Preliminary, comments welcome

The Racial Tipping Point in American Neighborhoods:

Unstable Equilibrium or Urban Legend?[1]

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[1] I am grateful for comments received from participants in the CEPR Conference on Macroeconomics and Geography in Modena Italy in May 2003.

One of the most famous models of multiple equilibria in economics is Thomas Schelling's (1971) elegant model of racial segregation. He shows how only a modest preference of whites to live next to other whites could result in nearly complete residential segregation, because of the instability of intermediate points where one agent's residential location depends on the actions of other agents. In this model, even a relatively small fraction of nonwhites could cause the neighborhood to "tip" from completely white to completely nonwhite. The fraction at which this happens is called the "tipping point."

Much work since Schelling's model came out stresses the importance of neighborhoods for human capital formation through public schooling, human capital spillovers, and economic outcomes (Borjas 1993, 1996, Benabou 1993, 1996, Durlauf 2002, 1999, 1996). Hence, Schelling's model is potentially one of the important building blocks in understanding inequality between whites and blacks, or inequality in general, in the US (Durlauf 2002 cites it in this context). It has much in common with increasing returns models of poverty traps in the growth literature. It is also one of the canonical examples of models with strategic interdependence and multiple equilibria (see its coverage in Dixit and Nalebuff 1991, for example).

The tipping view of neighborhood change had been around long before Schelling's piece. In articles described by Schelling (1971) from the 1950s, the tipping process was described as universal, as was the instability of mixed neighborhoods. Once a neighborhood had begun to change from white to black, there was rarely a reversal. The process was very nonlinear. An article in 1960 defined it thus:

Although the movement of whites out of the area may proceed at varying rates of speed, a "tipping point" is soon reached which sets off a wholesale flight of whites. It is not too long before the community becomes predominantly Negro.[2]

The idea of the "tipping point" is very much alive today in popular folklore . For example, the recent bestseller called *The Tipping Point* by Malcolm Gladwell defined this point as the moment on the graph when the line (in our case the share of nonwhites in a neighborhood) shoots straight upward. An Atlantic Monthly article by Jonathan Rauch in April 2002 discussed Schelling's model of racial segregation, then went on to apply the same concept to phenomena as diverse as collapsing civilizations, riots, and genocides. The tipping point model is also applied to racial segregation (as well as other kinds of sorting such as by gender) in other venues like schools or private clubs. In my unscientific sample of conversations with my neighbors, most were aware of the "tipping point" idea in neighborhoods. In the equally unscientific method of doing a search for "racial segregation tipping point" on Google, I turned up hundreds of hits.

However, the model has undergone surprisingly little large-scale empirical testing. There have been some empirical testing using survey methods to ascertain people's preferences for segregation, or testing small samples of neighborhoods or school districts(see references in bibliography). There has never been a full-scale test of the hypothesis with nationwide data on American metropolitan neighborhoods. Such a test has become feasible thanks to the availability of a new database from the Urban Institute and a firm called Geolytics.com, which matches census tract information from the U.S. censuses for 1970, 1980, 1990, and 2000. This is called the Neighborhood Change Data Base (NCDB). It covers census tracts that are virtually all in metropolitan areas.

[2] Oscar Cohen (1960) quoted in Wolf (1963).

This database confirms that American neighborhoods continue to be highly segregated in the year 2000, despite some decrease in segregation and despite years of rhetoric and legal action in favor of integration. Nonwhites made up 28 percent of the sample population in the NCDB in 2000. Blacks make up 14 percent of the sample population. If each neighborhood were a random draw of whites and nonwhites, with the probability of drawing a nonwhite = .28, the odds against a neighborhood nonwhite share of less than 10 percent would be astronomical. Yet 35 percent of all census tracts had nonwhite shares less than 10 percent. Similarly, the probability that a nonwhite would live in a neighborhood where the nonwhite share exceeds 50 percent would be extremely low if the population were distributed randomly. Yet the median black lived in a neighborhood that was 52 percent black. The Tauber dissimilarity index, a widely used indicator of segregation, was .53 in the year 2000 for America as a whole (the index ranges from 0 if nonwhites are evenly distributed across neighborhoods to 1 if whites and nonwhites are completely segregated). The index can be interpreted as the fraction of either whites or nonwhites that would have to move to achieve even distributions of racial groups across neighborhoods.[3]

Of great relevance for the tipping point hypothesis, changes in neighborhoods from majority white to majority nonwhite are common in the dataset. Of the 41,321 urban census tracts in the NCDB that have data for both 1970 and 2000, 3965 neighborhoods had a drop in white share of .5 or greater from 1970 to 2000. Thus nearly 10 percent of the neighborhoods in the sample changed drastically from majority white to majority nonwhite over these 30 years. A weaker definition of tipping, the change from

[3] See the discussion by Cutler, Glaeser, and Vigdor 1999 of different measures of racial segregation. They also present evidence that segregation declined from 1970 to 1990.

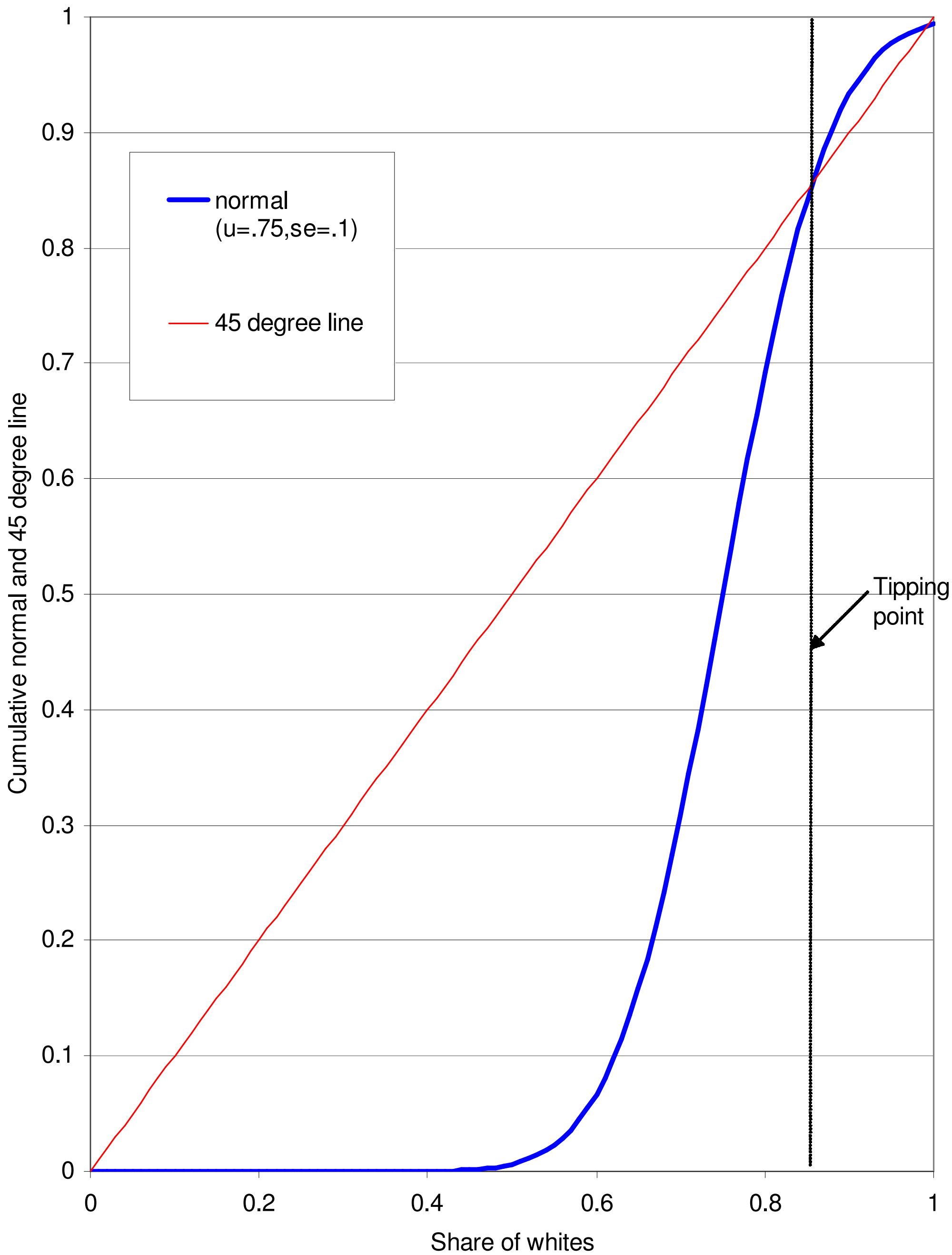
any white majority in 1970 to a nonwhite majority in 2000, reveals 14 percent of the neighborhoods tipped during this 30 year period.

This paper uses this database to conduct tests of some of the predictions of the Schelling "tipping point" model. It will ask the fundamental question of whether the high degree of segregation observed in American neighborhoods is a consequence of the dynamic instability of intermediate points due to strategic interdependence, with only weak preferences for living next to your own racial group, or is instead the result of strong preferences for segregation.

Schelling's model

Schelling's model is simple and elegant. It is a canonical model for herd behavior. Suppose that whites' preferences for neighborhood segregation between whites and blacks can be summarized as follows: each white individual j prefer to live in a neighborhood that has at least w_j percent of whites. If white individual j finds himself in a neighborhood containing less than w_j percent of whites, then he will exit the neighborhood. As long as the neighborhood contains more than w_j percent of whites, then individual j will stay in the neighborhood. Whites have diverse preferences for racial segregation ranging from integrationist to segregationist, which can be summarized by assuming a normal distribution for w_j across all white individuals. Thus, the cumulative density function of the normal distribution with mean μ and variance σ^2, $F(w;\mu,\sigma^2)$, gives us the percent of whites that have an w_j less than or equal to w. For example, assuming that $\mu=.75$ and $\sigma=.1$, Figure 1 shows the corresponding cumulative density function.

Figure 1: The cumulative normal distribution for racial preferences



The CDF thus shows the percent of whites that will live in a neighborhood that is w percent white – it is all those who have an w_j less than or equal to w. The CDF is highly nonlinear, with flat segments at either end but climbing steeply in the middle. This reflects the characteristics of the normal distribution, with flat tails but steep increases in the number of individuals contained in the middle. The actual fraction of whites who live in the neighborhood is given by the 45 degree line.

To relate the CDF to the whites who desire to live in the neighborhood as a fraction of the neighborhood population, the reasoning seems to be something like this. Suppose that whites have a right of first refusal on the homes in any neighborhood – so all the homes are offered to a representative sample of whites, F(w) of whom accept. The remainder of homes are then occupied by non-whites. Hence F(w) also gives the ratio of whites desiring to live in the neighborhood to the total neighborhood population.

Note that Schelling's basic model assumes the outcome is entirely driven by whites' preferences.[4] Nonwhites are assumed to passively replace whites whenever whites decide to exit a neighborhood. This assumption is debatable (and perhaps even offensive), but it reflects the traditional view of neighborhood segregation as mainly driven by whites' behavior. In future versions of this paper, I will explore the micro-foundations of the model to see under what conditions the model is consistent with optimizing behavior by nonwhites and whites.

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[4] Schelling actually did a version of the model that also incorporated nonwhites' preferences for neighborhood composition, but it has not caught on like the original model and it did not dramatically change the predictions of the model.

The point where the cumulative density function crosses the 45 degree line in Figure 1 is where the fraction of whites willing to live in a neighborhood that is w percent white is in fact equal to w:

(1) $w = F(w; \mu, \sigma^2)$

This is an equilibrium outcome for racial composition of the neighborhood. Note that this outcome is a higher fraction of whites w than the mean of the normal distribution of white preferences. For example, in the figure the equilibrium point is .86, while the mean of the normal distribution was .75. Any mean of the normal distribution greater than .5 cannot be an equilibrium, because only .5 of whites are willing to live in the neighborhood with the mean of the normal distribution for fraction of whites. The equilibrium always lies above the mean in this case.

Note however, that this equilibrium is unstable. If there is a disturbance such that a few whites leave the neighborhood or a few nonwhites enter and the white share drops below equilibrium, then the fraction of whites willing to live in the neighborhood falls below the actual share. There is a further decrease in white share, and yet a further white exodus. This process does not stop until the neighborhood becomes completely nonwhite – a white share of 0 is a stable equilibrium. The neighborhood has 'tipped" from being majority white to completely nonwhite.

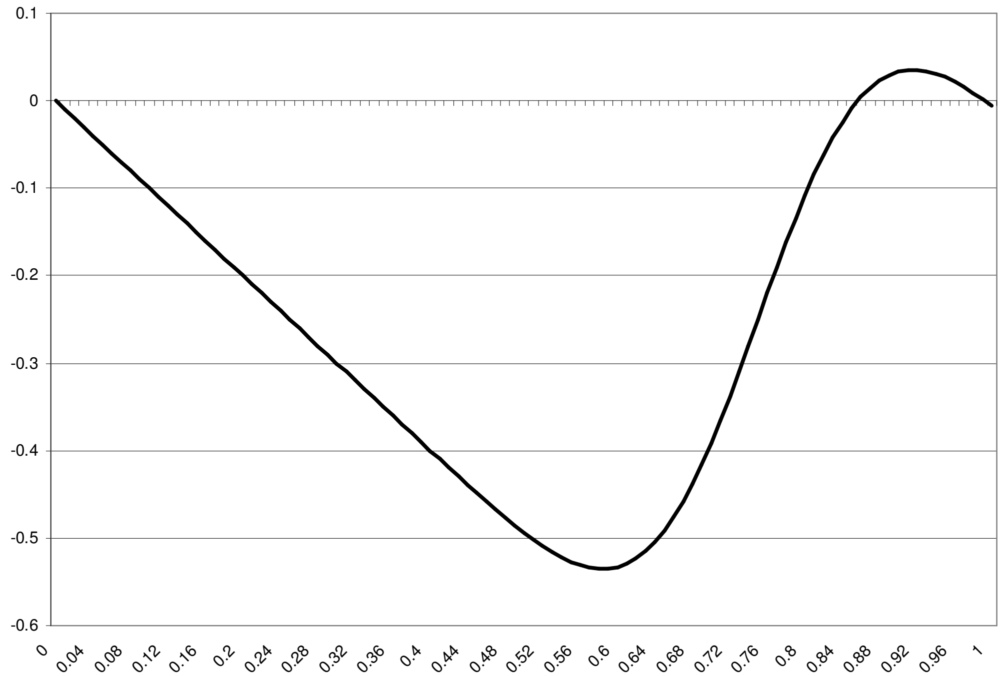
Conversely, any deviation of the white share above the equilibrium will lead to a fraction of whites willing to live in the neighborhood that is greater than the actual share. This will cause the white share to increase. A new equilibrium is not reached until the cumulative density function intersects the 45 degree line from above. In the diagram, this happens at a white share of about .992. Hence, the remarkable outcome of Schelling's model is that the long run equilibrium is for neighborhoods to be either entirely nonwhite or 99.2 percent white, despite the preferences of the median white for a mixed neighborhood that is 75 percent white and 25 percent nonwhite.

The crossing point of the CDF and the 45 degree line is the tipping point. Any neighborhood that falls below a white share of .86 will tip over to being completely nonwhite. The dynamics of the white share can be specified by giving the change in white share as the distance between the CDF and the 45 degree line.

(2) $\Delta w = F(w; \mu, \sigma^2) - w$

Figure 2 shows the predicted change in white share as a function of the initial white share. The relationship is highly nonlinear. Note also that the changes in white share as the neighborhood falls below the "tipping point" white share become very large – there is massive "white flight" even when whites are still in the majority. Note that this exodus does not reflect any expectations about the future composition of the neighborhood; it is simply the myopic individual behavior of whites who find the current composition of the neighborhood to be inconsistent with their preferences.

Figure 2: predicted change in white share with normal distribution with mean .75 and standard error = .1



It is interesting to relate this to some of the rhetoric about segregation. The folklore of the tipping point has historically been linked to racist justifications for segregation. If even a comparatively small number of nonwhites move into a neighborhood, with whom the majority of whites are perfectly content to coexist, there is a risk from the point of view of whites that the neighborhood will tip over to a nonwhite majority neighborhood that whites find unacceptable. Hence, whites acting collectively have historically resisted even modest integration of residential neighborhoods.

Although the tipping point idea is linked historically to racial scare-mongering, Schelling's contribution actually gives quite a different perspective on racial segregation. The point of Schelling's model was that only weak preferences for living next to people of the same race could lead to an outcome of almost total segregation. This contrasts with the traditional view that segregation reflects whites having a very strong preference for having white neighbors. Hence a test of Schelling's model is a test of whether residential segregation simply reflects the instability of herd behavior or instead reflects deep preferences for segregation amongst whites (and perhaps nonwhites).

In the context of scare-mongering, again note that Schelling's model did not have any role for expectations about future neighborhood composition. This may make sense if the individual does not have enough information to see the whole dynamic system. Otherwise, we could get even more extreme tipping from white to black as individuals react to the expected future composition of the neighborhood – there could be "racial panics" as whites suddenly fear being in the minority in their neighborhood at some future date.

An alternative version of Schelling's model is one where the variety of segregation preferences applies to the increment in the white population. Suppose that there is population growth such that a new generation of homeowners enters neighborhoods for the first time each period. Suppose this new generation of white homeowners has the same diversity of preferences as that modeled above, except that they react to the existing composition of neighborhoods. Suppose there is a fixed number of new homes that come on the market as the previous generation retires to Florida or dies. As before, the new whites have "right of first refusal" to take the entry places in the neighborhood, and a normal cumulative density function F(w) gives the proportion of them that accept. The remainder of places are taken by nonwhites. Then we have the composition of the new population following the cumulative normal density function F(w):

$$(3)\ \frac{\Delta W}{\Delta P} = F(w;\mu,\sigma^2)$$

The stability of equilibrium follows a similar structure as before. If we think of the curve in Figure 1 as now representing (3), then whenever it lies above the 45 degree line the white share will increase. Whenever it falls below the 45 degree line, the white share will decrease. The place where it crosses the 45 degree line is an unstable equilibrium. The dynamic equation is as follows:

$$(4)\ \Delta w = \left(\frac{\Delta W}{\Delta P} - w\right)\frac{\Delta P}{P}$$

Hence, we still get tipping towards the extremes. Now the outcome depends on whether the share of whites in new entrants to the neighborhood is higher or lower than the existing white share. (This is the form of the Schelling model popularized by Dixit and

Nalebuff 1991.) If population growth is positive, then a higher share of whites in the increment than in the existing population leads to increased white share.[5] I will test this form of the tipping model in the data also.

The data

The database used in this analysis was originally called the Underclass Database (UDB). It was put together for 1970, 1980, and 1990 by the Urban Institute, a nonpartisan think tank in Washington DC. Given the interests of the Institute, the data covered metropolitan neighborhoods (where "metropolitan" is defined as in the census to include central city, inner suburbs, and outer suburbs). The database has been updated to include the 2000 census by a commercial firm called Geolytics Inc.[6] The unit of analysis in the database is the census tract, a division meant to approximate a "neighborhood", usually containing between 2500 and 8000 people. The tract boundaries are chosen to capture neighbors with similar social characteristics (which means that measures of segregation based on tract data will tend to exaggerate segregation). Tract boundaries do not cross county, metropolitan area, or state boundaries.[7]

There are several difficult issues surrounding the data construction. Of those tracts that have data for both 1970 and 2000, two-thirds changed boundaries. Some tracts were merged into a single tract, and some single tracts were divided into multiple tracts. Unfortunately, in the majority of tract changes, there are boundary changes that are not simple mergers or divisions of existing tracts. The constructors of the database addressed this problem in several different ways, depending on what data was available for different

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[5] If population growth is negative, then things obviously reverse – a greater share of whites in the population decline than in the population would lead to falling white share.
[6] The new database is available on CD-ROM from geolytics.com. The description of the data contained here is based on the NCDB Data User's Guide, including Appendix J on tract matching.
[7] Except in New England, some tracts cross metropolitan area boundaries.

census years. They used geographic information software (GIS) to overlay 2000 tract boundaries on earlier tract boundaries. They then used 1990 block data to estimate the proportion of the old tracts in various racial categories that went into the new tract, and then recalculated the 1990 tract data using the 2000 tract boundaries.

Block data located spatially were not available for 1970 and 1980. The 1980 tracts were matched to the 1990 tracts and 1970 tracts matched to 1980 tracts using Census Bureau information on tract correspondence based only on spatial changes in tract boundaries. Hence, the 1970 and 1980 tract matching to 1990 and 2000 is less accurate than the tract matching between 1990 and 2000.

The database includes an indicator of which tracts changed boundaries. The use of the full sample could be justified if we think any errors introduced by boundary changes are random, i.e. uncorrelated with the right hand side variables in my regressions below. However, I will run a robustness check of my results by running them on the sub-sample which did not change boundaries between 1970 and 2000.

Some 2000 tract boundaries include areas that were not covered at all by 1970 data. As long as the covered area is a random sample of the whole tract, with the error term uncorrelated with the 1970 white share, the use of the full sample could still be justified. Nevertheless, I will run another robustness check by omitting these observations from the sample.

Census data has the commonly known problem that it undercounts the population because some people are harder to reach for enumeration. Of concern for our exercise, the undercount is thought to be proportionally greater for nonwhite populations. The undercount percentage has been falling over time. I do not have any solution to this problem, but hope that it is of small enough magnitude not to distort the results. In 1990, the Census estimated the overall undercount as 2 percent, down from 5 percent in 1950. The undercount for blacks was estimated at 5.7 percent in 1990, an increase from 4.5 percent in 1980.

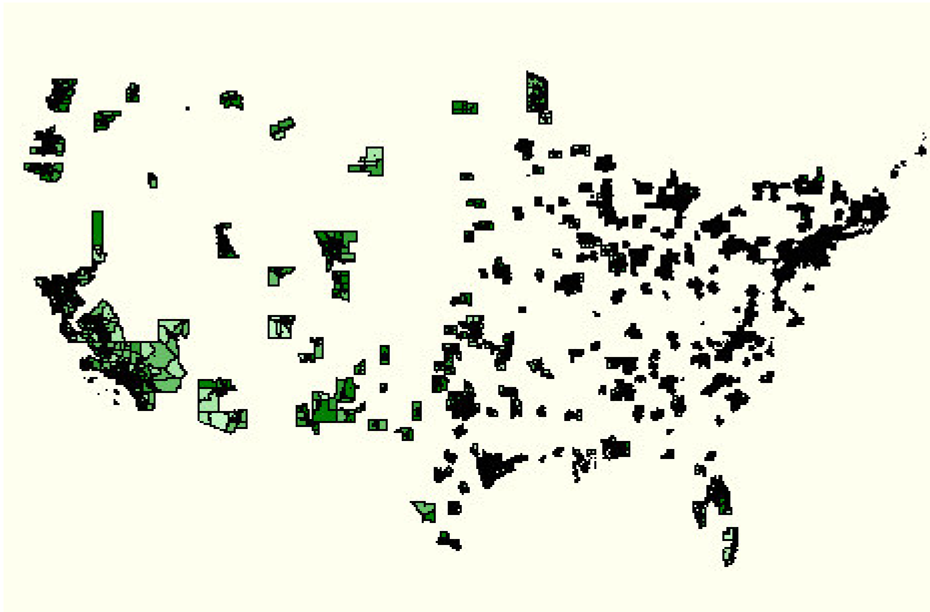
Another problem was that the 2000 census introduced a change in its racial classification methodology. Racial classification is done by self- identification. In 2000, individuals were allowed to select more than one race to describe themselves, in contrast to earlier years when they could only pick one. 2.4 percent of respondents chose multiple races in 2000. To match 2000 data to earlier years, the NCDB creators used the principle that anyone who selected a nonwhite category, even if it was in addition to white, would be classified as nonwhite. Since this conforms to the social convention for defining nonwhites, which probably influenced individuals' self-classification in prior years, and since the number choosing multiple races is small, I do not think this will overly distort the results.[8]

Table 1 shows the variable definitions and summary statistics. The sample is all available data in the NCDB, which as I noted is mainly for metropolitan census tracts (Map 1 shows the coverage of NCDB for 1970). Census tracts have a mean population in 1970 of 3,208 people. I eliminated any census tracts with a population of less than 100 in either 1970 or 2000 from the sample so as to avoid extreme outcomes in very small

[8] For some reason, the database authors violated this rule only with Native Americans, who were counted as Native Americans only if they did not also choose "white." However, the proportion of Native Americans in the sample is small in any case. Other racial issues arise with classifying Hispanics. "Hispanic" is a national origin classification, which is different than racial classification. There is a category "other" in the racial classification, which in earlier work co-authors and I have found to be strongly correlated with "Hispanic" (Alesina, Baqir, and Easterly 1999).

census tracts. The maximum population of census tracts in the sample is 31, 903 in 1970 and 36,146 in 2000.

Map 1: coverage of NCDB in 1970



The restriction of the NCDB to metropolitan census tracts is fine for my purposes, since the tipping model is mainly about urban neighborhoods.

Table 1: Variable Definitions and Summary Statistics

Variable	DSHRWHT70	SHRWHT7	LPOPDENS7	LFAVINC7
Definition	Change in white share from 1970 to 2000	White share of population in 1970	Log of population density in 1970	Log of median family income in 1970
Mean	-0.185	0.894	7.451	9.323
Median	-0.117	0.983	7.851	9.320
Maximum	0.813	1.000	12.394	12.178
Minimum	-1.000	0.001	-2.197	6.957
Std. Dev.	0.207	0.217	1.987	0.318
Skewness	-1.119	-2.739	-0.633	0.340
Kurtosis	4.435	9.740	3.250	4.882
Observations	41321	41321	41321	41284

Empirical testing 1970 to 2000

Note from Table 1 that the mean white share declined considerably from 1970 to 2000, reflecting the faster growth of nonwhite population than white population in metropolitan areas. We could think of this influx of nonwhite population as a natural experiment of the Schelling model – predicting that neighborhoods in the vicinity of the tipping point would flip over to nonwhite majorities, while neighborhoods well above the tipping point would have retained stable white majorities.

Using the NCDB, I estimate dynamic equations for the change in white share as a function of initial white share. To accomodate the highly non-linear prediction of the Schelling model, I estimate the change in white share as a function of a fourth-order polynomial of initial white share.[9] I test first the change in white share from 1970 to 2000, and then I will test the change over each decade. Table 2 shows the basic

[9] I experimented with a fifth-order polynomial also, but it did not make a difference to the shape of the curve described below.

regression for this fourth-order polynomial. All of the polynomial terms are significant, which does confirm the highly nonlinear dynamics of the white share.

Table 2: Regressions of change in white share on nonlinear function of initial white share

Dependent variables: change in white share from 1970 to 2000

	[1]	[2]
_cons	**0.10**	**-0.11**
	10.75	*-4.34*
White share, 1970	**-2.02**	**-2.09**
	-	-
	14.86	*20.87*
White share^2, 1970,	**7.58**	**7.16**
	14.92	*17.30*
	-	**-**
White share^3, 1970	**12.00**	**11.26**
	-	-
	17.44	*19.10*
White share^4, 1970	**6.18**	**5.80**
	20.06	*21.37*
Log (Population/Land Area), 1970		**-0.04**
		-
		86.41
Log Family Income, 1970		**0.07**
		23.29
R squared	0.071	0.226
Number of observations	41912	41284

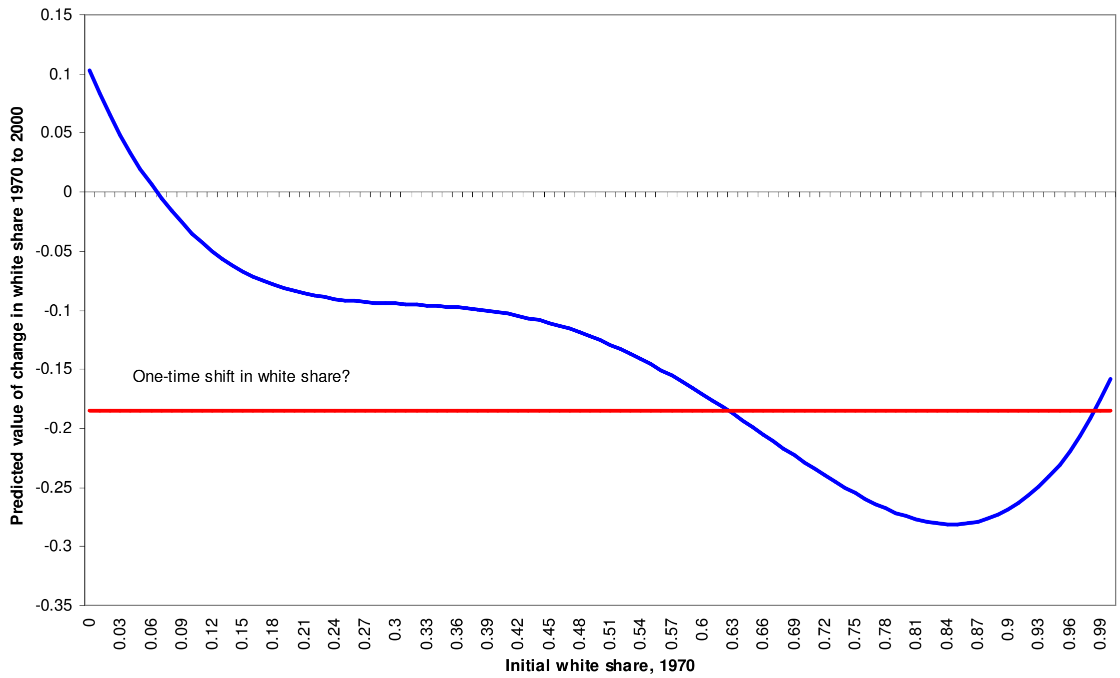
Figure 3 shows the fitted curve as a function of initial white share. Comparing Figure 2 and Figure 3, the shape of the curve is not very supportive of the tipping point hypothesis. The predicted change in white share at very high levels of initial white share is above the predicted drop in white at intermediate levels of a white share of .6 or below. Although the dip in the curve between .6 and 1.0 is consistent with the prediction of the tipping model, the turn up in the curve as the white share falls below .6 is at variance with the tipping model. In the tipping model, the predicted change in white share fell as white share decreased because all whites were leaving the neighborhood and the fall in white share could not be more than the existing white share. In the estimated curve, the fall in white share at values below .6 is modest and falls well short of all whites leaving the neighborhood. In fact, the only range of the data with a predicted increase in white share is at very low values of initial white share!

Figure 2 predicted a positive relationship between initial white share and the change in white share over a significant intermediate range of initial white share (this is necessary to get the 'tipping point'). In contrast, Figure 3 shows the actual estimated curve has only a small positively sloped segment at very high values of initial white share.

. The long run dynamic property of the curve in figure 3 is that all neighborhoods will converge to a white share of around 7 percent! This is of course a nonsensical prediction, since the share of whites in the urban population in 2000 is .72. I have not imposed any "adding up" constraint that would rule out outcomes that were incon sistent with the overall racial composition of the population. Strictly speaking, such adding up constraints are not binding since the sample neighborhoods are not a closed system – they reflect migration from the rest of the US (or even from outside the US) into or out from the metropolitan neighborhoods. Technically it could be feasible in the long run for all metropolitan neighborhoods to become majority nonwhite through the exodus of whites from urban areas (and the influx of nonwhites).

However, it is more plausible that the drop in white share at initial levels of majority white share reflects a one-time drop rather than a permanent dynamic tendency. In order to know the long-run dynamic properties of the system, we need to subtract out the one-time shift from the predicted change as a function of initial white share. Unfortunately, there is no way of detecting what part is a one-time shift in the simple estimated model here. Suppose for illustration purposes that the one time shift is equal to the average change in white share from 1970 to 2000 of -.185 (except for those neighborhoods below an initial share of .185 of course). Then the long run properties of the system could be analyzed by seeing where the predicted change in white share intersects the horizontal line at -.185 in figure 2. This would have two stable equilibria, one of white share =1, and another at white share of .63, with tipping in between. The lower level stable equilibrium is at a neighborhood with a small white majority, exactly the kind of neighborhood that was supposed to be unstable according to the original spirit of the tipping point hypothesis.

Figure 3: Change in white share, 1970 to 2000 as function of initial white share



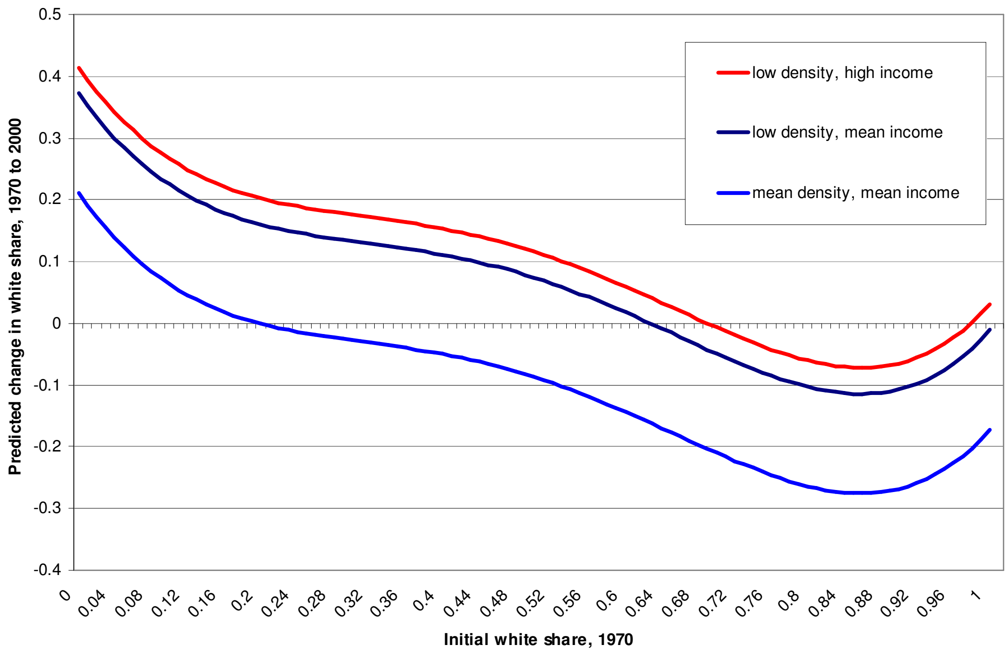
Tipping is not the only factor that could lead to changes in white share during this period, so to test robustness I consider two obvious controls besides initial white share. One well-known phenomenon is suburbanization, where population is migrating from the central city to the suburbs, and from the inner ring of suburbs to an outer ring of suburbs. This has been particularly noted among the white population. Hence, I also introduce the log of initial population density as a control for change in white share, to test the alternative hypothesis that the change in white share reflects a shift in preference among whites from high density central city or inner suburban neighborhoods to low density outer suburban neighborhoods. This may also have had racial motivations – perhaps segregationist whites perceived that blacks were less likely to live in the outer suburbs and so chose to move there. But this would be a different model than the tipping point hypothesis.

Another obvious control is income. Whites might also have a preference to reside in high income neighborhoods, and might be willing to live in a neighborhood with a lower white share if it has a higher income level. Whites also may be more reluctant to live next to low-income nonwhites than to high-income nonwhites. Hence, I control for the log of initial median family income.

Table 2 also shows the regression of change in white share on these right hand side variables. All of the polynomial terms for initial white share are still highly significant. The population density variable is significant with an extremely high t-statistic, reflecting the large explanatory power of the "white suburbanization" hypothesis for changing white share. Family income is also very significant, reflecting the tradeoff between initial white share and family income in stability of white neighborhoods. All variables together have decent explanatory power for such a noisy variable in a large sample, with an R-squared of .226.

Figure 4 shows the shape of the relationship between initial white share and change in white share at mean values of population density and family income, and then considers shifts in income and density.

Figure 3: Estimated relationship between change in white share 1970 to 2000 and initial white share 1970



The drop in white share at high levels of initial white share could be reflecting the alternative suburbanization hypothesis mentioned earlier. Figure 3 shows how the curve would look if the initial log population density were two standard deviations below its mean. The predicted drop in white share is much less, and close to zero for white share close to one. If in addition, the log family income were two standard deviations above its mean, then at last we get a predicted increase in white share at high initial values of white share (moving both variables two standard deviations means that this applies to only a small part of the sample). We get an unstable 'tipping point" type equilibrium at a white share of around .97. However, this is far from the large tipping over to majority nonwhite envisaged by the tipping point hypothesis. The drop in white share is fairly modest below

.97 and there is a stable equilibrium at a white share of around .7. Below .7, there is a predicted increase of white share which becomes quite large at low initial white share. That is to say, at low density and high income, any neighborhood with low initial white share will rapidly revert to a much higher white share. Again, we cannot be confident that these estimates reflect permanent dynamic properties of the system as opposed to one time shifts.

The appendix shows maps of some metropolitan areas to show the phenomenon of white flight from the city center and the inner ring of suburbs towards outer suburbs from 1980 to 2000 (I use 1980 instead of 1970 because more tracts have data for 1980). These pictures make clear that the dominant force in neighborhood change was a massive change in preferences by whites in favor of outer suburbs, not a tipping of individual neighborhoods by a process of multiple equilibria.[10] (The white flight out of the dense metropolitan areas could have been tipping on a very large scale, but the fact that it happened to all neighborhoods and to virtually all cities is at variance with the idea of multiple equilibria.)

To sum up, the main determinant of changes in white share from 1970 to 2000 seems to be the propensity of whites to move from high density to low density areas, and not "tipping" of neighborhoods from major ity white to majority nonwhite. Even controlling for density (and income) we don't see anything like the kind of dynamic behavior of neighborhoods predicted by the tipping point model. The change in neighborhood composition does not fit the predictions of a normal CDF for individual preferences for white share.

[10] One possible econometric problem these maps make clear is that there may be spatial correlation in the dataset, i.e. adjoining census tracts are not likely to be independent observations.

Robustness checks

One issue that is visible from the maps of metropolitan areas is that there is a high degree of spatial correlation in the data. A neighborhood with a declining white share is not independent of its neighbors, who also often turn out to be neighborhoods with declining white share. If the assumption of independence was violated, as seems certain, that would imply that the standard errors and hence t-statistics were incorrectly estimated in the regressions above.

Hence, I run another set of regressions with clustered standard errors. I use two different definitions of clustering. First, each zip code typically contains a handful of census tracts, and so correcting for clustering by zip code will take into account very local spatial dependence. This yields 8227 clusters. Second, it may be as suggested by the maps that tracts in high density and low density areas of each metropolitan area behaved similarly to other tracts in those same areas. Hence, I define a new set of groups that are first broken down by metropolitan area, and then broken down into tracts above median density and those below median population density for the whole sample. This second method yields 404 clusters (i.e. 202 metropolitan areas, with low and high density areas in each one).

The results of clustered standard errors are shown in Table 3. The t-statistics do fall drastically, especially on the population density variable, but also on the initial white share. All variables remain significant at the 1% level, however.

Table 3: Robustness checks for clustered standard errors and restricted sample

	[1]	[2]	[3]	[4]	[5]
_cons	**-0.11**	**-0.106**	**-0.112**	**-0.141**	**-0.303**
	-4.34	*-2.12*	*-1.11*	*-1.36*	*-3.63*
White share, 1970	**-2.09**	**-2.114**	**-2.082**	**-2.132**	**-1.426**
	-20.87	*-15.08*	*-8.96*	*-8.02*	*-7.77*
White share^2, 1970,	**7.16**	**7.270**	**7.154**	**7.395**	**4.344**
	17.30	*12.41*	*6.76*	*6.29*	*5.97*
White share^3, 1970	**-11.26**	**-11.370**	**-11.252**	**-11.677**	**-7.747**
	-19.10	*-13.34*	*-6.87*	*-6.5*	*-6.86*
White share^4, 1970	**5.80**	**5.830**	**5.795**	**6.012**	**4.458**
	21.37	*14.58*	*7.3*	*6.97*	*7.92*
Log (Population/Land Area), 1970	**-0.04**	**-0.040**	**-0.040**	**-0.041**	**-0.046**
	-86.41	*-35.95*	*-10.31*	*-11.11*	*-13.51*
Log Family Income, 1970	**0.07**	**0.066**	**0.066**	**0.072**	**0.093**
	23.29	*11.94*	*4.72*	*4.94*	*9.72*
Number of observations	41284	41862	41304	31985	11773
R squared	0.226	0.2169	0.2155	0.2246	0.278
# Clusters	none	9099	404	403	368
Cluster definition	none	zipcodes	metro areas (LD and HD)	metro areas (LD and HD)	metro areas (LD and HD)
Excluded observations	none	none	none	1970 coverage of 2000 tract<98 percent	Any changes in tract definitions

LD and HD refer to Low and High Density

Another robustness check I perform is to omit observations that may be questionable for reasons described in the data section. There are two types of problematic observations: 1) those in which the 1970 data apply to only part of the area contained in the 2000 tract boundaries, and 2) those in which the tract definition changed from 1970 to 2000. Note that 1) is a subset of 2). 1) is the most problematic kind of tract change, because there is simply missing information on a part of the tract for the year 1970. For other tract changes, there was an attempt by the database builders to map from the old tract data to the new tract boundaries, as described in the data section above.

Table 3 shows what happens when observations falling under either 1) or 2) are eliminated. All of the variables are still statistically significant in the smaller, more reliable samples. The coefficients are relatively unchanged for the sample that omits observations in which 1970 data did not cover the whole 2000 tract. The coefficients do change quite a bit in the restricted sample with no tract redefinitions at all. However, the picture of the predicted changes in white share looks qualitatively similar with these coefficients to that shown in figure 3.

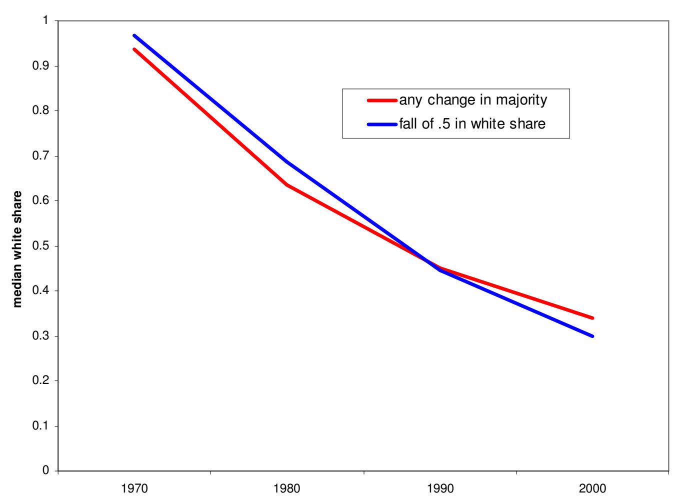
Episode analysis of the tipping point hypothesis

Another way of testing the tipping point hypothesis is to look at those neighborhoods that actually did 'tip." The tipping point hypothesis suggests a particular profile of such a neighborhood: it will start in an intermediate range of white share, and it will experience an accelerating decline in white share as it moves from majority white to majority nonwhite, winding up almost totally nonwhite. I consider three definitions of neighborhoods that tipped: (1) a neighborhood that had a fall in white share of .5 or more, (2) any neighborhood that changed from majority white to majority nonwhite, (3) any neighborhood that started from majority white share to a white share of less than 10 percent.

Figure 4 shows the medians for each decade in the tipped neighborhoods according to the first two definitions. There is little difference in behavior between the first two definitions of neighborhoods that tipped. The pattern of dynamic change does not fit the tipping story. The initial white share is very high for the neighborhoods that subsequently tipped, not so different than the sample median. The rate of decline in white share does not accelerate over time as the Schelling model would predict – there is no catastrophic decline in white share as the neighborhood crosses the tipping point. Rather, there is simply a nearly constant fall in white share from one decade to the next. And lastly, the tipped neighborhoods after 30 years still have a sizeable white minority, not the extreme of becoming a virtually all nonwhite neighborhood.

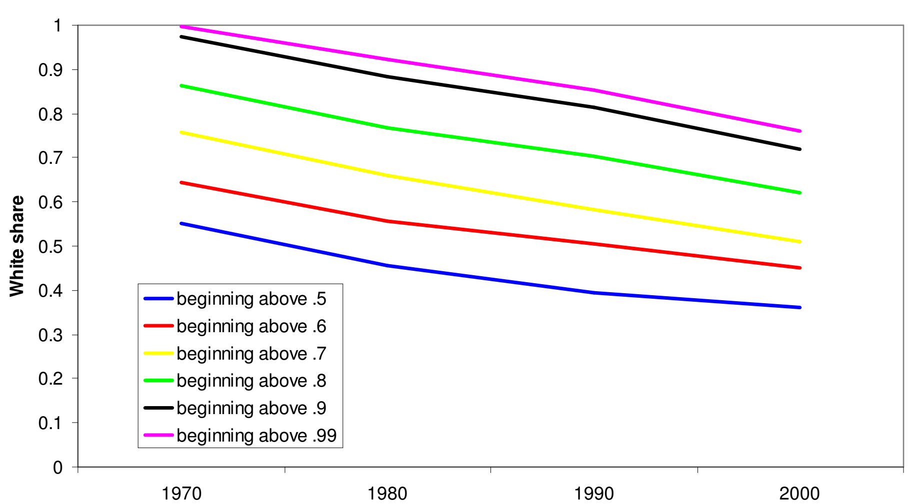
To place these numbers in context, compare them to neighborhoods that actually had an increase in white share from 1970 to 2000. There were 2872 tracts that had a higher white share in 2000 than in 1970. The initial white share in these neighborhoods is only .69, far below the high initial white share in the neighborhoods that tipped. This is at odds with the prediction that it would be the intermediate neighborhoods that would be more likely to tip than the neighborhoods with very high initial white share.

Figure 4: White share in neighborhoods that went from majority white in 1970 to majority nonwhite in 2000



Another test using episode analysis is to consider what subsequently happens to neighborhoods that have a decrease in white share in the first decade, from 1970 to 1980. The tipping point hypothesis would suggest that those above the tipping point would remain stable, while those below it would tip over to a nonwhite majority. The latter would show the accelerated decline in white share characteristic of the tipping model. Figure 5 shows the pattern of evolution for neighborhoods beginning at different white shares in 1970, all of which experience a drop in white share between -.05 and -.15 from 1970 to 1980. The different subgroups are defined as those above the white share indicated in the legend and below the white share in the next category up. The lines in Figure 5 are almost parallel and linear – we see a steady decline in white share in all neighborhoods. Those that began with higher white share end up with higher white share, but all neighborhoods have white share decline by about the same amount. There is no discernible breakpoint at which neighborhoods tip or do not tip. There is no accelerated decline for any of the subgroups, regardless of the starting point.

Figure 5: Trajectory of white share with initial fall between -.15 and -.05 from 1970 to 1980 for different starting points in 1970



I last consider a more stringent definition of tipping: which white majority neighborhoods in 1970 are most likely to have only a small white minority in the year 2000? I arbitrarily define "a small white minority" as white share less than 10 percent, without any iteration on different thresholds. The value is chosen high enough to include a decent sample of neighborhoods, given that all nonwhite neighborhoods are very rare, while low enough that it is clearly an overwhelmingly nonwhite neighborhood. This more stringent definition of tipping is arguably more in line with the original tipping point hypothesis. The tipping point hypothesis would say that neighborhoods with a high white share well above the tipping point would be least likely to tip over, while those with lower white shares below the tipping point would be more likely to tip over. Table 4 shows that this prediction is not borne out by the data. The third highest predicted tipping is for neighborhoods with an initial white share greater than .99. The highest probability of tipping is for a white share in 1970 between .65 and .7, but then there is no tipping at all for neighborhoods with an initial share between .55 and .65.

Table 4: Transitions 1970 to 2000 from white majority to very small white minority

Range of white share in 1970		Number of observations in this range	Percent of observations in this range in 1970 that were below a white share of 10 percent in 2000
>.99		16517	0.64%
<=.99	>.95	5601	0.00%
<=.95	>.90	2224	0.04%
<=.9	>.85	1368	0.37%
<=.85	>.80	999	0.40%
<=.8	>.75	727	0.55%
<=.75	>.70	574	0.70%
<=.7	>.65	466	0.86%
<=.65	>.60	361	0.00%
<=.6	>.55	288	0.00%

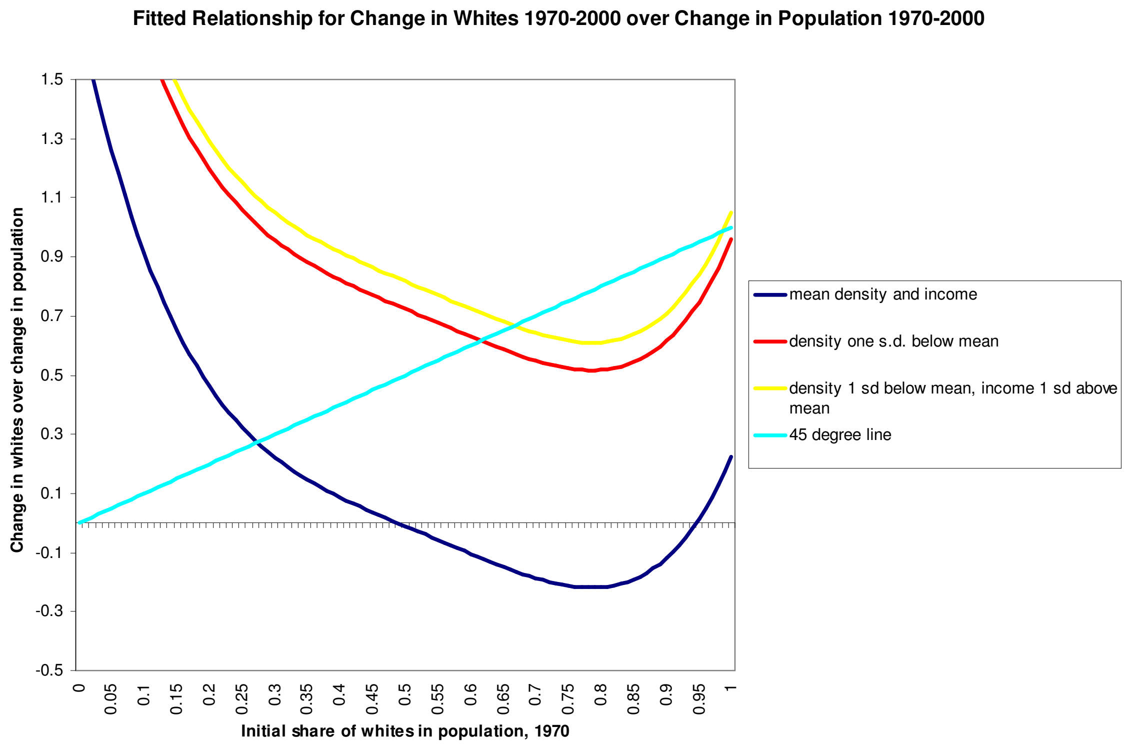
Testing the incremental version of the Schelling model

I now move to a test of equations (3) and (4) that describe the composition of new entrants to the neighborhood as a function of existing share. I need to impose several restrictions on the data to make this test viable, although these restrictions are econometrically problematic. First, the prediction of the model is different with positive or negative population growth in the neighborhood. Hence, I restrict the sample to neighborhoods with positive population growth. Second, the ratio ÄW/ÄP is prone to blow up at values of ÄP near zero. It is intuitive that these extreme values will influence the shape of the function quite a bit. I arbitrarily restrict the sample to values of ÄW/ÄP that are between -10 and +10 (that is between -1000% and +1000 percent). These restrictions create their own econometric problems as the selection of the sample may be correlated with the right hand side variables. I do this as a descriptive exercise anyway and will address these econometric problems in a future version. Table 5 shows the regression for ÄW/ÄP over 1970-2000 as a function of a fourth-order polynomial for initial white share in 1970, the log of population density in 1970, and the log of family income in 1970.

Table 5: Regression for incremental form of Schelling model
Dependent Variable: DWHTDPOP70
Method: Least Squares
Sample: 1 41321 IF DPOP70>0 AND DWHTDPOP70>-10 AND
DWHTDPOP70<10
Included observations: 25766

Variable	Coefficient	t-Statistic
C	1.15	3.77
SHRWHT7	-10.34	-5.72
SHRWHT7SQ	26.33	4.29
SHRWHT7CU	-32.71	-4.19
SHRWHT7QU	15.24	4.56
LFAVINC7	0.33	10.85
LPOPDENS7	-0.37	-89.76
R-squared	0.25	
Adjusted R-squared	0.25	
S.E. of regression	1.29	
Mean dependent var	0.11	
S.D. dependent var	1.49	

Again the variable with the most explanatory power is population density, although all of the polynomial terms for initial white share are significant. As the following figure shows, the estimated form for ÄW/ÄP as a function of initial white share departs very strongly from a normal CDF. Over most of the range of white share, there is a *negative* relationship between ÄW/ÄP and initial white share. At mean density and income, there is no tipping point. The share of incremental whites in incremental population is remarkably low at high levels of initial white share, and surprisingly high at low initial white share. At low density and high income, there is a tipping point at a white share of .98, but there is a stable equilibrium with a majority white share. Density has a quantitatively much more important effect than changes in initial white share. These results do not provide much support for the incremental version of the Schelling model.



Decade to decade changes in white share

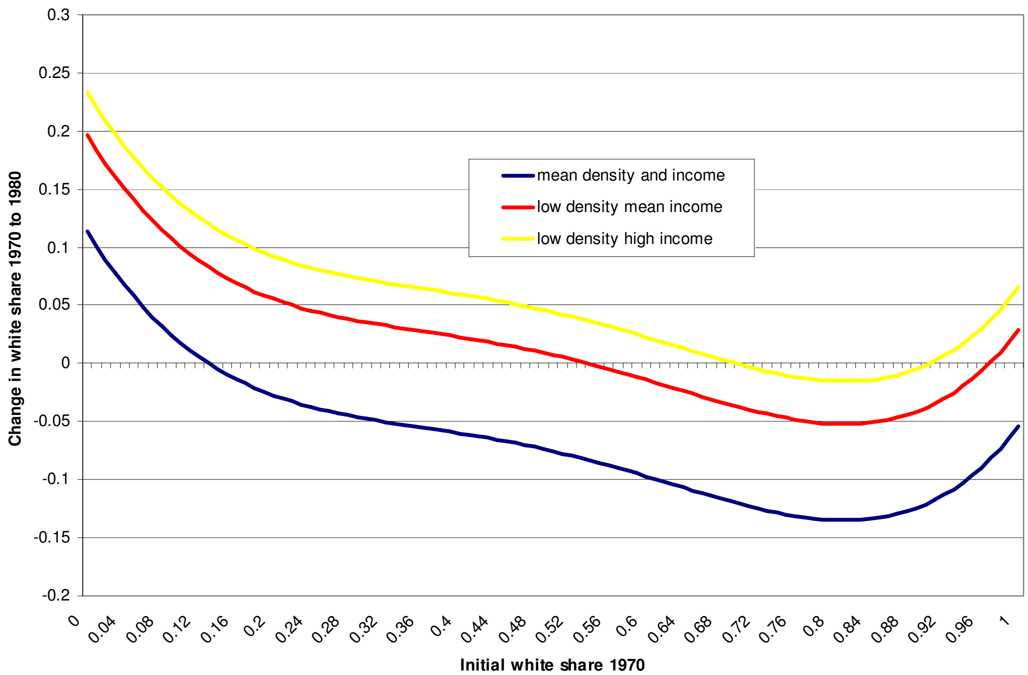
The results are similar when I look at the individual decade changes from 1970 to 1980, 1980 to 1990, and 1990 to 2000. Table 6 shows these three regressions.

Table 6: Estimates of dynamic equations for white share 1970-1980,1980-1990, and 1990-2000
Method: Least Squares
White Heteroskedasticity-Consistent Standard Errors & Covariance

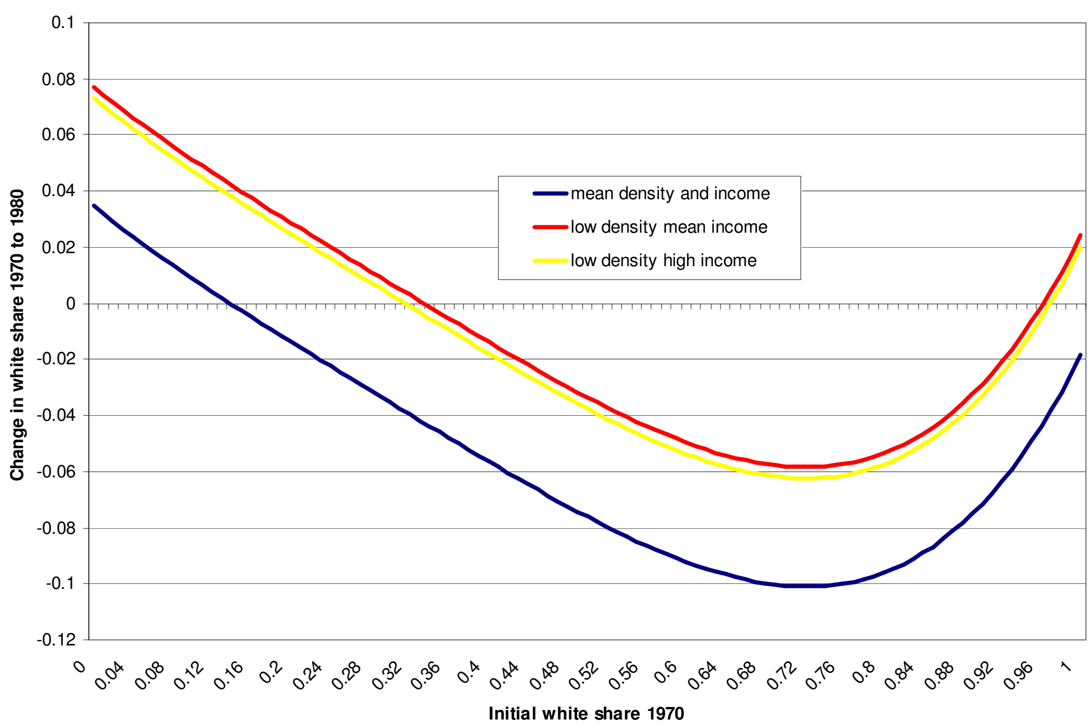
Dependent Variable:	DSHRWHT8		DSHRWHT9		DSHRWHT0	
Variable	Coefficient	t-Statistic	Coefficient	t-Statistic	Coefficient	t-Statistic
C	-0.280	-15.802	0.069	4.844	0.082	7.711
SHRWHT	-1.307	-17.041	-0.285	-6.513	0.252	6.987
SHRWHT^2	4.083	12.534	0.340	1.864	-1.633	-10.770
SHRWHT^3	-5.957	-12.753	-0.740	-2.845	1.695	7.793
SHRWHT^4	3.014	14.035	0.633	5.287	-0.356	-3.529
LPOPDENS	-0.021	-63.531	-0.012	-43.747	-0.009	-31.776
LFAVINC	0.059	29.660	0.006	3.990	0.000	0.342
R-squared	0.175		0.183		0.193	
Adjusted R-squared	0.175		0.183		0.192	
S.E. of regression	0.118		0.081		0.082	
Mean dependent var	-0.073		-0.050		-0.063	
S.D. dependent var	0.130		0.089		0.091	
Observations	41284		41218		41205	

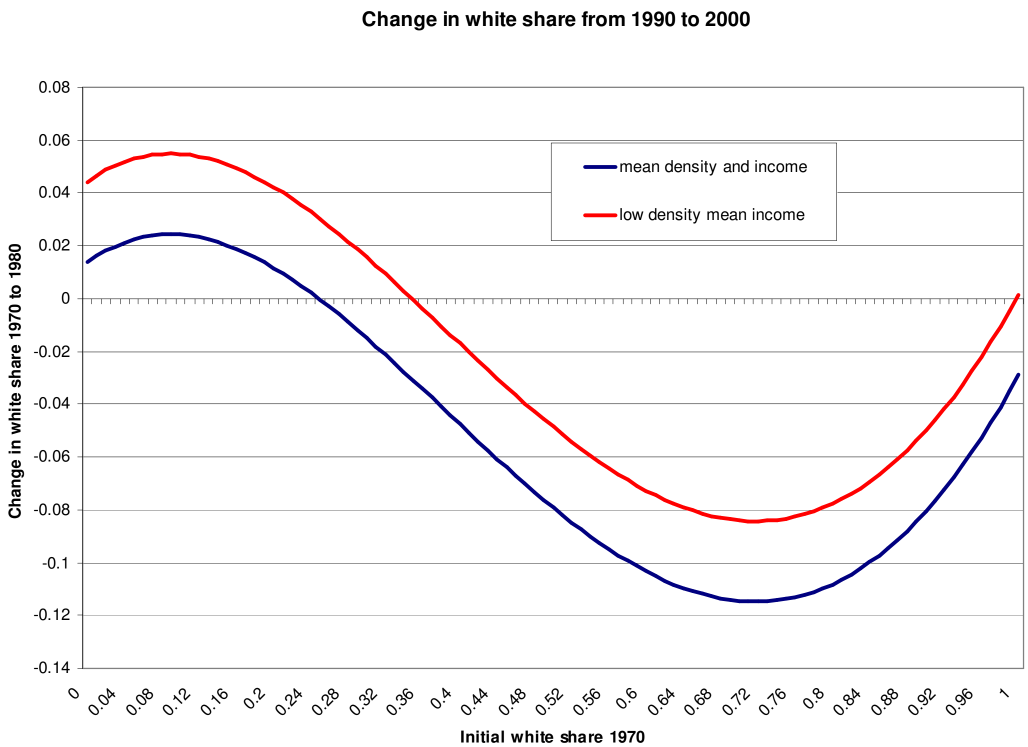
Again, population density is by far the strongest predictor of change in white share. The effect of initial family income is weak in the 1980 to 1990 regression and insignificant in the 1990 to 2000 regression. The nonlinear terms for initial white share are significant, but much less so than density. The following figures show the dynamic curves for each regression, comparing the curve at mean log population density with that with density 1.96 standard deviations below the mean, and then both density and income 1.96 standard deviations away from the mean. The curves are quite different from one decade to the next, but none of them fit comfortably with the picture predicted by the tipping point model.

Change in white share from 1970 to 1980



Change in white share from 1980 to 1990





There are multiple equilibria for some low values of density in these graphs, but the lower stable equilibrium is one with a white majority. At mean density, all of the neighborhoods with high white share show a decline in white share, with only a modest trough at intermediate values of the white share. (The curvature in this zone is consistent with the predictions of the normal CDF for preferences, but we do not find a tipping point except at low density.)

The curve for changes from 1990 to 2000 comes the closest to fitting the tipping model. At low density, the stable equilibria are a white share equal to one, and a white share equal to about .4. This captures the idea that neighborhoods could tip from homogeneous white neighborhoods to minority white neighborhoods. However, the lower equilibrium of .4 is much higher than in the typical view of the tipping point. And the tipping point itself is implausibly high – any white share less than .99 will tip over to the minority white neighborhood. While providing some support for the tipping point view, these parameters do not portray a very plausible tipping story. Anyway, we must set against this evidence the failure of all the other tests for the tipping hypothesis presented earlier.

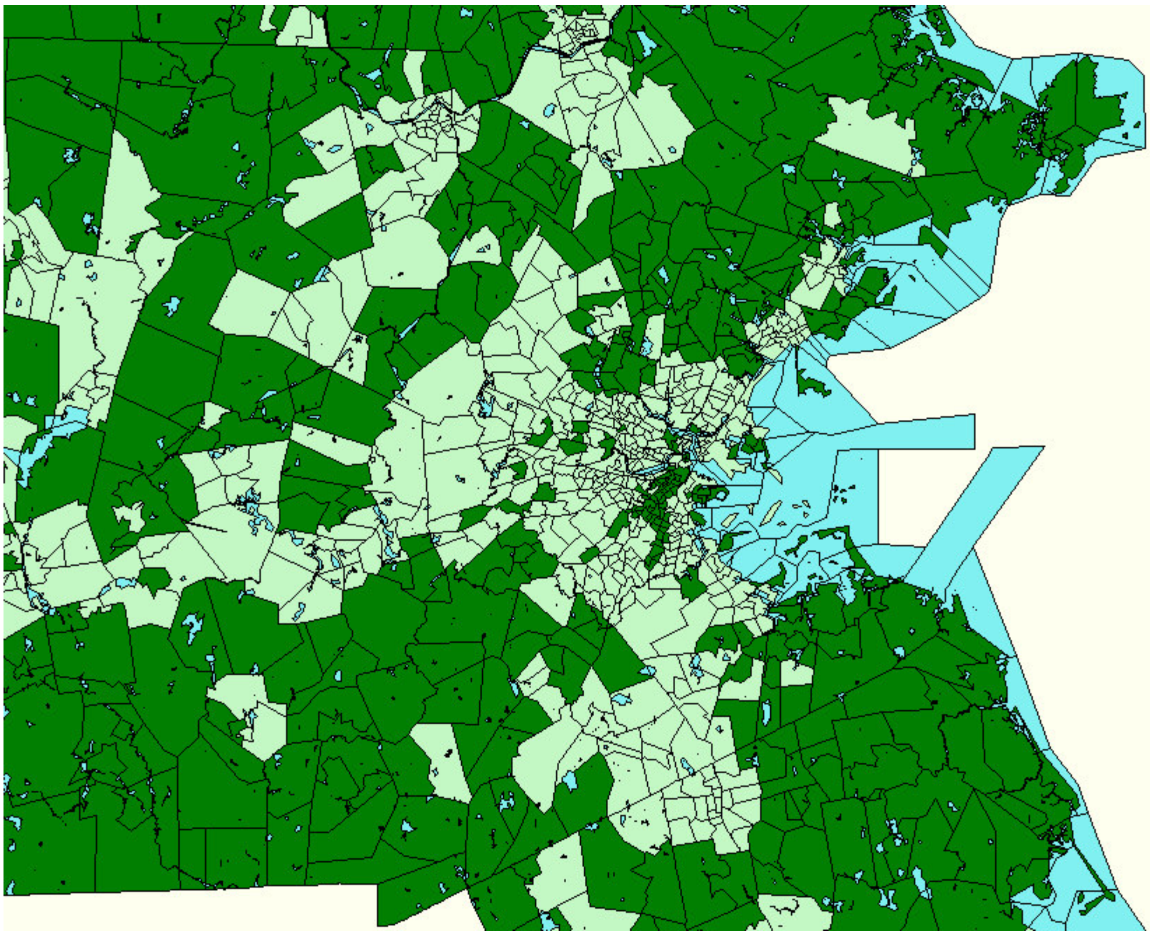
Conclusions

Although a significant fraction (about 10 percent) of the sample of urban American neighborhoods did change from majority white to majority nonwhite over 1970 to 2000, they did not do so as the "tipping point" hypothesis suggests. The main factor in neighborhood change was a movement of whites from central cities and inner suburbs to outer suburbs in metropolitan areas. The relationship between change in white share and the initial white share does not fit the "tipping point" model very satisfactorily. Episodic analysis does not show evidence of "tipping" at intermediate levels of white share. Based on this dataset, the "tipping point" is closer to an urban legend than an unstable equilibrium that explains racial segregation.

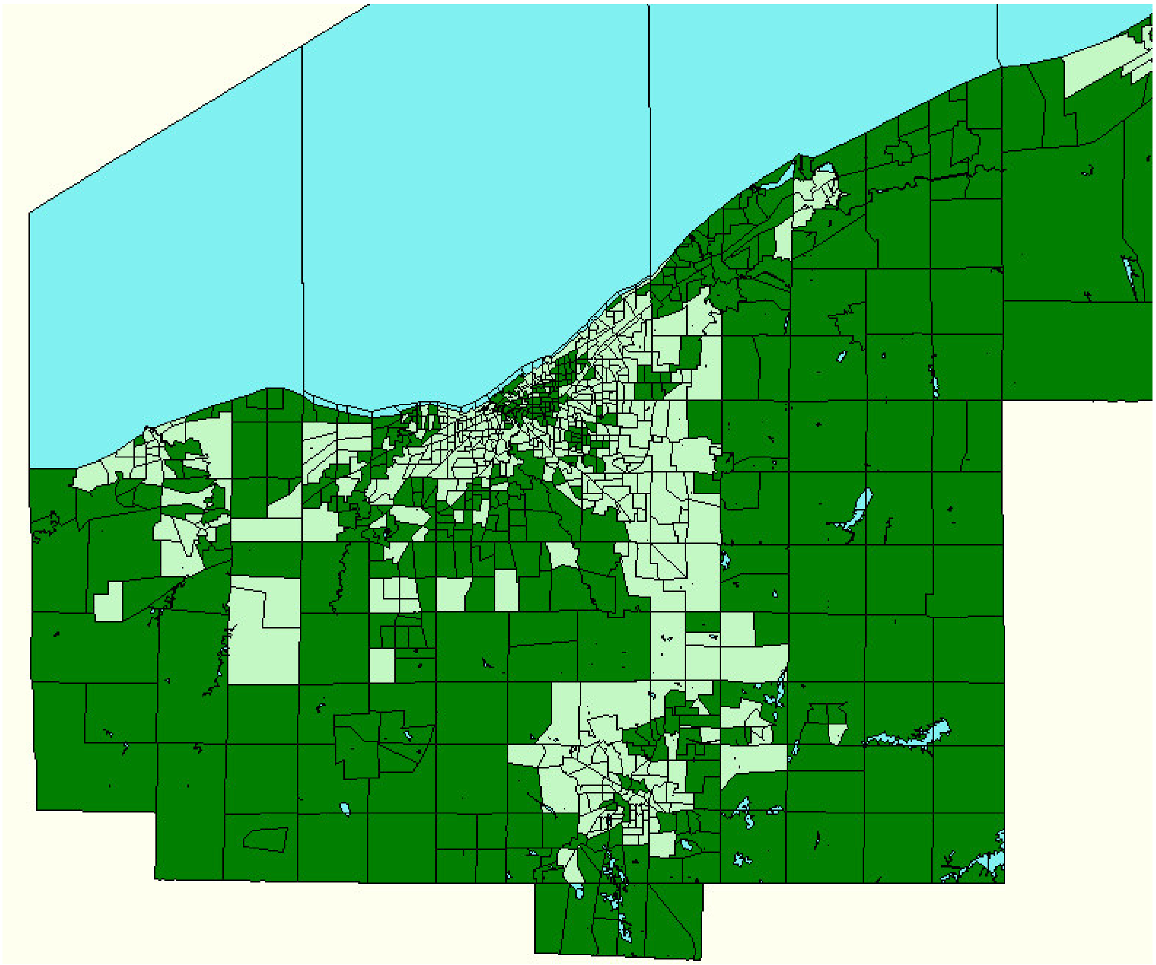
Although the tipping point model has been portrayed as a classic model of strategic interdependence and multiple equilibria, it does not work well here in explaining American neighborhood segregation. This is not to say that strategic interdependence and multiple equilibria are not important phenomena in other contexts. Schelling's model remains a classic milestone for understanding instability of interdependent behavior. As far as racial segregation goes, however, research should seek to understand more the fundamentals that determine why people wind up living next to people of the same race.

Appendix: Maps of change in White share by metropolitan area, 1980 to 2000 – Dark green indicates increase or no change in white share, light colors a decrease in white share

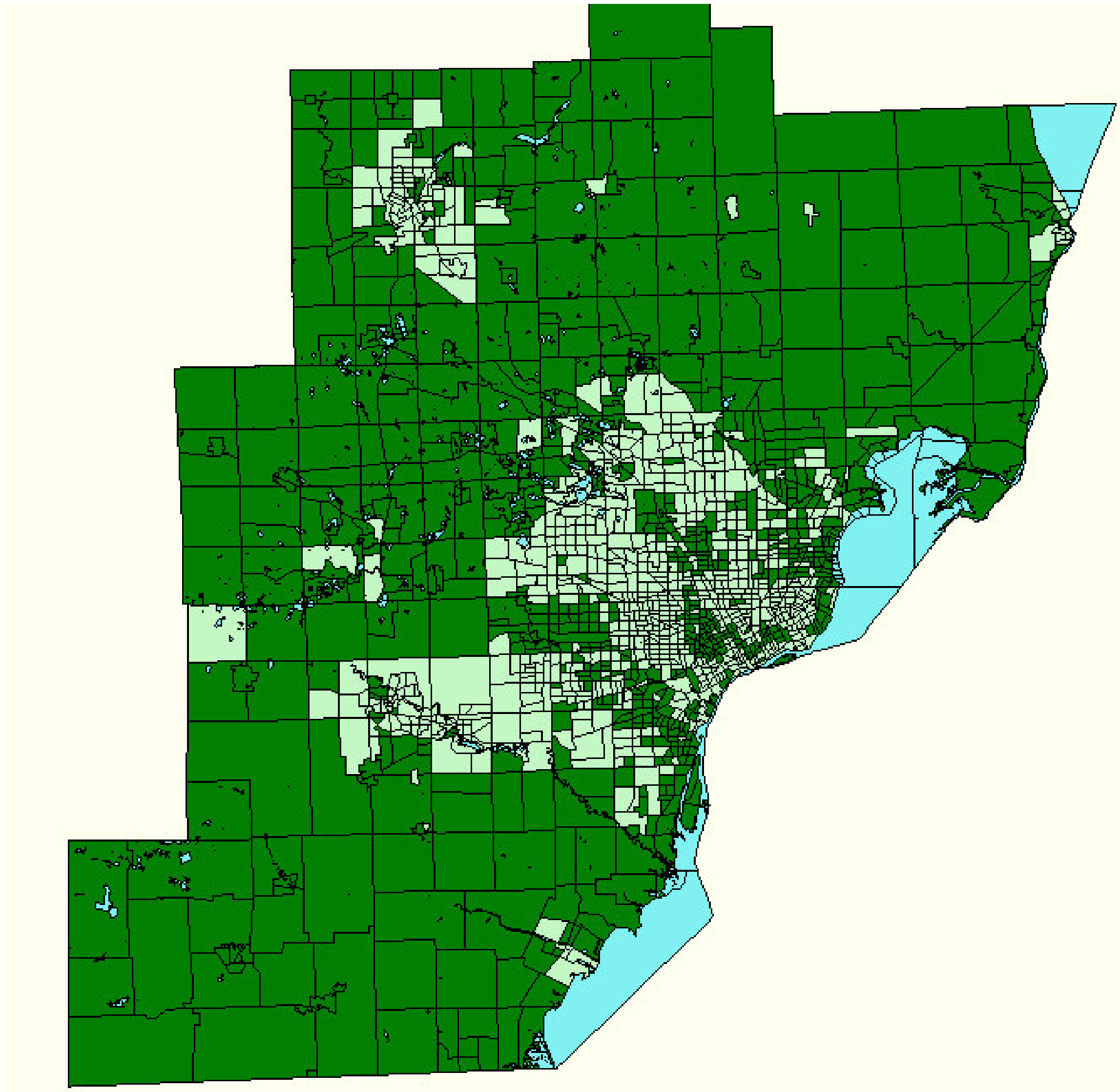
Boston



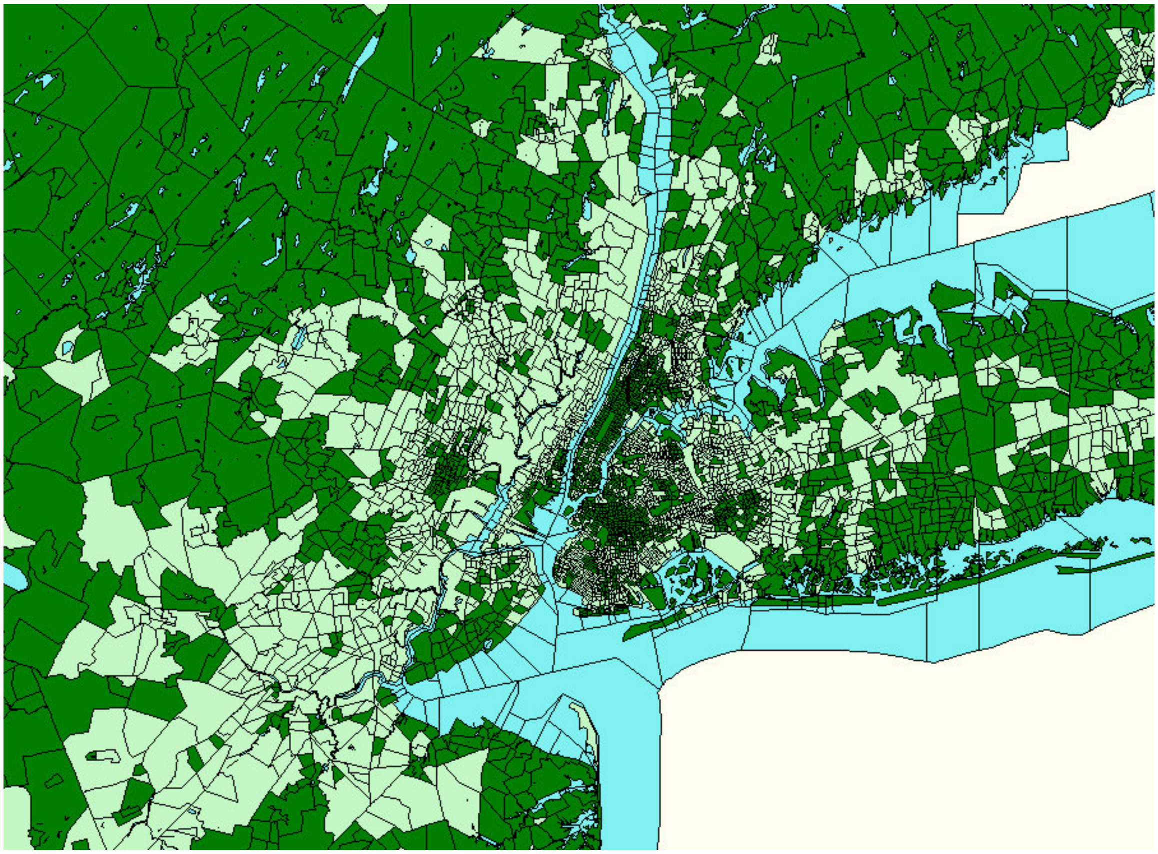
Cleveland



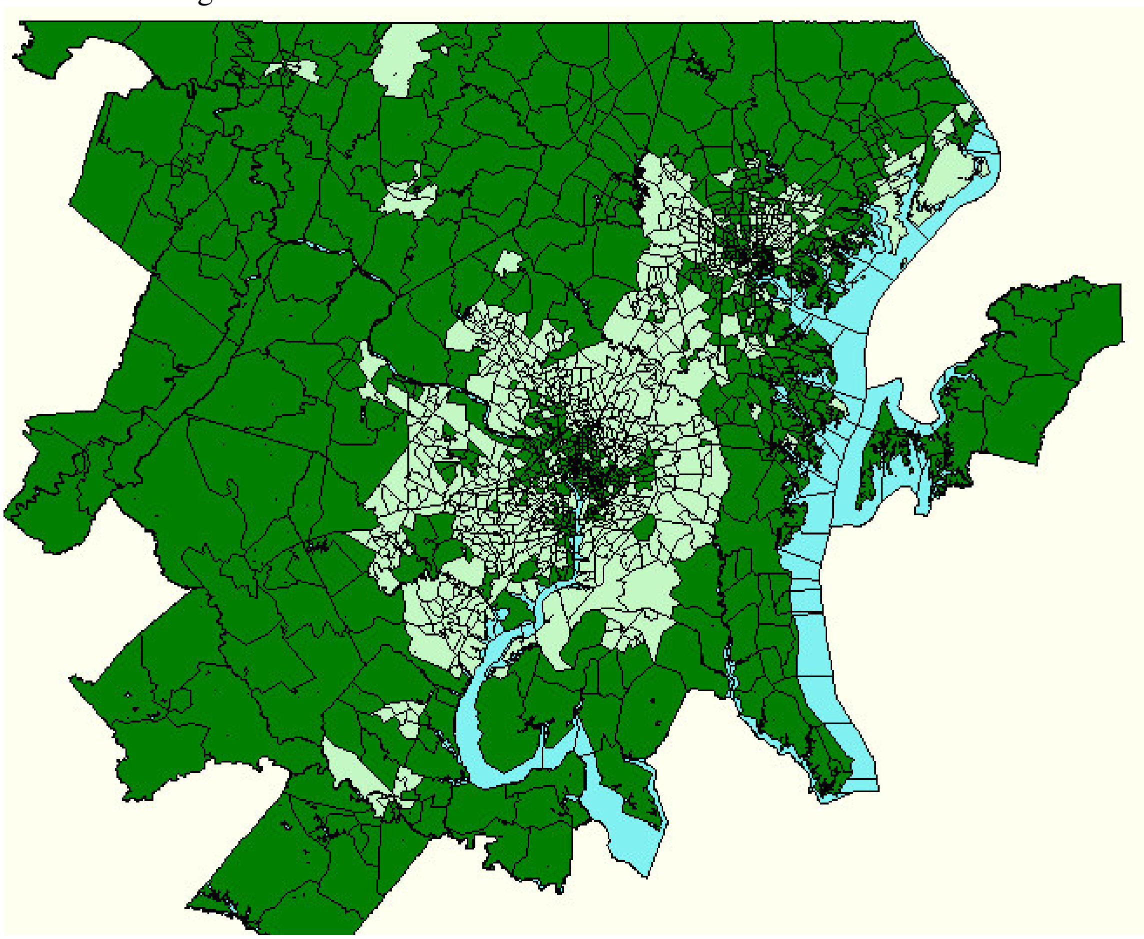
Detroit



New York



Washington-Baltimore



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