likely to affect the relative willingness of high- and low-income families to pay for certain neighborhood attributes.

The data show a strong relationship between income inequality and segregation by income percentile. A one standard deviation increase in inequality raises income segregation by 0.4 standard deviations. This result is foreshadowed by Figure 4, which plots the relationship between growth in income segregation and growth in income inequality between 1970 and 2000.

A fixed effects specification using four decennial censuses (1970-2000) controls for any unobserved attributes of metropolitan areas that do not change over time and that could be correlated with both inequality and segregation levels. I estimate the following reduced form model:

$$\text{Segregation}_{mt} = \beta_1 * \text{Inequality}_{mt} + \beta_2 * \text{PredictedEmployment}_{mt} +$$
$$\beta_3 * \text{Predicted Employment For Less Skilled Men}_{mt} + \beta_4 * \text{Predicted Central City Employment Share}_{mt} +$$
$$\text{other MSA characteristics}_{mt} * \beta_5 + \alpha_m + \delta_t + \mu_{mt}.$$

Three industrial composition variables – predicted employment, predicted employment for less skilled men, and predicted central city employment share - are constructed using 1970 industrial shares in each metropolitan area interacted with national industry trends.[14] Metropolitan area fixed effects, α_m, and year fixed effects, δ_t, are included, as are additional time-varying metropolitan area characteristics.

Results of the fixed effects model are shown in Table 4. Column I presents a baseline model, in which the 80-20 ratio is the measure of inequality and the Centile Gap Index is the measure of segregation. As predicted by theory, income inequality is highly correlated with observed income

[14] The construction of these variables is described in Appendix Two.

segregation. After controlling for the effects of industrial composition and a number of other factors, the coefficient on inequality is 0.108. This number implies that one standard deviation increase in income inequality raises income segregation by 0.4 standard deviations. Both inequality at the top of the income distribution and at the bottom affects segregation. Furthermore, inequality at the top of the income distribution is associated with residential isolation of the top quintile, while inequality at the bottom of the income distribution is associated with isolation of the bottom quintile. This pattern is consistent with a model in which income inequality affects the relative willingness to pay for neighborhood attributes across income groups.[15]

II.b. Segregation and Growth

The second prediction of the model is that the extent to which observed levels of segregation reflect demand shocks depends on the economic growth of a metropolitan area. That is, a comparable change in factors demand for segregation should have a larger impact on observed segregation in a growing metropolitan area than in a stagnant metropolitan area. One empirical challenge is that a similar increase in income inequality may have different implications for demand in growing and declining cities.

The fixed effects analysis described above is repeated separately for three groups of cities categorized by population growth. Table 5 shows these regressions for the most rapidly growing and most slowly growing cities. The empirical evidence supports the hypothesis for the effect of inequality at the top of the distribution, but not at the bottom of the distribution. That is, declining metropolitan areas have larger responses a given change in the 50-10 family income ratio, while growing metropolitan areas are more responsive to a given change in the 90-50 family income. It may be the case that the economic prospects of the poor affect demand for segregation differentially in stagnating cities, where a given observed change in inequality may be associated with a variety of social ills.

[15] Inequality affects residential sorting within central cities and within suburbs, as demonstrated in Watson (2005). The data also indicate a strong negative relationship between predicted employment demand for less-skilled men and segregation, after controlling for employment decentralization and overall levels of employment. This may be an indication that manufacturing job loss causes a change in the relative quality of rich and poor neighborhoods. Declining employment for less-skilled men is associated with rising isolation of families in the bottom income quintile. Decentralization of employment also contributes to rising segregation. Several other metropolitan area characteristics are also important; see Watson (2005) for a further discussion.

If a given change in the 90-50 ratio represents a similar demand shock across different types of cities, then the larger coefficient for rapidly growing cities is consistent with the model. The estimated coefficients imply that a one standard deviation change in the log of the 90-50 ratio is associated with a 0.21 standard deviation increase in isolation of the top quintile in a slow-growth city, but a 0.70 standard deviation increase in isolation in a rapid-growth metropolitan area. The difference is statistically significant.

IV.c. New Housing Construction

The model predicts that rising segregation will be accompanied by higher than expected levels of new housing construction in declining cities. Because of the durable nature of housing, the supply of housing does not adjust immediately to changing preferences. In declining metropolitan areas, rising segregation will be observed if the demand for segregation is sufficient to induce the construction of new housing or the retrofitting of old housing. In growing cities, on the other hand, there is no reason to expect segregation to be associated with new housing construction. New housing in rapidly growing cities is induced by population growth and is not sensitive to the demand for segregation.

To test this hypothesis, I consider the relationship between new housing construction and economic segregation across different types of metropolitan areas. The dependent variable is new construction relative to the existing housing stock – that is, housing units housing built in the last 10 years divided by housing units built 10 or more years ago. I control for the 10-year population growth rate and the population growth rate squared, as well as metropolitan area fixed effects and year effects. The key independent variable of interest is segregation, measured by the Centile Gap Index, interacted with categories of metropolitan area growth. The theory predicts that, after controlling flexibly for population growth, segregation should be positively correlated with new housing construction in stagnating areas but not in rapidly growing areas.

The empirical evidence presented in Table 6 is consistent with the hypothesis. Slow growth metropolitan areas show a significant positive relationship between segregation and new construction. A one standard deviation increase in the Centile Gap Index is associated with an extra 5 percentage points new construction in a distressed metropolitan area. As expected, rapidly growing metropolitan areas show no significant relationship between segregation and housing construction (indeed the correlation is weakly negative), and the difference between growth categories is statistically significant.

One concern with the above analysis is that an unobserved third factor might be influencing the housing market such that both segregation and construction rise in some cities. To address this, I consider a two-stage least squares analysis. In the first stage, segregation is predicted by a number of "demand" factors including inequality, industrial composition, and other metropolitan area characteristics. In the second stage, the predicted level of segregation is interacted with categories of metropolitan area growth. The results are quite similar; predicted demand for segregation is positively correlated with unexpectedly high levels of new construction in distressed metropolitan areas but not in growing metropolitan areas. Metropolitan areas with almost no population growth appear to construct new housing in response to demand for segregation.

IV d. The Persistence of Segregation by Income

The model suggests that the housing stock of a metropolitan area tends to reflect the underlying demand for segregation at the time it was built. Thus, market forces generating demand for economic segregation will tend to have persistent effects on segregation levels even after the forces themselves have disappeared. This is especially true in slowly growing cities; the model suggests that levels of segregation are more persistent if the housing stock is not growing quickly.

Segregation appears to be quite persistent in the sample. The raw correlation between the Centile Gap Index in 1970 and the CGI in 2000 is 0.69 across metropolitan areas. The cross-sectional regressions in the first two columns of Table 7 show a sizeable and statistically significant effect of the 1970 segregation level on 2000 segregation levels, even after controlling for 2000 inequality and a large number of other factors likely to affect 2000 segregation levels.

Columns 3 and 4 test the hypothesis that the persistence of segregation is related to the durability of housing. A variable indicating the fraction of homes built before 1970 in a 2000 metropolitan areas is included and interacted with the 1970 segregation index. As expected, the predictive power of the 1970 segregation level rises with a higher fraction of homes built before 1970. In metropolitan areas with a large fraction of their housing built since 1970, the 1970 segregation level is less correlated with the 2000 segregation level. When all control variables and interactions are included, the coefficient on the interaction term is statistically significant only at the 20 percent level, but the pattern of coefficients is similar. The evidence is largely consistent with a "bricks and mortar" view of segregation in metropolitan areas.

IV.e. Racial Segregation and Income Segregation

A discussion of residential segregation in metropolitan areas is incomplete without mention of racial segregation. Racial segregation has been declining since its peak in 1970 (Cutler, Glaeser, and Vigdor, 1999). Although the model does not explicitly consider racial segregation, the framework may have some relevance racial segregation as well. In this context "demand" for racial segregation could be viewed as stemming from racial differences in the willingness-to-pay for various neighborhood attributes, which could include racial composition of the neighborhood. The housing market in rapidly growing metropolitan areas may be able to respond changing preferences with regard to racial segregation.

The three metropolitan area growth categories had similar levels of racial segregation in 1970, as measured by the exposure of blacks to non-blacks.[16] By the year 2000, however, rapid-growth metropolitan areas had witnessed much larger drops in racial segregation, as shown in Table 3. Furthermore, racial and economic segregation are positively correlated in slowly growing metropolitan areas, but not in rapidly growing areas (analysis not shown). This is consistent with the notion that some metropolitan areas may be moving more quickly to a new equilibrium – one in which racial segregation is replaced by economic segregation. However, the relationship between income and race is complicated and a full analysis is beyond the scope of this paper.

V. Conclusion

Neighborhood segregation by income grew between 1970 and 2000 in American metropolitan areas. Segregation grew most quickly in distressed manufacturing cities as well as a subset of rapidly growing metropolitan areas. This paper proposes a model of demand for segregation and metropolitan growth, and tests several implications of the model.

Divergence in the valuation of neighborhood attributes across income groups leads to competitive pressure, or "demand", for segregation. It may take years for residential markets to fully respond to changes in demand for segregation, especially in stagnant metropolitan areas. Observed segregation depends both on the underlying pressure for segregation and the adjustment costs associated with new housing construction. Rapidly growing metropolitan areas accommodate

[16] The exposure index used here adjusts for relative group size. See Cutler, Glaeser, and Vigdor, (1999) for details.

changing preferences easily, but slowly growing metropolitan areas will witness rising segregation only if demand shocks are sufficient to induce new construction.

The empirical findings are generally consistent with the model. First, higher levels of income inequality are associated with higher levels of residential segregation by income. Second, inequality at the top of the distribution (though not the bottom of the distribution) has a bigger effect on segregation in rapidly growing areas than in slowly growing areas. Third, among slowly growing metropolitan areas, large increases in segregation are coupled with higher than expected housing construction. This is not the case in rapidly growing areas. Finally, segregation levels are persistent. The 1970 level of segregation affects current segregation even after controlling for contemporaneous factors likely to affect segregation. The persistence is more pronounced in cities with older housing stocks.

The "bricks and mortar" framework explains the U-shaped relationship between the economic success of a metropolitan area and its growth in income segregation. In cities facing industrial decline, the demand for income segregation rose between 1970 and 2000 because of growth in inequality and falling demand for less-skilled men. Despite the fact that housing prices were below the cost of new construction, middle-class and rich residents of stagnant cities were willing to move to the suburbs to segregate from the poor. These areas experienced rising income segregation and higher than expected new housing construction.

On the other hand, some rapidly growing cities experienced rising segregation despite modest growth in inequality. These boom towns had cheap adjustment costs; the housing market was able to adapt quickly to changing consumer preferences. In rapidly growing areas, isolation of the rich is very sensitive to inequality at the top of the distribution. It is two groups of cities – those suffering economic hardship and a subset of the most rapidly growing cities – that account for rising income segregation over the period.

The work presented here has implications for redistributive policy. Family income inequality generates residential segregation by income within American metropolitan areas. To the extent that residential segregation adversely affects the outcomes of those families at the bottom of the economic ladder, it follows that relative income matters to absolute outcomes. Furthermore, the results suggest that a short period of high inequality could change the long run shape of American metropolitan areas. Because housing is built to reflect current preferences and it is durable, segregation is persistent. Thus, the legacy of income inequality could persist into the next generation even if inequality itself fades.

VI. Appendix One – Income Segregation Measures

This appendix discusses the Centile Gap Index at length in Part A. Formulas for other income segregation measures are reported in Part B.

A. The Centile Gap Index

The Centile Gap Index (CGI) estimates how far the average family income within a tract deviates in percentile terms from the median tract family income, compared to how far it would deviate under perfect integration.

As noted in the text, the formula for the Centile Gap Index (CGI) is:

$$CGI_m = (0.25 - (1/J_m) \Sigma_j |P_j - P_{medtj}|) / 0.25,$$

where CGI_m is the Centile Gap Index in metropolitan area m, J_m is the number of families in metropolitan area m, P_j is the estimated percentile in the metropolitan area m income distribution of family j, and P_{medtj} is the estimated income percentile of median family in the tract of family j. That is, the term $|P_j - P_{medtj}|$ represents the estimated income percentile distance of a given family from the median family in their tract. Note that, although I refer to income percentiles for clarity, I do not divide families into 100 discrete groups. Rather, the ranking is continuous on a scale from 0 to 1. In principle, the Centile Gap Index goes from 0 to 1, with 1 meaning perfect segregation. In practice, as I will discuss below, perfect segregation could never be observed with a small number of income bins.

As a benchmark, consider what I will call the "true" Centile Gap, CGI*, which hypothetically could be computed if the full distribution of income in each census tract were reported without error by the census. The CGI* is defined by the formula:

$$CGI_m^* = (0.25 - (1/J_m) \Sigma_j |P_j^* - P_{medtj}^*|) / 0.25.$$

where the CGI_m^* is the "true" CGI of metropolitan area m, the term $|P_j^* - P_{medtj}^*|$ represents the true percentile distance between family j and the median family in family j's tract, and J_m is the number of families in metropolitan area m.

Because the full income distribution in a census tract is unavailable in practice, P_j^* and P_{medtj}^* must be estimated using the information available in 15, 17, 25, or 16 family income bins (for the years 1970, 1980, 1990, and 2000 respectively). Some assumptions are necessary in order to estimate P_j^* and P_{medtj}^*. As is noted in the text, I assume that income percentiles are distributed uniformly within an income bin within a census tract. A simple example illustrates the calculation. Suppose I know that in a given metropolitan area, income bin x represents exactly 4 percent of the population, from the bottom of the 60^{th} through the top of the 63^{rd} percentile. A given tract has 60 families in bin x. I assume these families are uniformly spread among the four percentiles. In other words, 15 of them are uniformly spread in the 60^{th} percentile, 15 are uniformly spread in the 61^{st}, and so on. Further, suppose I know that there are 1000 families in the tract, 450 of which are in bins below bin x and 490 of which are in bins above bin x. I therefore know that the median income percentile in the tract is in bin x. Using the uniformity assumption, I estimate the median family in the tract as having income rank 0.633.

The CGI computed using the uniformity assumption systematically understates the CGI* to the extent that income sorting is an important phenomenon. This can be seen be considering two extreme cases. If there is no income segregation, the CGI correctly estimates income segregation to be zero. On the other hand, if there is perfect income segregation, the CGI estimates segregation to be less than one.

The degree of deviation between CGI and CGI* also depends on the number of income bins and where they fall in the income distribution. In particular, the deviation of the "typical" family from the boundaries of its income bin is important. If more families are in wide income bins (i.e., bins that represent a many income percentiles), income segregation is understated to a greater degree by the CGI. This implies that the CGI computed using fewer bins will tend to be lower than the CGI computed using more bins. One concern that I discuss in Watson (2005) is that the rise in income segregation over time is a spurious result due to a change in the number of income bins. Using simulations I demonstrate that the bias in the Centile Gap Index induced by the uniformity assumption is small relative to changes over time and differences across metropolitan areas.

I have not addressed two types of measurement error which might also be a problem in estimating income segregation, as discussed in Davidoff (2003). Families misreport income and annual income is a noisy indicator of permanent income. Davidoff (2003) suggests that correcting for measurement error might lead to double the estimated fraction of variance that is attributable to sorting between neighborhoods. Note that, in my case, the measurement problem would arise from noise in a family's rank in the distribution rather than income per se. Assuming changes in measurement error are uncorrelated with inequality, measurement error would tend to attenuate my results. I do not address this issue in the analysis.

The NSI, or Neighborhood Sorting Index, is the square root of the ratio of between tract variance to total variance of income:

$$NSI_m = \sigma_{Nm} / \sigma_{Jm}, \text{ where}$$

σ_{Nm} = standard deviation of mean tract income in metro area, and
σ_{Jm} = standard deviation of family income in metro area.
See Jargowsky (1995, 1996) for more details.

The formula for an exposure index of quintile x to quintile y in metropolitan area m is

$$Exposure_{xym} = \Sigma_t \ (X_t/X_m) * (Y_t/J_t), \text{ where}$$

X_t = number of quintile X families in tract t,
X_m = number of quintile X families in metro area m,
Y_t = number of quintile Y families in tract t, and
J_t = number of families in tract t.
The exposure of quintile x to quintile y can be interpreted as the average fraction of quintile y families in the typical quintile x family's census tract.

Also see Cutler, Glaeser, and Vigdor (1999). In the present analysis, no adjustment is necessary for group size since all family income quintiles are the same size. Exposure indices were developed to study segregation between discrete racial groups and are not ideal for analyzing segregation along a continuous dimension such as income. Nevertheless, they are useful as a supplement to overall income segregation measures.

Note that none of the income segregation measures I use here are explicity spatial. That is, I do not use geographic information about proximity of neighborhoods to one another.

VII. Appendix Two. Data and Other Variables

This appendix discusses a range of other issues: data description, metropolitan area definitions, families versus households, construction of industrial mix variables, data on family income by race, racial segregation measures, metropolitan area income inequality measures, and central city and suburb definitions.

A. Data Description
Tract-level census data for 1980, 1990, and 2000 are taken from Census CDs and for 1970 they are taken from the Urban Institute Underclass Database. I also use county-level information from the Census CDs and the City and County Data books. I use the IPUMS to estimate national trends in industrial mix and job centralization.

The income data for families in the tract-level data sets is the number of families in different income bins in the year previous to the census year. There are 15 income bins in the 1970 data, 17 in the 1980 data, 25 in the 1990 data, and 16 in the 2000 data. For data on family income by race, there are 9 bins the years 1970-1990 and 16 bins in 2000.

Gainesville, FL is excluded from the analysis due to missing data. There are 216 remaining metropolitan areas in the analysis.

B. Metropolitan area definitions.
The boundaries of metropolitan areas change over time and a researcher must make a decision about how to deal with this fact in the analysis. One values consistency, but at the same time wants to capture genuine changes in the area of the residential market. I pursue an intermediate approach. I use the consolidated metropolitan areas defined by the Census Bureau as of 2003, including all of the counties that were tracted in a particular year. Therefore, the boundaries of about half of the metropolitan areas in the sample change over time. I throw out metropolitan areas that had no tracted counties in 1970. For New England, I use the county-based metropolitan area definitions developed by the Census (NECMAs) rather than the standard town-based definitions. Metropolitan areas outside of New England are always based on counties or county-equivalents.

C. Families versus Households.
I use data for families because they are available for all four Census years. Families, which are households in which at least two residents are related by blood or marriage, make up a large fraction (ranging from 68 percent in 2000 to 75 percent in 1980) of households. Comparing In 1980-2000, families have higher segregation levels than all households. If I run the baseline regression using household segregation and household income inequality for 1980-2000, the results are very similar to the family-based analysis and highly significant.

D. Industrial Mix Variables
Ten initial metropolitan area industry shares are interacted with national industry changes over time to predict the level of total employment relative to 1970 total employment, the level of employment of less-skilled men relative to 1970 total employment, and the fraction of metropolitan employment in the central city. Less-skilled workers are defined as those with a high school degree or less. The national trends for centralization and skill level are computed using IPUMS data on 18-65 year olds in metropolitan areas who worked at least 15 hours in the previous week. Predicted variables are used rather than direct measures of employment growth, demand for less-skilled men, and job centralization because these characteristics may be

endogenous to segregation. Therefore, the industrial mix variables in some sense "under-control" because they do not capture the effect of idiosyncratic changes in industrial composition.

The formula for Predicted Employment is

$$PredEmp_{mt} = \Sigma_i\ (Emp_{im70}/Emp_{m70}) * (NatEmp_{it}/NatEmp_{i70}),$$

where $PredEmp_{mt}$ is the predicted employment level in metropolitan area m at time t, Emp_{im70} is the employment in metropolitan area m in 1970 in industry i (from aggregated county-level data), Emp_{m70} is the total employment in metropolitan area m in 1970 (from aggregated county-level data), $NatEmp_{it}$ is the total employment in all metropolitan areas in industry i at time t (from aggregated county-level data), and $NatEmp_{i70}$ is the total employment in all metropolitan areas in industry i in 1970 (from aggregated county-level data). It is clear from the formula that all metropolitan areas have a predicted employment of 1 in 1970.

The formula for Predicted Employment of Less Skilled Men is

$$PredEmpLSM_{mt} = \Sigma_i\ (Emp_{im70}/Emp_{m70}) * (Nat2LSM_{it}/Nat2Emp_{it}) * (NatEmp_{it}/NatEmp_{i70}),$$

where $PredEmpLSM_{mt}$ is the predicted employment of less-skilled men in metropolitan area m at time t, $Nat2LSM_{it}$ is the employment of less-skilled men in all metropolitan areas at time t in industry i (from the PUMS), $Nat2Emp_{it}$ is the total employment of less-skilled men in all metropolitan areas at time t (from the PUMS), and other variables are as above. The variable is a prediction of employment of less-skilled men in year t relative to total metropolitan area employment in 1970.

The formula for Predicted Job Centralization is

$$PredCent_{mt} = \Sigma_i\ (PredFrac_{imt}) * (Nat2CC_{it}/Nat2Emp_{it}),$$

where $PredCent_{mt}$ is the predicted fraction of employment in the central city, $Nat2CC_{it}$ is the employment in industry i at time t in all central cities (from the PUMS), $Nat2Emp_{it}$ is the employment in industry i at time t in all metropolitan areas (from the PUMS), and $PredFrac_{imt}$ is the predicted fraction of employment in industry i in metropolitan area m at time t and is defined by:

$$PredFrac_{imt} = Emp_{im70} * (Nat2Emp_{it}/Nat2Emp_{i70})\ /\ \Sigma_i\ [Emp_{im70} * (Nat2Emp_{it}/Nat2Emp_{i70})].$$

In the formula, Emp_{im70} is the employment in industry i in metropolitan area m in 1970 (from aggregated county-level data), $Nat2Emp_{i70}$ is the employment in industry i in 1970 in all metropolitan areas (from the IPUMS), and other variables are defined as above.

E. Racial Segregation Measures

The measure of racial segregation used in the analysis is a person-based measure (rather than family-based) similar to that used by Cutler, Glaeser, and Vigdor (1999). It is an exposure index of black residents to other black residents, adjusted for the exposure that would be expected given the number of black residents and white residents in the metropolitan area. For details, see p.459 of Cutler, Glaeser and Vigdor (1999). Note, however, that they consider isolation of black residents from all other residents while I consider the isolation of black residents from white residents.

Hispanic families may be of any race. Some of the rise in exposure of black residents to white residents may be due to an increase in exposure to white Hispanic residents.

F. Measurement of Metropolitan Area Income Inequality

The construction of metropolitan area income inequality measures is based on a methodology described and tested in Jargowsky (1995). In particular, metropolitan area income is assumed to be distributed with a linear distribution below the mean and a pareto distribution above the mean.

G. Central City and Suburbs

Central cities are those places identified by the Census Bureau as such in 2003 based on metropolitan area residential and commuting patterns, and represent a consistent geographic area over time. There may be more than one central city in a metropolitan area; these are combined for the purpose of the analysis. The suburbs include all remaining tracted portions of the metropolitan area in a given year. Suburbs are also combined for the purpose of the analysis. Census tracts in 1980-2000 are matched to places, which in turn are matched to central cities. For cases in which a census tract includes both central city places and suburban places, it is considered part of the central city if at least half of the tract area is within the central city. In 1970, neither central cities nor places are identified in the data.

H. New Construction

New construction is defined as newly constructed housing relative to previously existing housing. The variable in any given year is the number of housing units built in the past 10 years divided by the number of housing units built more than 10 years ago.

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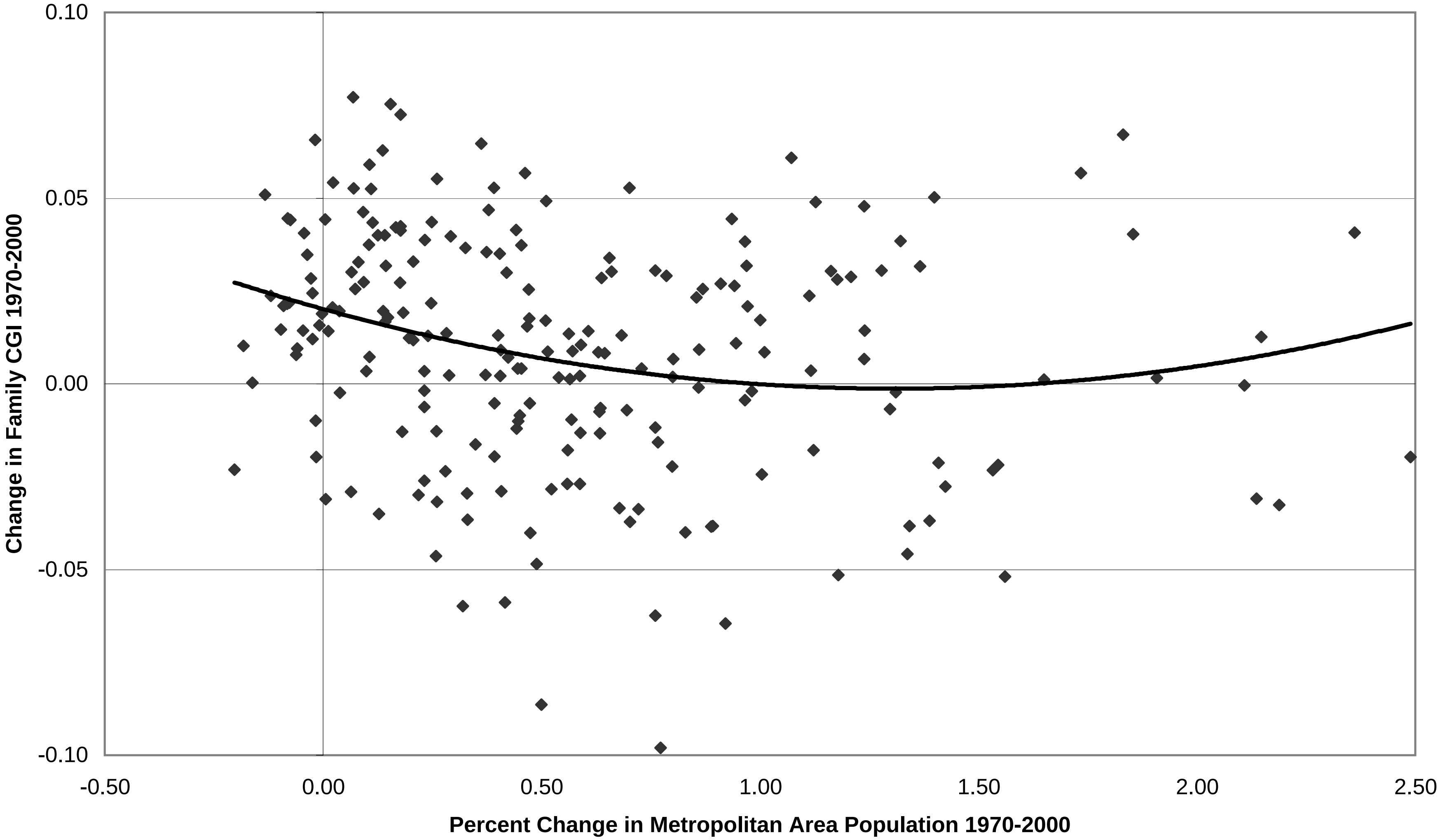
Figure 1. Change in Income Segregation v. Population Growth



Note: 3 outliers with more than 250% population growth omitted from graph.

Figure 4. Change in Family CGI v. Change In Inequality

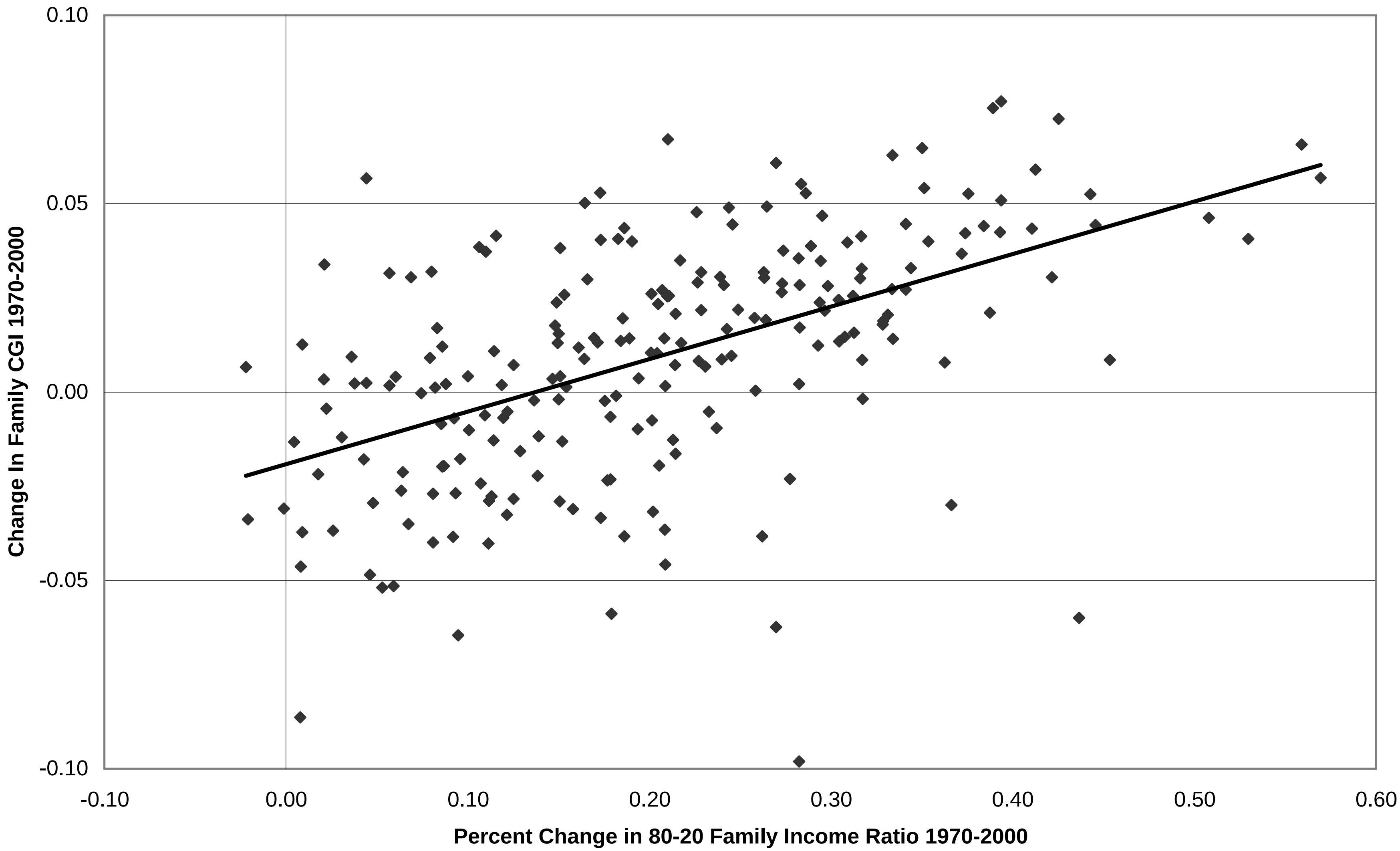


Table 2a. Sample Means of Metropolitan Area Characteristics, 1970-2000

	Means of 216 Metropolitan Areas Unweighted			
	1970	1980	1990	2000
Metropolitan Area Characteristics				
Number of Families	164,878	188,255	219,737	244,766
Number of Tracts	151	171	196	220
Population (000s)	661	754	851	967
Mean Family Income Last Year (2000 dollars)	50,604	54,330	57,750	63,940
Median Family Income Last Year (2000 dollars)	44,789	47,597	48,188	51,659
80-20 Family Income Ratio	2.83	3.10	3.34	3.39
90-50 Family Income Ratio	1.94	2.00	2.13	2.23
50-10 Family Income Ratio	2.99	3.10	3.32	3.21
Predicted Employment Rel. to 1970	1.00	1.28	1.54	1.73
Predicted Employment of Less-Skilled Men Rel. to 1970 Total Employment	0.44	0.43	0.38	0.38
Predicted Central City Share of Employment	0.57	0.52	0.52	0.48
Fraction Black	0.10	0.10	0.11	0.12
Fraction Hispanic	0.05	0.06	0.07	0.10
Fraction Foreign Born	0.03	0.04	0.05	0.07
Fraction of 25+ College Grads	0.11	0.16	0.20	0.24
Fraction of 25+ High School Grads	0.55	0.68	0.71	0.85
Fraction Under 18	0.35	0.29	0.26	0.25
Fraction Under 65	0.91	0.90	0.86	0.88
Racial Segregation Index	0.38	0.32	0.28	0.22
Land Area (square miles)	1,894	2,469	2,844	2,843
New Housing Construction	0.40	0.41	0.27	0.22

Source: Tract-level and county-level Census data, U.S. Census Bureau, Census CD, Urban Institute Underclass Database, IPUMS, and author's calculations.

Notes: Median income and income ratios are estimated. Inflation adjustment based on CPI-U, 1982-4 base year. Predicted variables based on 1970 industry mix interacted with national trends. For some cities 1970 black and Hispanic populations are imputed. College graduates include those with 4 or more years of college in 1970 and 1980. High school graduates include GED in 1990 and 2000. Racial segregation refers to the isolation of blacks from whites, adjusting for group populations.

Table 2b. Sample Means of Metropolitan Area Characteristics (continued), 1970-2000

	1970	1980	1990	2000
Family Income Segregation Measures				
Centile Gap Index (CGI)	0.110	0.106	0.123	0.120
Neighborhood Sorting Index (NSI)	0.342	0.391	0.417	0.420
Isolation of Bottom Quintile	0.263	0.267	0.281	0.276
Isolation of Top Quintile	0.275	0.271	0.286	0.283
Family Suburbanization Measures (210 Metro Areas)				
Fraction of All Families in Central City	--	0.464	0.425	0.439
Fraction of Bottom Quintile in Central City	--	0.528	0.499	0.519
Fraction of Top Quintile in Central City	--	0.439	0.399	0.408
Fraction of Central City in Bottom Qunitile	--	0.239	0.249	0.253
Fraction of Central City in Top Qunitile	--	0.184	0.182	0.178
Within Central City/Suburb Segregation (210 Metro Areas)				
Centile Gap Index Within Central City	--	0.125	0.147	0.138
Isolation of Bottom Quintile in Central City	--	0.390	0.444	0.445
Isolation of Top Quintile in Central City	--	0.253	0.268	0.254
Centile Gap Index Within Suburbs	--	0.067	0.082	0.079
Isolation of Bottom Quintile in Suburbs	--	0.191	0.195	0.187
Isolation of Top Quintile in Suburbs	--	0.276	0.286	0.286

Source: Tract-level Census data, U.S. Census Bureau, Census CD, Urban Institute Underclass Database and author's calculations.

Notes: See text and appendix for description of segregation measures. Suburbanization variables not available for 1970. Within central city and suburb CGI computed using city or suburb income percentiles.

Table 3. Sample Characteristics for Slowly and Rapidly Growing Metropolitan Areas, 1970-2000

	Bottom Third Slow Growth Metropolitan Areas			Top Third Rapid Growth Metropolitan Areas		
	1970*	2000	Fraction Positive Change	1970*	2000	Fraction Positive Change
Metropolitan Area Characteristics						
Population (000s)	995	1,083	**0.67**	436	998	**1.00**
80-20 Family Income Ratio	2.58	3.31	**1.00**	3.04	3.48	**0.96**
90-50 Family Income Ratio	1.86	2.17	**1.00**	2.02	2.29	**1.00**
50-10 Family Income Ratio	2.80	3.18	**0.89**	3.12	3.25	**0.71**
Racial Segregation Index	0.389	0.310	**0.29**	0.353	0.137	**0.18**
Land Area (square miles)	1,558	1,866	**0.49**	2,529	4,159	**0.78**
New Housing Construction	0.25	0.13	**0.01**	0.55	0.32	**0.09**
Family Income Segregation Measures						
Centile Gap Index (CGI)	0.088	0.111	**0.83**	0.125	0.128	**0.57**
Isolation of Bottom Quintile	0.253	0.281	**0.92**	0.268	0.272	**0.61**
Isolation of Top Quintile	0.259	0.271	**0.71**	0.289	0.293	**0.61**
Family Suburbanization Measures (210 Metro Areas, 1980-2000)						
Fraction of All Families in Central City	0.412	0.373	**0.19**	0.473	0.458	**0.39**
Fraction of Bottom Quintile in Central City	0.511	0.502	**0.43**	0.513	0.503	**0.44**
Fraction of Top Quintile in Central City	0.357	0.298	**0.15**	0.472	0.463	**0.36**
Fraction of Central City in Bottom Qunitile	0.262	0.288	**0.89**	0.225	0.230	**0.65**
Fraction of Central City in Top Qunitile	0.166	0.150	**0.21**	0.197	0.198	**0.49**
Within Central City/Suburb Segregation (210 Metro Areas, 1980-2000)						
Centile Gap Index Within Central City	0.107	0.121	**0.81**	0.139	0.151	**0.67**
Isolation of Bottom Quintile in Central City	0.449	0.548	**0.88**	0.355	0.373	**0.69**
Isolation of Top Quintile in Central City	0.199	0.178	**0.28**	0.293	0.310	**0.58**
Centile Gap Index Within Suburbs	0.057	0.067	**0.72**	0.075	0.091	**0.74**
Isolation of Bottom Quintile in Suburbs	0.166	0.154	**0.31**	0.209	0.218	**0.53**
Isolation of Top Quintile in Suburbs	0.286	0.314	**0.92**	0.267	0.261	**0.67**

Source: Tract-level Census data, U.S. Census Bureau, Census CD, Urban Institute Underclass Database and author's calculations.

Notes: Suburbainization measures reported for 1980 rather than 1970. Suburbanization variables not available for 1970. Slow growth metro areas are those in the bottom third of the population growth rate distribution; rapid growth are those in the top third. Changes for populatoin, number of families, and land area reported in percentage terms. See text and appendix for description of segregation measures. Within central city and suburb CGI computed using city or suburb income percentiles.

Table 4. Fixed Effects Analysis of Income Segregation, 1970-2000

Dependent Variable:	Centile Gap Index		Isolation of Bottom Quintile		Isolation of Top Quintile	
	I	II	III	IV	V	VI
Log (80-20 Family Income Ratio)	**0.108****		**0.060****		**0.084****	
	(0.020)		(0.015)		(0.015)	
Log (90-50 Family Income Ratio)		**0.115****		**0.010**		**0.163****
		(0.028)		(0.026)		(0.025)
Log (50-10 Family Income Ratio)		**0.040****		**0.055****		**0.007**
		(0.013)		(0.011)		(0.009)
Pred. Employment	**0.197****	**0.200****	**0.188****	**0.178****	**0.086**	**0.100***
	(0.073)	(0.071)	(0.062)	(0.062)	(0.055)	(0.053)
Pred. Employment of Less-Skilled Men	**-0.894****	**-0.927****	**-0.812****	**-0.801****	**-0.321**	**-0.378***
	(0.281)	(0.281)	(0.238)	(0.238)	(0.199)	(0.194)
Pred. Central City Employment	**-1.082****	**-1.127****	**-0.803****	**-0.847****	**-0.593****	**-0.593****
	(0.364)	(0.350)	(0.327)	(0.327)	(0.215)	(0.202)
Log (Population)	**0.018***	**0.016***	**0.007**	**0.006**	**0.008**	**0.007**
	(0.010)	(0.010)	(0.007)	(0.007)	(0.007)	(0.006)
Fraction Black	**0.083**	**0.107**	**0.133****	**0.117***	**0.047**	**0.083**
	(0.079)	(0.080)	(0.063)	(0.062)	(0.055)	(0.054)
Fraction Hispanic	**0.013**	**0.037**	**0.000**	**-0.002**	**0.041**	**0.061***
	(0.057)	(0.057)	(0.050)	(0.050)	(0.036)	(0.031)
Fraction Foreign Born	**-0.051**	**-0.063**	**-0.079***	**-0.069**	**0.038**	**-0.003**
	(0.053)	(0.052)	(0.047)	(0.049)	(0.037)	(0.032)
Log (Mean Family Income in 2000 dollars)	**-0.036****	**-0.054****	**-0.012**	**-0.014**	**-0.029***	**-0.043****
	(0.016)	(0.016)	(0.014)	(0.013)	(0.015)	(0.015)
Fraction of 25+ High School Grads	**-0.033****	**-0.030****	**-0.007**	**-0.010**	**-0.029****	**-0.026****
	(0.014)	(0.014)	(0.012)	(0.012)	(0.010)	(0.010)
Fraction 25+ College Grads	**0.194****	**0.223****	**0.071**	**0.086***	**0.214****	**0.219****
	(0.056)	(0.056)	(0.046)	(0.045)	(0.050)	(0.050)
Fraction Under 18	**0.194****	**0.171****	**0.193****	**0.180****	**0.012**	**-0.012**
	(0.082)	(0.084)	(0.077)	(0.079)	(0.066)	(0.065)
Fraction Under 65	**0.199****	**0.219****	**0.091**	**0.070**	**0.102**	**0.170****
	(0.096)	(0.100)	(0.079)	(0.080)	(0.071)	(0.073)
Log (Square Miles)	**-0.015****	**-0.014****	**-0.014****	**-0.013****	**-0.005***	**-0.005***
	(0.005)	(0.005)	(0.003)	(0.004)	(0.003)	(0.003)
Year Fixed Effects	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
MSA Fixed Effects	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
Observations	864	864	864	864	864	864
Number of Metropolitan Areas	216	216	216	216	216	216
R-squared	0.93	0.93	0.91	0.91	0.92	0.92

Notes: Standard errors clustered on metropolitan area in parentheses. * and ** indicate statistical significance at the 10 and 5 percent level, respectively. The analysis is unweighted. See notes in Table 2 and text for variable descriptions.

Table 5. Fixed Effects Analysis By Metropolitan Area Growth Rate

Dependent Variable:	Slow-Growth Metro Areas			Rapid-Growth Metro Areas		
	Centile Gap Index	Isolation Bottom Quintile	Isolation Top Quintile	Centile Gap Index	Isolation Bottom Quintile	Isolation Top Quintile
Log (90-50 Family Income Ratio)	**0.050**	**0.028**	**0.073****	**0.142****	**-0.019**	**0.239****
	(0.039)	(0.030)	(0.036)	(0.053)	(0.049)	(0.045)
Log (50-10 Family Income Ratio)	**0.038****	**0.062****	**0.006**	**-0.012**	**0.001**	**-0.014**
	(0.015)	(0.013)	(0.013)	(0.029)	(0.022)	(0.019)
Pred. Employment	**0.254****	**0.229****	**0.262****	**0.185**	**0.139**	**0.088**
	(0.099)	(0.083)	(0.103)	(0.111)	(0.086)	(0.079)
Pred. Employment of Less-Skilled Men	**-1.409****	**-1.114****	**-1.200****	**-0.695**	**-0.457**	**-0.348**
	(0.397)	(0.345)	(0.402)	(0.458)	(0.352)	(0.290)
Pred. Central City Employment	**-1.283****	**-0.937****	**-1.092****	**-0.847**	**-0.460**	**-0.513***
	(0.336)	(0.274)	(0.341)	(0.558)	(0.508)	(0.291)
Log (Population)	**-0.010**	**-0.012**	**-0.006**	**0.018**	**0.005**	**0.019***
	(0.020)	(0.023)	(0.016)	(0.016)	(0.014)	(0.011)
Fraction Black	**0.169***	**0.285****	**0.104****	**0.067**	**0.107**	**0.028**
	(0.085)	(0.095)	(0.052)	(0.122)	(0.088)	(0.079)
Fraction Hispanic	**0.049**	**-0.000**	**0.026**	**-0.082**	**-0.057**	**-0.042**
	(0.060)	(0.102)	(0.066)	(0.109)	(0.088)	(0.067)
Fraction Foreign Born	**-0.161***	**-0.194****	**-0.060**	**0.166**	**0.106**	**0.081**
	(0.081)	(0.094)	(0.089)	(0.130)	(0.115)	(0.081)
Log (Mean Family Income in 2000 dollars)	**-0.046****	**-0.014**	**-0.047****	**-0.064****	**-0.040**	**-0.021**
	(0.020)	(0.017)	(0.017)	(0.031)	(0.030)	(0.038)
Fraction of 25+ High School Grads	**0.022**	**0.016**	**0.005**	**-0.039***	**-0.016**	**-0.033****
	(0.025)	(0.020)	(0.020)	(0.021)	(0.018)	(0.017)
Fraction 25+ College Grads	**0.326****	**0.101**	**0.292****	**0.162**	**0.134***	**0.067**
	(0.065)	(0.066)	(0.057)	(0.103)	(0.071)	(0.102)
Fraction Under 18	**0.051**	**-0.014**	**0.045**	**0.229**	**0.263***	**-0.016**
	(0.098)	(0.088)	(0.078)	(0.148)	(0.137)	(0.115)
Fraction Under 65	**0.340****	**0.309***	**0.248****	**0.260**	**0.089**	**0.262***
	(0.134)	(0.165)	(0.115)	(0.188)	(0.123)	(0.136)
Log (Square Miles)	**-0.009**	**-0.004**	**0.000**	**-0.009**	**-0.006**	**-0.005**
	(0.007)	(0.009)	(0.006)	(0.007)	(0.004)	(0.004)
Year Fixed Effects	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
MSA Fixed Effects	**yes**	**yes**	**yes**	**yes**	**yes**	**yes**
Observations	288	288	288	288	288	288
Number of Metropolitan Areas	72	72	72	72	72	72
R-squared	0.97	0.96	0.96	0.90	0.88	0.90

Notes: Standard errors clustered on metropolitan area in parentheses. * and ** indicate statistical significance at the 10 and 5 percent level, respectively. The analysis is unweighted. Growth rates are defined by metropolitan area population growth rate 1970-2000. Slow growth areas are in the bottom third of growth; rapid-growth areas are in the top third. See notes in Table 2 and text for variable descriptions.

Table 6. New Construction and Segregation

Dependent Variable: New Construction Relative To Old Construction	OLS	2SLS
Centile Gap Index	**1.209****	
	(0.270)	
Centile Gap Index * Intermediate Growth	**-0.570**	
	(0.551)	
Centile Gap Index * Rapid Growth	**-1.909****	
	(0.545)	
Centile Gap Index (predicted)		**1.882****
		(0.374)
Centile Gap Index (predicted) * Intermediate Growth		**-0.991***
		(0.590)
Centile Gap Index (predicted) * Rapid Growth		**-2.779****
		(0.825)
10-year Population Growth Rate	**0.551****	**0.574****
	(0.080)	(0.080)
10-year Population Growth Rate Squared	**-0.044**	**-0.076**
	(0.120)	(0.118)
Year Fixed Effects	**yes**	**yes**
MSA Fixed Effects	**yes**	**yes**
Observations	864	864
Number of Metropolitan Areas	216	216
R-squared	0.88	--

Notes: Standard errors clustered on metropolitan area in parentheses. * and ** indicate statistical significance at the 10 and 5 percent level, respectively. The analysis is unweighted. Intermediate growth is a dummy indicating the metropolitan area is in the middle third of 30-year population growth rates. Rapid growth is a dummy indicating the metropolitan area is in the top third of 30-year population growth rates. In the two stage least squares model, the CGI is predicted using the following variables: log of 90-50 family income ratio, log of 50-10 family income ratio, predicted employment, predicted demand for less-skilled men, predicted central city employment, fraction black, fraction Hispanic, fraction foreign born, log mean family income, fraction high school, fraction college, fraction under 18, and fraction under 65, all interacted with the growth category dummy variables.

Table 7. The Persistence of Segregation

Dependent Variable: 2000 Centile Gap Index	I	II	III	IV
1970 Centile Gap Index	**0.668****	**0.449****	**0.072**	**0.168**
	(0.047)	(0.054)	(0.183)	(0.210)
Fraction Housing Units Built Before 1970			**-0.106****	**0.420**
			(0.042)	(1.570)
1970 CGI * Fraction Units Built Before 1970			**1.374****	**0.625**
			(0.370)	(0.465)
2000 Log (80-20 Family Income Ratio)		**0.079****		**0.058**
		(0.021)		(0.088)
2000 Log (80-20 Family Income Ratio) * Fraction Built Before 1970				**0.011**
				(0.174)
Other 2000 Metropolitan area characteristics	**no**	**yes**	**no**	**yes**
Other 2000 Metropolitan area characteristics *Fraction Built Before 1970	**no**	**no**	**no**	**yes**
Observations	216	216	216	216
Number of Metropolitan Areas	216	216	216	216
R-squared	0.49	0.53	0.82	0.87

Notes: Standard errors clustered on metropolitan area in parentheses. * and ** indicate statistical significance at the 10 and 5 percent level, respectively. The analysis is unweighted. Control variables include all variables in column I of Table 4 for the year 2000.