Tenure Tipping

N. Edward Coulson
Department of Economics and Lied Institute for Real Estate Studies
University of Nevada, Las Vegas

Gregory Wommer
Smeal College of Business
Penn State University

Abstract: In light of the increased importance of the single family rental market, local policymakers and homeowners associations have expressed concern that neighborhoods might turn over, rapidly or otherwise, from largely owner-occupied homes to rental occupied properties. We construct a theoretical model of tenure tipping and employ the methods of Card, Mas and Rothstein (2009) to understand the nature of this type of neighborhood turnover. We estimate the model for the last four decadal census intervals and find generally owner-occupation rate falls when the initial renter penetration is higher. In the 2000s and 2010s neighborhoods are far more sensitive to renter penetration, such that tenure tipping—rapid turnover from owner to renter at low initial renter penetrations-- may be observed. This is in contrast to Card, Mas and Rothstein's findings that racial tipping has declined in later decades.

Acknowledgements: We thank the Penn State Institute for Real Estate Studies for financial support and Jesse Rothstein for helpful conversations. All errors are the authors'. This paper is preliminary and subject to revision.

Section 1: Introduction

Homeownership is often held to create benefits not only for the owners themselves but also for their neighborhoods. Such beneficial spillovers constitute a major argument in favor of public subsidies (through the US income tax and otherwise) for homeownership. As noted in much of this literature (e.g. DiPasquale and Glaeser, 1999), the high cost of ownership transactions provides incentives for residence spells to be greater for owner-occupiers, and thus incentives for greater investment in the social capital of the neighborhood. Dietz and Haurin (2008) and Coulson and Li (2013) summarize the literature for and against the general proposition that homeowners generate positive externalities and Coulson and Li (2013) provide evidence that, indeed, properties in single-family neighborhoods with a greater preponderance of owners have higher sale prices even controlling for other neighborhood characteristics.

However, rental property has an increasing presence in single-family neighborhoods. Figure 1, which presents estimates from the American Community Survey of single-family rental housing stock both in absolute numbers and as a percentage of the total single family stock, shows that both of these series have increased since 2005 (i.e. the start of the housing and financial crisis) and that the percentage has been accelerating particularly strongly since about 2009. This is not just from new construction of residences designed for the rental market, but from the conversion of previously owner-occupied property into rental – occupied units. Table 1 looks at matched data from units surveyed in the American Housing Surveys of 2009 and 2011. The tenure and vacancy status of these units is observed in both periods. As can be seen from the Table, about 4.6% of owner-occupied houses became renter occupied over the two year period.

Media reports reinforce the idea that owners are preferred neighbors; these reports have especially proliferated in light of the increasing use of single-family structures as rental properties Dewan (2013) notes the disquiet displayed by owners as renters move into neighborhoods that were once predominantly owner-populated areas. Schmit (2012) documents similar concerns. Additionally, homeowner association covenants often restrict a property owner's ability to rent out units, presumably in the belief that owner-occupiers bring greater value to localities (Pindell, (2009)).

Policymakers have taken note as well. In State College, Pennsylvania, an area dominated by a large university, borough officials found that renters, largely students, were increasingly the predominant population in neighborhoods once mainly occupied by owner-occupiers. The concern was that once a neighborhood had reached a certain level of penetration by renters, it would become largely avoided by potential owner-occupiers, and that the neighborhood would become dominated by rentals, to the potential detriment of neighborhood quality and property values. The concern was sufficiently strong that the State College borough government secured $5 million in loans to establish a Homestead Investment program, the purpose of which is to purchase homes in neighborhoods that are at risk of conversion to rental properties, and resell to owner-occupiers, with a deed restriction that it only be resold to other owner-occupiers. One city official described the goal of the program as creating "neighborhood stability and diversity" (Carroll, 2014)[1].

The rapid neighborhood change foreseen by these policymakers is sometimes called "tipping". The term is first used by Schelling (1976) to describe white flight from neighborhoods that receive a sufficiently large influx of racial minorities. White residents lower their valuations of neighborhoods, while black households do not, and thus black households become the highest bidders for properties in that neighborhood. This increased proportion of black households increases the differential of white and black property bids, causing further, and more rapid, turnover of property from white to black households. Miyao (1978), O'Sullivan (2009), and Zhang (2011) provide more formal models of this phenomenon[2]. Bond and Coulson (1989) extend this literature in two ways: first, they consider differences in income rather than differences in race as the measure of neighborhood quality. The importance of this distinction is that they assume that both high and low income households prefer to live with high income households, rather than each group preferring to live with its own type. Also, a missing piece of the Schelling framework is the source of the original influx of the "new" group. Bond and Coulson surmise that at some point, and no matter how rich the neighborhood, the oldest houses in a neighborhood will eventually depreciate sufficiently that low income households (who have a lower marginal willingness to pay for quality) outbid high income households. This is the familiar "filtering" model of housing turnover, which has a long history in urban economics (e.g. Lowry, 1960). Thus, if the stock of old housing is sufficiently "thin", the penetration of the low income group will be "slow" and rapid turnover will not occur. The integrated equilibrium is stable. But if the stock of vintages has a tight distribution, the number of houses that filter to low income groups can be large enough, that even new houses become relatively more preferred by low income households, and the neighborhood tips to an all low-income equilibrium. Thus, tipping can arise out of the typical filtering model.

In Section 2 below, we reformulate the Bond-Coulson framework to model the phenomenon of "tenure tipping," wherein neighborhoods turn over from predominantly owner-occupied to rental properties, perhaps quite rapidly. We then discuss this model's empirical implications, based on the presentation in Card, Mas and Rothstein (2006). In Section 3 we present the empirical models to be estimated, along with a discussion of the Neighborhood Change Database, the source of data used in our empirical models. This model follows the leading example in this literature, that of Card, Mas and Rothstein (CMR, 2009). This empirical model first estimates the maximum likelihood value of the tipping point (if it exists). CMR's methodology is to estimate the most likely structural break in the rate of outflow of the original, incumbent group, as a function of the initial neighborhood penetration of the incoming new group. That structural

[1] Such a restriction is legal, since neither students nor renters are protected under the Fair Housing Act of 1965.
[2] See also Anas (1980) for an analysis of tipping that involves potentially rapid changes in neighborhood composition in the face of gradual changes in underlying fundamentals, but with homogeneous preferences across groups.

break, where the rate of outflow discretely increases, is designated the tipping point. To estimate that tipping point, the percentage change in the housing stock occupied by the incumbent group over a census decade—incumbents being white households in CMR, owners in our model—is regressed on the percentage occupied by the new group at the beginning of that decade. We then look for values of the latter variable at which a structural break in the response function might occur. The maximum likelihood value of the break, defined by a search algorithm-- is defined to be the tipping point, if it exists. Then a regression model that examines neighborhood change as a function of a wider variety of variables is estimated. This regression allows for the structural break at the tipping point estimated in the previous exercise. Standard hypothesis tests allow us to test for the existence of tipping at the maximum likelihood tipping point. Section 4 describes the results of these empirical exercises. In brief, we find that tenure tipping points exhibit wide cross-sectional variety, but that they decline over time. Indeed they do not even seem to exist until the latter decades of our sample—the 1990s and 2000s. Section 5 concludes.

Section 2: Models of tipping

The original model of tipping is due to Schelling (1976), and its extension by Miyao (1979). Both of these authors modeled the case where one group either had a positive affinity for its own group, or a disdain for the “other”. In either case there is a net preference for living with one’s own type. In Schelling’s formulation even the smallest influx of blacks into a previously all-white neighborhood can lead to rapid turnover from white to black[3]. Miyao (1979) formalizes this model and finds that there are interior equilibria, but such equilibria are unstable. The only stable equilibria in this framework are fully segregated neighborhoods. Becker and Murphy (2000) extend this model to the case where the majority group may have preferences for a certain amount of (ethnic) diversity, such that white utility rises in the percentage of blacks in the neighborhood, but only up to a certain critical threshold. Such a taste profile may lead to a neighborhood equilibrium that is both integrated and stable. This model was exploited by Card, Mas and Rothstein (2009) in their model of racially-based tipping.

Bond and Coulson (1989), on the other hand, considered the case of heterogeneous income groups, wherein both high and low income groups globally preferred to live with the higher income group.[4] Moreover, the Bond and Coulson (1989) model explicitly deals with quality heterogeneity in the housing market (as represented by the age of the dwelling). This can be important if the tastes of the two groups for housing quality are different. This was shown to be the case empirically in Coulson and Bond (1990) in that higher income households had a higher willingness to pay for newer and larger units. As noted above, since

[3] In fact, as numerous authors have noted, in Schelling’s model the tipping might just as easily been from black to white. At the time of Schelling’s formulation, this did not have much evident importance, but is now interpretable as gentrification.

[4] Sethi and Somanathan use these preferences as well.

the age of a structure increases over time, quality declines, and eventually the lowest quality units turn over from rich to poor households. The pace of further turnover depends on both the relative preferences for neighborhood quality (as represented by average income) and housing quality (as represented by dwelling age), as well as the distribution of housing vintages within the neighborhood

We adapt the Bond-Coulson model to the case of tenure tipping. This model is more appropriate to the present case than that of Schelling, Miyao, and Becker and Murphy because of the two differences discussed above. Because owners contribute more to neighborhood quality than renters, both renters and owners prefer to live with other renters (Coulson and Li (2013)); and owners prefer to purchase higher quality housing than do renters. As shown in Hanson (2011), the tax preferences accruing to owner-occupation cause more housing to be purchased on the intensive margin. Tax breaks are worth more the bigger or newer the house you buy.

We assume an open city with a large number of households. These households are alike with respect to their preferences over housing quality, neighborhood quality and a composite good, and with respect to income. Their housing tenure is either that of owner or renter, and this status is exogenously imposed. These assumptions are made for tractability. In particular, we might alternatively assume some heterogeneity of income, in which case higher income households would sort themselves into homeowner status (because of the tax break) and also have greater preference for housing and neighborhood quality. Our set of assumptions will lead to the same kind of sorting. Tenure is exogenously imposed, but owners will have greater demand for housing and neighborhood quality, even when we require that owner and renter utility levels to be the same in equilibrium. This is because owners gain tax savings for housing consumption. These tax savings are completely capitalized into their housing bids, such that the *after tax* price paid for a unit of housing quality are the same for the two tenure types[5].

To be specific, let the utility function for households be given as

$$U = U(Q, X, r)$$

where U is the utility level, Q is a continuous measure of housing quality, X is a composite consumption good, and r is neighborhood quality, as manifested in the percentage of neighborhood residences occupied by renters. The derivatives of the utility function are positive in Q and X, and negative in r.

In an open city, utility for a household of income Y is constant across neighborhoods at some level U*. Define B(.) as the bid for a house with some level of quality Q and r that provides this level of utility:

[5] Since the variable of interest is tenure, rather than income, this formulation is preferable. Empirically, of course, tenure is, as noted in the text, highly correlated with income (and other things), so that among our important controls in the regression model will be measures of income. Also note that we are abstracting from the difference between a rental payment and a monthly mortgage payment. In a world where maintenance costs are observable, and capital gains from housing are absent, these will be equivalent.

$$U^* = U(Q, Y - K - (1 - t_o)B(Y, U^*, Q, r), r)$$

where for owners, t_o is the marginal income tax rate for an owner, and is equal to zero for renters. The idea is that any dollar spent on housing consumption only costs the owner ($1-t_o$) because of the mortgage interest tax deduction and/or the exclusion of the implicit rental income from taxable income. The parameter K represents a fixed cost that accrues to homeownership, representing the greater search and acquisition costs compared to renting.[6]

The implicit function B has the derivatives for Z= Q, r:

$$\frac{\partial B}{\partial Z} = \frac{1}{(1 - t_o)} \frac{U_Z}{U_X}$$

which is negative for Z=r and positive for Z=Q. The above derivatives imply that the willingness to pay for either a marginal increase in Q or a decrease in r is greater for owners by a factor of $(1-t_o)^{-1}$. An illustration of this is in Figure 1. In the figure we map two bids, notated $B(Q, r_i; T)$, as the willingness to pay a function of Q conditional on some level of r and tenure type T (suppressing the constants U* and Y). With percentage of renters equal to r_1, the slope of $B(Q, r_1; O)$ is greater than $B(Q, r_1; R)$ at the point where the two bids cross; this illustrates the point that when Q and r are identical, the slope of the owners bid function is steeper. Therefore, for levels of quality $Q< Q_1$, renters outbid owners for low quality units, while if $Q>Q_1$, owners are the highest bidders[7].

Now consider a neighborhood with a higher percentage of renters, r_2. Since this makes the neighborhood less desirable for both owners and renters, both bid curves shift down, but owners' bids shift down by a greater amount (again by the factor $(1-t_o)^{-1}$). The crossing point Q_2 is greater than the previous crossing point, Q_1, indicating that in a neighborhood with a higher percentage of renters, renters are willing to outbid owners for relatively higher quality housing than before.

For each renter percentage, we can draw the B(Q, r; T) functions and note where the crossing point Q is in each case. In Figure 1, the dashed line $B^*(Q_i, r_i)$ traces out the combination of turnover qualities, renter percentages, and bids that satisfy the condition

$$B(Q_i, r_i, O) = B(Q_i, r_i, R)$$

[6] If it were not the case that K>0 then in this simplified framework owners would outbid renters for all houses.
[7] To clarify notation, Q and r represent generic values of these two variables. With subscripts, Q_i is the level of housing quality which equalizes renter and owner bids when the rental percentage is r_i.

The $B^*(Q_i, r_i)$ function can be inverted to give the function $r_i=A(Q_i)$ which is upward sloping in (r_i, Q_i) space with derivative:

$$A_Q = -\frac{B_Q(.;O) - B_Q(.;R)}{B_r(.;O) - B_r(.;R)} = -\frac{B_Q(.;R)}{B_r(.;R)} > 0$$

where the second equality holds because owner and renter bids are identical except for the factor $(1-t_o)^{-1}$. Figure 2 displays an example. Note that the area above A(Q) are pairs (Q, r) that are relatively high quality, and for which owners would outbid renters. Renters are the highest bidders below this curve.

Across neighborhoods, A(Q) is invariant. However each neighborhood is going to have a distinct distribution of qualities, and it is clear that not all combinations of Q and r that solve $r_i=A(Q_i)$ will be congruent with the actual distribution of qualities in the neighborhood housing stock. To that end, let F(Q) be the usual cumulative distribution function of neighborhood housing quality. The cumulative distribution function F is, like A, upward sloping in (Q, r) space. For clarity we assume that it is strictly so over the range of possible qualities. We also assume, for illustrative purposes, a single interior crossing point, i.e. a single interior equilibrium (Q_i^*, r_i^*). Figure 2 provides such an illustration, in this instance one in which A is steeper than F. Note that a *relatively* steep A curve implies some combination of (1) a relatively disperse distribution of quality (i.e. a flatter cdf function); (2) high marginal valuation of housing quality; and (3) low marginal valuation of neighborhood tenure distribution. Under such circumstances the interior equilibrium is unique and stable. The formal proof is identical to that contained in Bond and Coulson (1989); here we consider the intuition behind this result. Let a particular neighborhood be populated with r_1 renters, but in this neighborhood, the distribution of housing qualities is such that $Q_2 > Q_1$ solves $r_1=F(Q)$. As can be seen from Figure 1, (Q_2, r_1) is below the A(Q) locus and owners outbid renters. Owners enter from other neighborhoods and replace renters, causing r to fall. The fall in r improves neighborhood quality and Q_i decreases as well, converging to the equilibrium where A(Q) and F(Q) intersect. In this instance, tippng is avoided.

A different situation is pictured in Figure 3. Here A(Q) cuts F(Q) from above. The distribution of qualities is narrow, and preferences for neighborhood quality relative to housing quality are stronger. (Q_1, r_1) is again the crossing point, and this pair of constitutes an equilibrium, but this equilibrium is unstable. Suppose again that the distribution of housing qualities is such that the Q that solves r=F(Q) is $Q_2>Q_1$. At (Q_2, r_1) we are now *above* the A locus, so that renters outbid owners, and r rises, moving away from the crossing point (Q_1, r_1). This process repeats until the absorbing state $(\overline{Q}, 1)$ is reached. If the neighborhood is to the left of (Q_1, r_1) owners outbid renters and r falls until $(\underline{Q}, 0)$ obtains. Thus (Q_1, r_1) is an equilibrium but is unstable, and we define tipping as the process which occurs when the neighborhood is perturbed from that unstable equilibrium. As in most tipping models of this type, the segregated equilibria at r=0 and r=1 are stable.

Tipping is therefore more likely when preferences for neighborhood composition are strong. This is somewhat obvious. What is less obvious is that a narrow distribution of qualities is also conducive to tipping. As an illustration, in Bond-Coulson (1989) perturbations to the equilibrium occur as the housing stock ages. In our framework this implies a shift of the F curve to the left (as housing at all points in the neighborhood spectrum loses quality). When the neighborhood housing quality spectrum is narrow, this implies that a larger measure of the stock is newly occupied by renters, lowering the quality of the neighborhood which in turn brings in more renters, until the neighborhood is fully occupied by the new (renter) group.

But the opposite may occur. New construction, or perhaps more to the point, rehabilitation, may occur in an area, drawing in new owner-occupiers which in turn raises neighborhood quality and pushes more renters out of the area. Discussion of the costs and benefits of historical preservation and other policies that are seen to spur gentrification often turn on the demographic transition of areas from renter to owner-occupied properties (Coulson and Leichenko, 2004).

The empirical implications of this model are discussed in Card, Mas and Rothstein (2006)[8]. If a neighborhood is characterized by a stable interior equilibrium as in Figure 2, neighborhoods that experience change, such as a degradation of the housing stock that shifts the quality distribution F to the left, will not experience a large change in the neighborhood's renter share. However if the neighborhood were at the unstable interior equilibrium depicted in Figure 3, such a shock to F would cause the initial influx of renters to engender further turnover to renters, and the neighborhood would head in the direction of the stable equilibrium at r=1. Similarly, a shock to the number or share of owners, such as new high-quality construction, or a policy change such as the homestead investment program, would have the opposite effect in Figure 3, a relatively rapid tip toward r=0. All of this suggests that in the case of unstable interior equilibria, we should observe a discontinuity in the response of the rate of change in r to the level of r. We proceed in the next section to examine empirical models that estimate this tenure tipping point, and causes of tenure tipping.

3. Empirical models

There are two empirical goals in this paper. The first is to identify tipping points, if they exist, and then to examine their temporal and cross-section variation. Tipping points are identified at the metropolitan area level by letting the unit of observation be the census tract and assuming that the tipping point is the same

[8] Note that this is a working paper version; this discussion is not in the final, published version of Card, Mas and Rothstein (2009).

across census tracts within each metro area. We will also estimate them separately for each sequence of decennial censuses.

In order to estimate these tipping points, we employ the methodology of Card, Mas, and Rothstein (2009). The idea is that if a tipping point exists, we will observe a discontinuity in the response of the *change* in the owner share to the *level* of the rental share at the beginning of the period. Define $HO_{ic,t}$, $R_{ic,t}$, and $A_{ic,t} = HO_{ic,t} + R_{ic,t}$ to be the numbers of homeowners, renters, and total occupied, residential single family units in tract, *i*, in city, *c*, in the year, *t*. The dependent variable of interest is the change in the tract's HO population, taken as a share of the base year total household count: $\Delta HO_{ic,t} = (HO_{ic,t} - HO_{ic,t-10})/A_{ic,t-10}$.[9] A tipping point, if it exists, can be estimated from the data that simply compares average changes in the homeowner share above and below candidate tipping points. We employ the regression model

$$\Delta HO_{ic,t} = a_{ct} + b_{ct} * d_{ct}\left[r_{ic,t-10} > r^{*}_{c,t-10}\right] + \varepsilon_{ic,t} \quad (1)$$

where *d* is an indicator function equaling 1 if the bracketed expression is correct, and zero otherwise. The parameter a_c is the average change in the owners' share below the tipping point $r_{c^*,t-10}$, and b_{ct} is the change in that variable above the tipping point. The $r^*_{c,t-10}$that maximizes the fit of (1) is chosen as the maximum likelihood estimate of the tipping point.

To estimate the model of neighborhood tenure transitions we assume that $\Delta HO_{ic,t}$ is generally a smooth function of the rental share, $r_{ic,t}$, except at the tipping point , r^*_{ic}. Thus, our model will contain a smoothing function $s(r_{ic,t})$, a binary variable for whether the tract is over or under the respective city's tipping point, city fixed effects τ_c, and a vector of tract-level control variables dated at the beginning of the period $X_{ic,t-10}$:

$$\Delta HO_{ic,t} = s(r_{ic,t-10}) + \alpha_t * 1[r_{ic,t-10} > r^*_{c,t-10}] + \tau_c + X_{ic,t-10}\beta_t + \varepsilon_{c,t} \quad (2)$$

However, using the same sample to both estimate the tipping point and analyze the main regression could result in falsely rejecting the null hypothesis (that the tipping point has no effect on the change in the proportion of homeowners) too frequently (Hansen, 2000). We follow Card, Mas, Rothstein (2009) who use a randomly selected portion of the sample to estimate the change point and the remaining sample used in the empirical specification which includes the change point. We will use a randomly selected 2/3 of tracts in each

[9] In these calculations, we restrict our attention to single family homes. While there is evidence that the presence of multi-unit structures has an effect on neighboring property values (Song and Knapp (2004)) this may have more to do with density and the putative unsightliness of larger structures than with owning vs renting as such. Moreover, decisions about the spatial distribution of multifamily structures and their tenure status are almost always made by zoning boards or investor-owners rather than their inhabitants. See also Coulson and Fisher (2016)

city to estimate the tipping point via equation (1) and then use the remaining 1/3 of each city's sample to estimate equation (2) above.

Section 3: The Data

Our data comes from the Neighborhood Change Database (NCDB) a product of Geolytics, a private marketer of demographic data.[10] The NCDB provides tract level data from the 1970, 1980, 1990, 2000 and 2010 censuses, all of which recalibrated to correspond to 2010 census tract boundaries, mapped to the current 2010 census tracts by Geolytics[11]. We observe four transitional periods starting in each of the following base years – 1970, 1980, 1990, and 2000 – and going forward for one census period (10 years). Within each transitional period analysis, we observe tract level data sorted into panels by city. Our cities are defined by the 2009 metropolitan statistical areas (MSAs) from the U.S. Census Bureau.[12]

We restrict the tracts in our sample using the following conditions: (1) We remove tracts in which the total number of single-family households is less than 50, because these tracts are often the byproduct of imperfect cross-census tract mapping and tend to become outlier observations. (2) We drop MSA's with less than or equal to 100 qualifying tracts as too few tracts will not provide an accurate estimation of the candidate tipping point.

In the estimation of equation (2), the tract-level variables used as conditioning variables include: the number of owner-occupied units, rental units, vacant properties, average household income, the local unemployment rate, and the proportion of old homes per tract - as defined by homes older than 30 years. The homeowner, rental, and vacant property counts are observed for all properties as well as subcategories of property, such as single unit properties only.

Table 1 provides relevant summary statistics. [MORE]

Section 4: Results

Candidate Tipping Points

First we present the results of our tipping point identification. We estimate (1) for each decade and MSA in the data, sequentially inserting values of r* for all percentages between 0 and 60 at 1 percentage point increments. As an illustration of the outcome for this procedure, Figure 4 presents data for the 2000-2010 censuses for Columbus, OH. To reiterate, the dependent variable, on the vertical axis, is the change (from

[10] www.geolytics.com. Aside from Card, Mas and Rothstein the NCDB has been broadly used in research on neighborhood change. See e.g. Ellen, Horn and O'Regan (2012); Guerreri, Hartley and Hurst (2012) among others.

[11] The 2010 census data collocation process was separated into two projects: the 2010 census retained some of the original survey questions and some former census questions were transferred to the American Community Surveys collection from 2006-2010. Both surveys were sorted into tract level data and referred to as 2010 data below even if the data is not entirely from the 2010 Census.

[12] Our list of MSAs comes from the U.S. Census Bureau with MSAs defined by the Office of Management and Budget, 2009. See http://www.census.gov/population/metro/files/lists/2009/List4.txt for more information.

2000 to 2010) in the percentage of occupied units that are owner-occupied as a function of the initial (i.e. 2000 census) rental percentage in the tract. The candidate tipping point is represented by the vertical line at 12%, the maximum likelihood estimate for that year and MSA. The data are also plotted, along with (for illustrative purposes) a nonparametric fit of the data, allowing for the structural change. As can be seen, there is a substantial break in the function at the tipping point. Before the break, when the rental percentage was less than 12%, owner occupation, if anything, increased with rental percentage. Beyond that point, owner percentage drops dramatically, becoming negative. The evidence for tenure tipping in Columbus is fairly clear.

Equally clear is the evidence for Detroit (in the same decade). Figure 5 presents evidence similar to that of Figure 4.. The major difference for Detroit is that the nonparametric fit of the data only exceeds zero by a relatively small amount before the break, despite the existence of some tracts that have very large increases in ownership percentages. After the break the nonparametric function is well below zero, indicating, again, a kind of self-accelerating turnover process.

Summary statistics for tipping points across all MSAs, stratified by region and decade, are available in Tables 2 and 3. As more MSAs are added to the census distribution list and more qualifying census tracts became available, a greater number of cities could be included in our sample: starting with 92 cities in base year 1970 up to 112 cities in the latter two decades. The mean candidate tipping points across all cities for each decade are presented in Table 2. The main conclusion from Table 2 is that the candidate tipping points decline over time. Between 1970 and 2000 the average tipping point across all areas studied fell from 19% to 13%, with the most dramatic decrease coming in the new century as homeowners are more rapidly being replaced with renters. This is in stark contrast to the results of CMR, who find higher values of tipping points in later decades. One might interpret this pair of results as saying that racial tolerance in neighborhoods has increased over time, while tolerance for renters has declined. Recall, however, that these are merely candidate tipping points. We have not yet tested the hypothesis that the rate of ownership change is statistically different above and below that point.

Table 3 disaggregates the results of Table 2 by Census division. Here we concentrate on the last two columns, given the dramatic drop in tipping points observed in Table 2. Northeastern cities, where housing density and housing age are relatively higher, consistently have the highest tipping points throughout all four decades but especially so in the last two decades. Higher sensitivity to renters is indicated in the other regions, with average tipping points ranging from a low of 4.2% in the East South Central, to 14.9% in the South Atlantic.

We turn now to estimates of equation (2), which takes the tipping point as given from the estimates of equation (1) and adds covariates in order to examine the determinants of neighborhood change. These estimates use the remaining 1/3 of the sample after the 2/3 of the sample used for estimating the tipping point were discarded. The unit of observation is again, a census tract, but in this estimate we assume that the parameters are constant across metro areas—the entire national sample is used. As before the dependent variable is the percentage change in owner-occupation. Each model includes MSA fixed effects, as well as a quartic polynomial in the deviation of the tract's renting household percentage from the candidate tipping point. Following the analysis of Bond and Coulson (1990) we include a measure of the age distribution-- the proportion of homes that are greater than 30 years old in the base year, as these are, other things equal, the lowest quality homes and therefore at the greatest risk of transition, Several other control variables (specifically, the percentage of properties that are vacant, mean family income, proportion of the population at or below the poverty line, the tract unemployment rate, and the percentage of households that designate themselves white) are included as well.

Tables 4 through 7 display the estimation results for each census decade in our data set. In each case we present a sequence of models with an increasing number of covariates. In the first specification we include only the structural break and the renter polynomial. In the second we add our housing vintage distribution variable, the percentage of structures over 30 years of age. In the third specification we add the remaining tract variables from Table 1. In each specification, MSA fixed effects are included. We first discuss the impact of these background variables, because there is a great deal of similarity in their impact across the decades

Most evidently, our measure of housing vintage consistently has a substantial impact that generally increases across the decades. A one percentage point increase in the initial over-30 percentage in the housing stock reduces rate of change in ownership by about .33 to point .38 percentage points in the first two decades. This effect increases to nearly .6 percent decrease in the latter two time periods. This result confirms one part of the theory model in Section 2 that indicates that reductions housing quality (as measured by vintage) have a deleterious effect on homeownership, and that ownership choices become more sensitive to housing quality after 1990.

We use three measures of household resources: tract unemployment rate, log average income, and the tract poverty rate. The coefficients of these variables generally have the expected signs (negative for unemployment and poverty rate, positive for income) although the unemployment rate carries a positive coefficient in the latter two decades, which is something of a puzzle, especially in the 1990s where the effect is somewhat large and statistically significant. Income is always positive and the effect is statistically significant in each decade. The poverty rate also always has the expected negative sign, and the t-stat is at least marginally significant although note that its coefficient more or less decreases across the decades.

The initial vacancy rate has a substantial negative impact, with an effect that is rather precisely estimated in each decade and is consistently greater than one. That is, a one percentage point increase in the tract vacancy rate accelerates the turnover from owning to renting by more than one percent. Note, though that here too, the effect generally declines over the decades. Finally, the impact of ethnic composition as measured by the initial percentage of tract population that is white is, as might be expected, positive, but does not reach conventional levels of statistical precision, is never very large, and also decreases over the decades. Note that this does not contradict the results of Card, Mas and Rothstein (2009) that influx of black households causes an acceleration of the exit of white households. Our result merely implies that white owner occupiers are, other things equal, largely replaced with nonwhite homeowners in the latter decades of the sample, a result that corresponds both with the increased opportunities of nonwhite households to obtain ownership in those decades, and with Card, Mas and Rothstein's result that racial tipping has decreased in more recent time periods. As has been repeatedly noted, by the 2000s the effect of all of these background variables has been substantially reduced, compared to their effects in the 1970s and 1980s.

We turn now to the effect of initial renter percentage, about which the same cannot be said. Recall that the leading term in the regression is a binary variable that equals one for initial rental percentage greater than that estimated as the MSA's potential breakpoint. A large negative coefficient indicates the presence of tenure tipping—that is, a large decline in the ownership rate at the tipping point. This is not the case for the 1970s, where the coefficient is, in fact, positive, although very small and statistically insignificant. This is the case for all three of the model specifications in Table 4. In the 1980s the coefficient of the tipping point is, by the time all of the covariates are added to the model, is effectively zero. No tenure tipping occurs in these time periods. As can be inferred from above, other neighborhood characteristics seem more important.

This changes in the 1990s. The coefficient of the tipping point indicator is now negative and precisely measured. An initial renter percentage greater than that of the MSA tipping point increases the decline in owner percentage by 0.12 percentage points. The effect at the tipping point increases to .2 percentage points in the 2000s. So, while tenure tipping does not appear to be an important component of neighborhood change prior to 1990, it vastly increases in importance during and after that decade, while (as noted) the importance of other factors seems to notably decline. Note again the comparison to Card, Mas and Rothstein's results. Racial tipping in more recent decades has evidently been replaced by tenure tipping.

To further investigate the reaction of tract ownership change in response to initial rental percentage we plot in Figure 6 the polynomial response functions for each of the decades, both above and below an assumed breakpoint of 15%. Working backwards in time, note that in the 2000s the tipping phenomenon dominates the negative reaction of homeownership to initial rental penetration dropping to -20% when the neighborhood tips. Elsewhere, this response function is relatively flat and even positively sloped up to an initial rental occupancy rate of 60% given the positive coefficient on the linear term. The other three polynomials reach their greatest acceleration of neighborhood change at approximately the same rental rate of 60% but as noted, only in the 1990s does this occur with tipping. For the 1970s and 1980s the ownership rate change reaches or exceeds (in magnitude) that which occurs in the 1990s and 2000s, but does so gradually, without exhibiting any sudden change.

5. Conclusions

As discussed in the introduction, there is substantial evidence that homeowners bring value to neighborhoods. For this reason, there is concern from policymakers that neighborhoods may lose some appeal if homes in the area are occupied by renters. In light of the increased use of single-family homes for rental purposes, often by remotely-located landlords, this concern has become more salient.

In this paper, we have investigated tenure tipping, a potential phenomenon wherein a sufficient penetration of single-family rental properties into a neighborhood causes a rapid increase in that turnover rate. We propose a theoretical model based on Bond and Coulson (1989) in which increased renter percentage causes changes in the subsequent ownership rate, but that this change can be gradual or sudden, depending on both the relative preferences for neighborhood and housing quality, and the stock of housing quality in the neighborhood.

We find that the best estimate of tipping points decreased over the decades, indicating an increased sensitivity of the ownership decision to initial renter penetration. This increased sensitivity is reinforced in the empirical models of ownership change. Tenure tipping basically does not seem to exist in the 1970s and 1980s—other neighborhood factors seem to have greater importance—but after 1990 tenure tipping does seem to form an important part of the change in tract ownership rates.

References

Becker, Gary Stanley, and Kevin M. Murphy. Social economics: Market behavior in a social environment. Harvard University Press, 2009.

Bond, E. W., & Coulson, N. E. (1989). Externalities, filtering, and neighborhood change. Journal of Urban Economics, 26(2), 231-249.

Card, D., Mas, A., & Rothstein, J. (2006). Tipping and the Dynamics of Segregation. working paper

Card, D., Mas, A., & Rothstein, J. (2008). Tipping and the Dynamics of Segregation. The Quarterly Journal of Economics, 177-218.

Carroll, Matt (2014). State College secures $5 million to turn rental properties into owner-occupied homes near campus, Centre Daily Times, April 7

Coulson, N. E., & Li, H. (2013). Measuring the external benefits of homeownership. Journal of Urban Economics, 77, 57-67.

Coulson, N. E., & Leichenko, R. M. (2004). Historic preservation and neighbourhood change. Urban Studies, 41(8), 1587-1600.

Dewan, Shaila (2013) As Renters Move in, Some Homeowners Fret, New York Times, August 29, B1

Dietz, R. D., & Haurin, D. R. (2003). The social and private micro-level consequences of homeownership. Journal of Urban Economics, 54(3), 401-450.

DiPasquale, D., & Glaeser, E. L. (1999). Incentives and social capital: are homeowners better citizens?. Journal of Urban Economics, 45(2), 354-384.

Ellen, Ingrid Gould, Keren Horn, and Katherine O'Regan. "Pathways to integration: Examining changes in the prevalence of racially integrated neighborhoods." Cityscape (2012): 33-53.

Guerrieri, V., Hartley, D., & Hurst, E. (2012). Within-city variation in urban decline: The case of Detroit. The American Economic Review, 102(3), 120-126.

Hanson, Andrew. "Size of home, homeownership, and the mortgage interest deduction." Journal of Housing Economics 21.3 (2012): 195-210.

Lowry, I. S. (1960). Filtering and housing standards: A conceptual analysis. Land Economics, 36(4), 362-370.

Mills, J., Molloy, R., & Zarutskie, R. (2015). Large-Scale Buy-to-Rent Investors in the Single-Family Housing Market: The Emergence of a New Asset Class?. Federal Reserve Board working paper

Miyao, T. (1978). Dynamic instability of a mixed city in the presence of neighborhood externalities. The American Economic Review, *68*(3), 454-463.

O'flaherty, B. (1996). Making room: The economics of homelessness. Harvard University Press.

O'Sullivan, A. (2009). Schelling' s model revisited: Residential sorting with competitive bidding for land. *Regional Science and Urban Economics*, *39*(4), 397-408.

Pindell, N. (2009). Home Sweet Home? The Efficacy of Rental Restrictions to Promote Neighborhood Stability. *St. Louis University Public Law Review*,*29*, 41.

Schelling, T. C. (1971). Dynamic models of segregation†. Journal of mathematical sociology, 1(2), 143-186.

Schmit, J. (2012). Home rentals — the new American Dream? USA Today, June 6

Schnure, C. (2014). Single Family Rentals: Demographic, Structural and Financial Forces Driving the New Business Model. Structural and Financial Forces Driving the New Business Model (March 31, 2014).

Sethi, Rajiv, and Rohini Somanathan. (2004) "Inequality and segregation." Journal of Political Economy 112 1296-1321.

Song, Y., & Knaap, G. J. (2004). Measuring the effects of mixed land uses on housing values. *Regional Science and Urban Economics*, *34*(6), 663-680.

Zhang, J. (2011). Tipping and Residential Segregation: A Unified Schelling Model*. Journal of Regional Science, 51(1), 167-193.

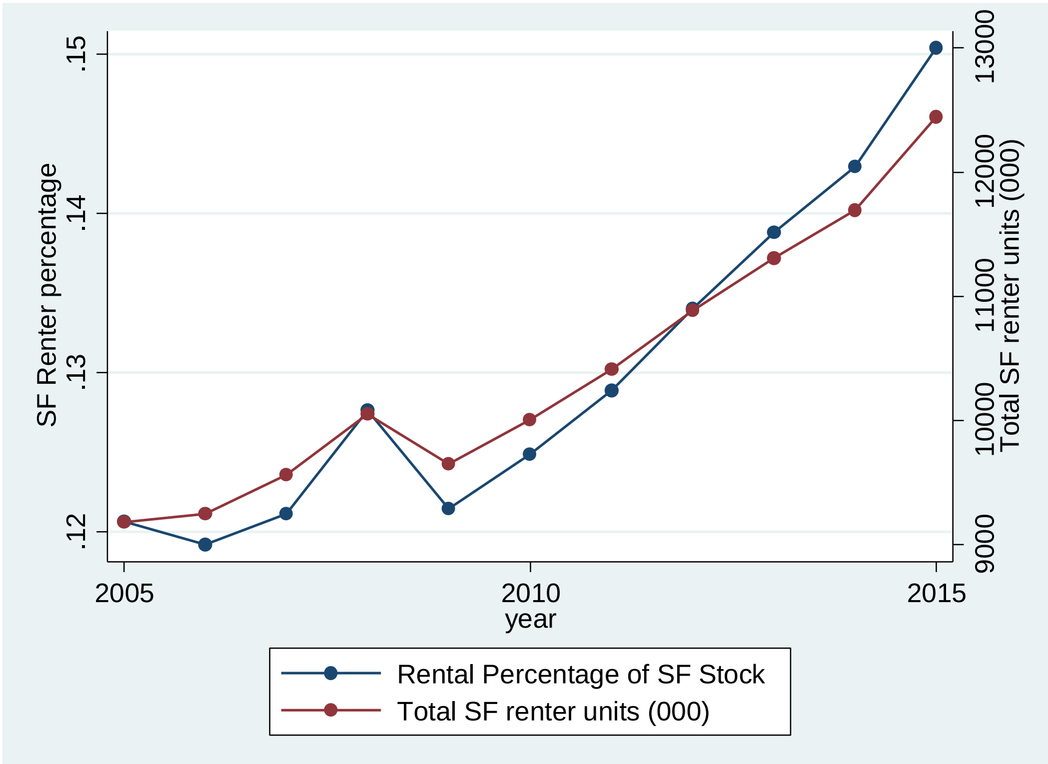


Figure 1: ACS estimates of total single family rental units, and percentage of single family housing stock.

Figure 1: Bid Functions

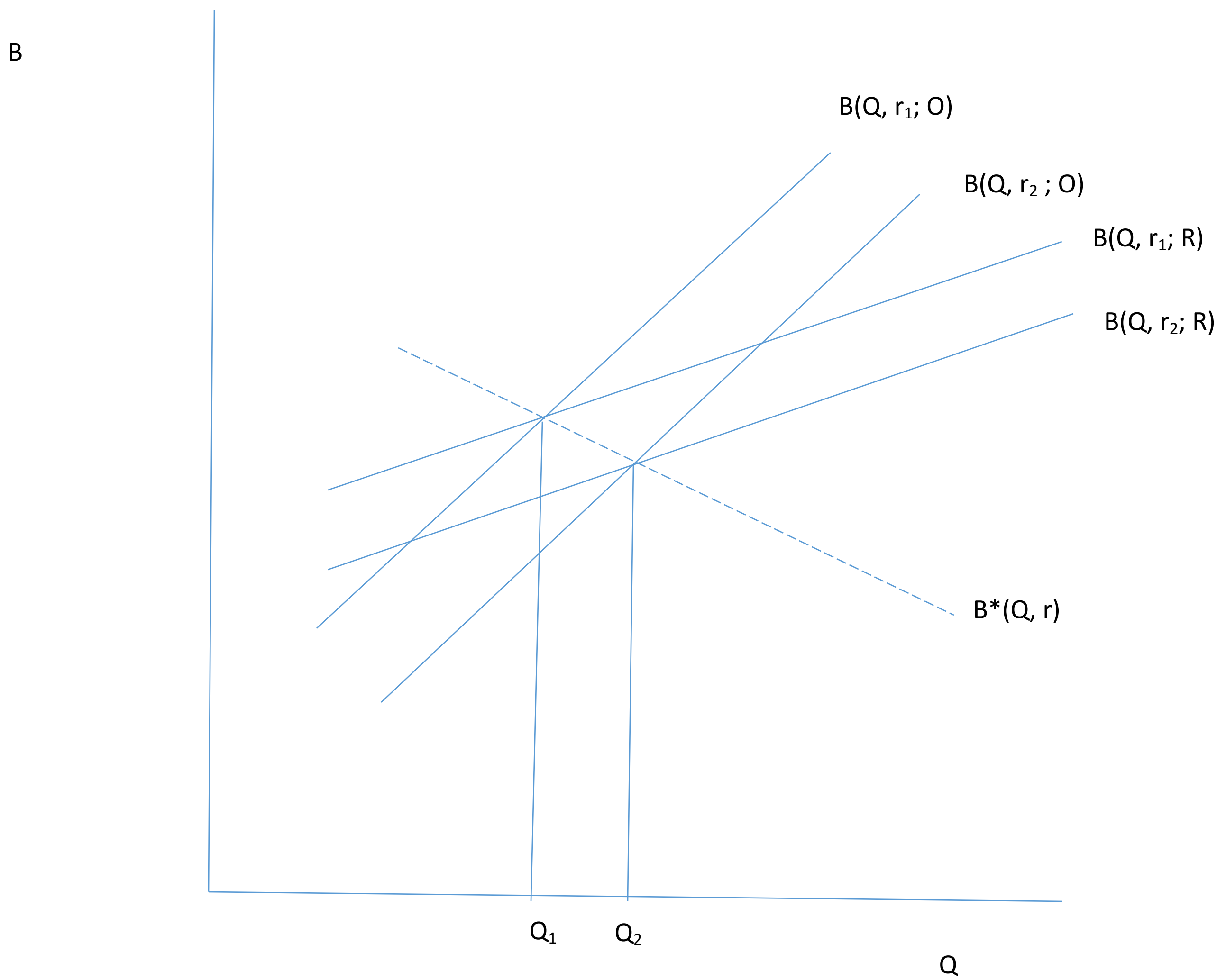


Figure 2: Neighborhood Equilibrium: Mixed Neighborhood is Stable

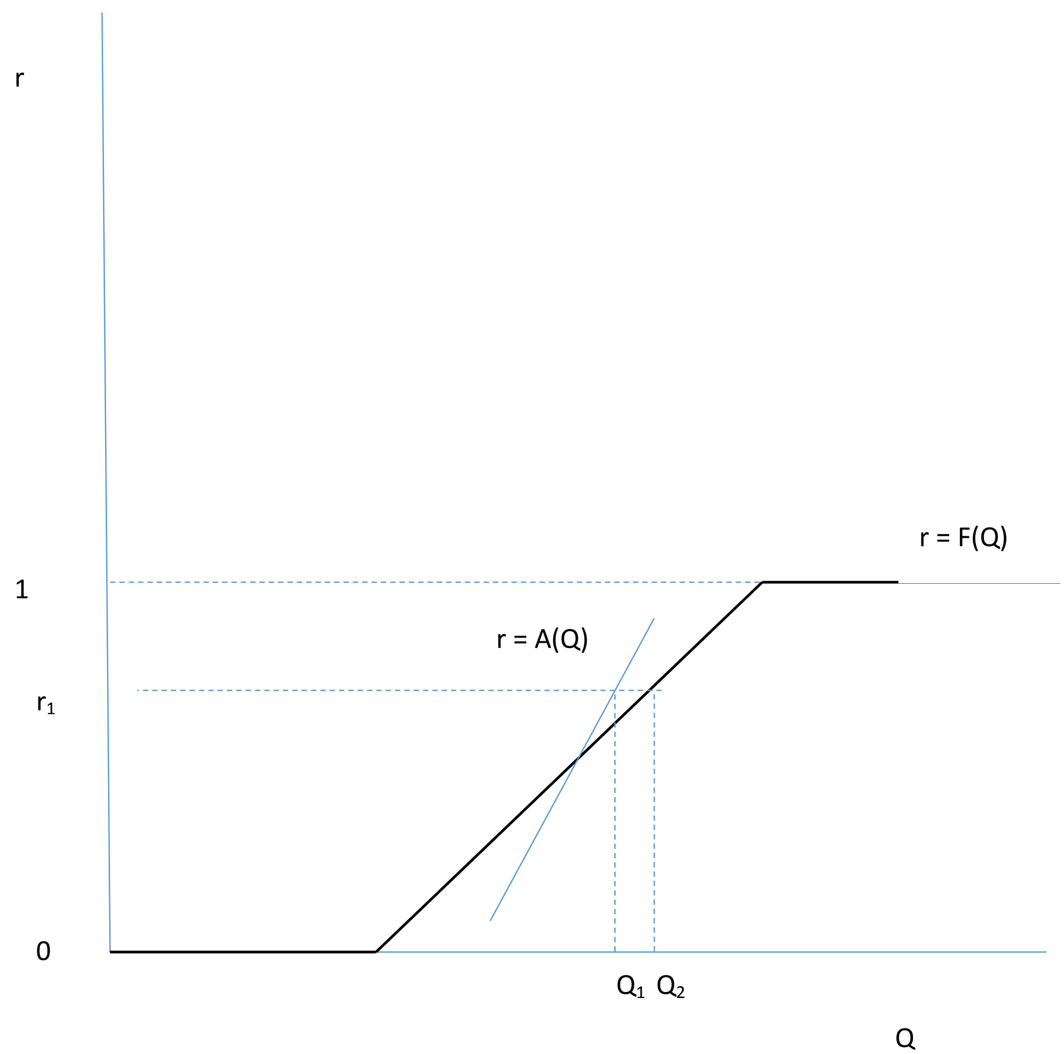


Figure 3: Neighborhood Equilibrium: Mixed Neighborhood is Unstable

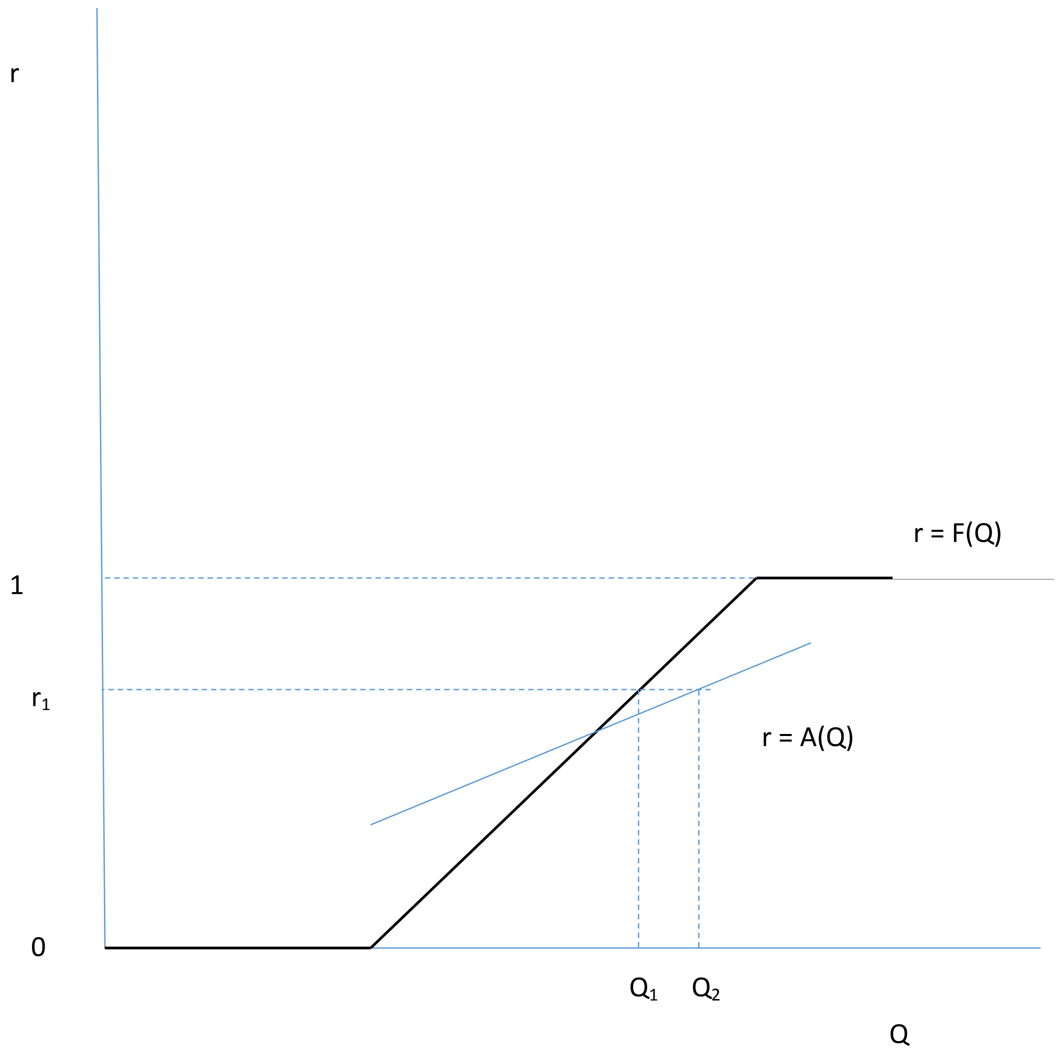
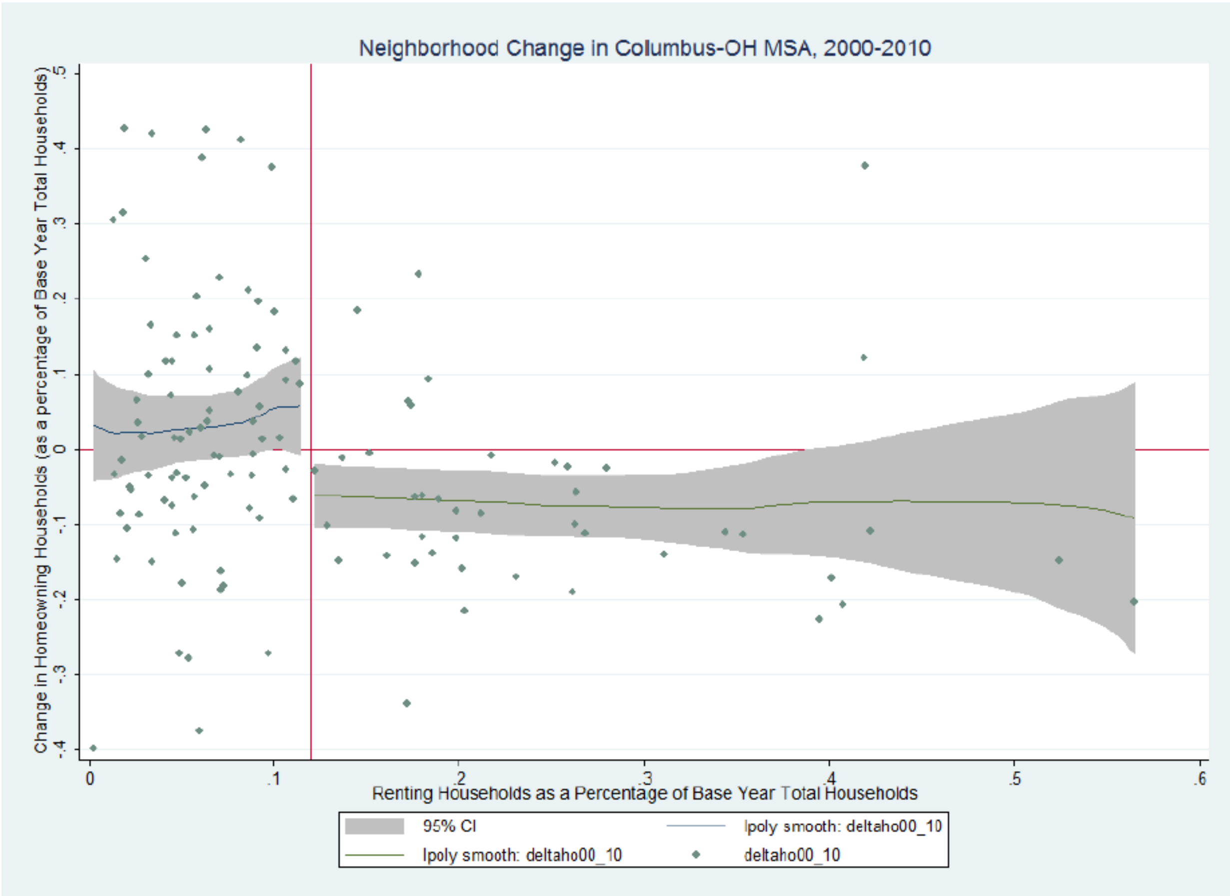
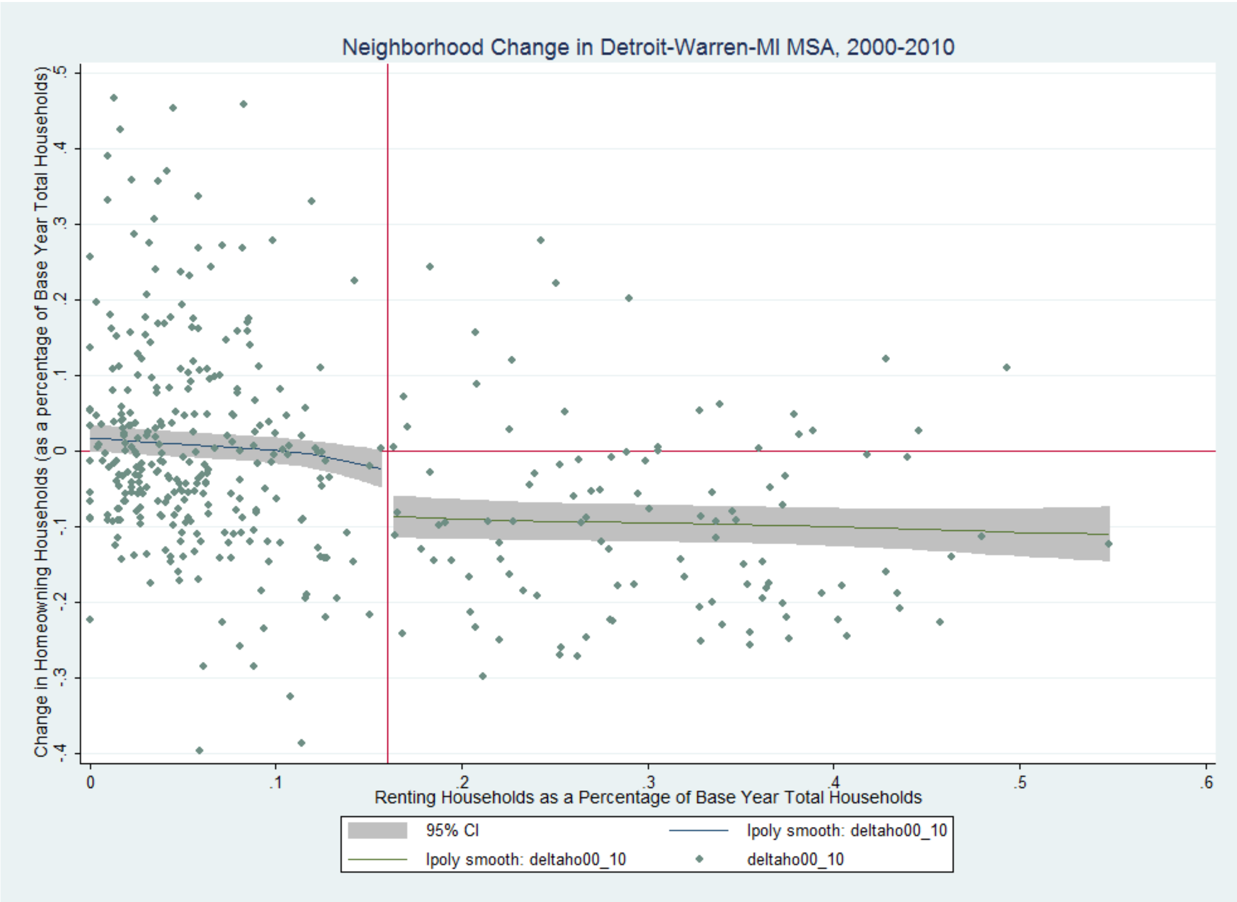


Figure 4: Columbus-OH Neighborhood Change



Neighborhood Change: Each point represents the change in homeowner units between 2000 and 2010 as a percentage of the total tract number of housing units. The vertical line represents the tipping point found via estimation procedures in Section II. The partitioned trend lines are created using local polynomial smoothing with a kernel density function, surrounded by a 95% confidence interval band.

Figure 5: Detroit Neighborhood Change



Neighborhood Change: Each point represents the change in homeowner units between 2000 and 2010 as a percentage of the total tract number of housing units. The vertical line represents the tipping point found via estimation procedures in Section II. The partitioned trend lines are created using local polynomial smoothing with a kernel density function, surrounded by a 95% confidence interval band.

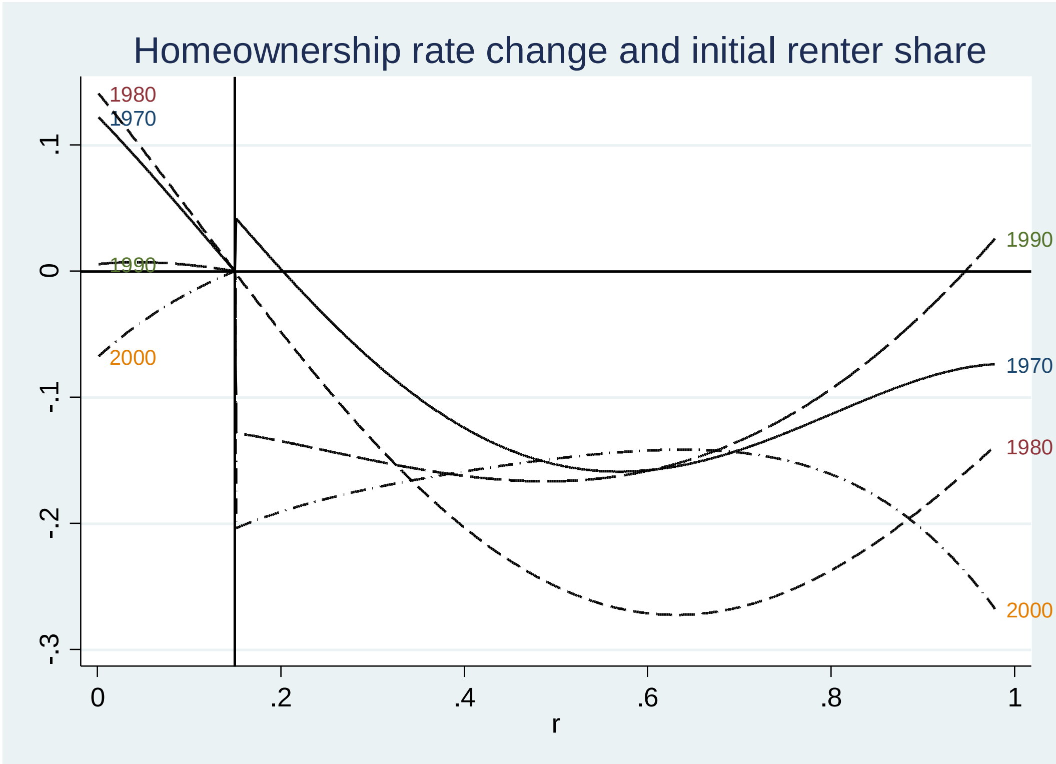


Figure 6: Plots, for each decade the change in tract ownership rates as a function of initial renter rate, assuming the breakpoint occurs at a 15% rental occupancy rate.

	2011 Status		
2009 Status	own	rent	vacant
own	24,789	1,195	1,613
rent	816	3,657	725
vacant	1,285	899	2,897

Table 1: Counts of vacant, rental and owner single family units from matched pairs in the 2009 and 2011 American Housing Survey.

Table 1—Means and Standard Deviations

	1970		1980		1990		2000		2010	
Variable, Average by Tract	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Rental rate	17.11	13.77	13.73	11.64	14.51	11.94	14.48	12.95	15.74	15.01
old home	30.62	29.45	29.84	27.43	39.32	29.73	49.78	31.23		
Unemployment rate	4.19	2.55	6.07	3.94	6.23	4.61	5.84	4.85		
Log average hh income	9.290	0.325	9.921	0.698	10.585	0.408	10.950	0.410		
Poverty rate	9.74	8.69	9.94	9.05	10.99	10.97	11.30	10.48		
Occupied	95.97	5.44	95.17	5.28	94.57	6.53	95.26	6.20		
White	89.98	21.58	84.02	23.94	79.48	25.47	73.42	26.60		

The table provides means and standard deviations of key variables from the regression model of equation (2)

Table 2

Mean Tipping Points				
	1970s	1980s	1990s	2000s
Mean	19.1	17.8	17.0	13.1
S.D.	17.7	14.8	17.0	9.7
Number of MSAs	92	106	112	112

Table 3

Mean Tipping Points, by Region				
	1970s	1980s	1990s	2000s
New England	16.5	17.31	25.81	20.69
Middle Atlantic	26.11	22.90	21.15	16.35
West South Central	15.35	21.25	18.29	13.97
East South Central	19.25	7.2	20.90	4.20
South Atlantic	22.58	16.67	15.40	14.88
West North Central	20.00	9.50	10.92	11.83
East North Central	11.82	11.50	10.86	11.18
Mountain	11.63	17.06	17.30	8.50
Pacific	25.96	18.04	17.36	10.64

Table 4

Model estimates: 1970s

	ΔH (70-80)	ΔH (70-80)	ΔH (70-80)
D(r>r*)	0.050 (0.74)	0.062 (0.88)	0.043 (0.67)
(r-r*)	-1.658 (4.72)**	-1.128 (3.25)**	-0.839 (2.30)*
$(r-r^*)^2$	-0.104 (0.17)	-0.028 (0.05)	0.247 (0.40)
$(r-r^*)^3$	2.643 (3.00)**	2.735 (2.81)**	2.193 (2.70)**
$(r-r^*)^4$	-1.177 (0.82)	-1.978 (1.30)	-1.779 (1.31)
Age>30		-0.490 (8.08)**	-0.331 (4.92)**
Unemployment rate			-1.248 (1.15)
Log average household income			0.101 (1.10)
Poverty rate			-1.155 (2.48)*
Percent vacant			-6.404 (3.12)**
Percent white			0.136 (1.74)
Intercept	0.401 (7.44)**	0.571 (12.01)**	5.768 (2.51)*
R^2	0.02	0.03	0.11
N	12,256	12,256	12,256

Notes: The table entries are coefficient estimates and standard deviations for the regression of the change (1970-1980) in tract homeownership percentage as a function of the indicated variables. The independent variables are all dated 1970.

Table 5

Model estimates: 1980s

	ΔH (80-90)	ΔH (80-90)	ΔH (80-90)
D(r>r*)	-0.050 (1.45)	-0.024 (0.71)	-0.001 (0.04)
(r-r*)	-1.376 (4.65)**	-0.832 (3.23)**	-0.955 (3.43)**
$(r-r^*)^2$	-0.324 ((0.63)	-0.399 (0.93)	0.223 (0.47)
$(r-r^*)^3$	1.763 (2.89)**	1.690 (3.00)**	1.704 (2.84)**
$(r-r^*)^4$	0.163 (0.17)	-0.290 (0.35)	-0.995 (1.09)
Age>30		-0.477 (12.06)**	-0.379 (8.61)**
Unemployment rate			-0.378 (1.01)
Log average household income			0.026 (3.04)**
Poverty rate			-0.732 (5.14)**
Percent vacant			-5.144 (5.47)**
Percent white			0.060 (1.25)
Intercept	0.219 (6.00)**	0.392 (13.72)**	4.997 (5.63)**
R^2	0.03	0.05	0.15
N	13,815	13,815	13,444

Notes: The table entries are coefficient estimates and standard deviations for the regression of the change (1980-1990) in tract homeownership percentage as a function of the indicated variables. The independent variables are all dated 1980.

Table 6

Model estimates: 1990s

	ΔH (90-00)	ΔH (90-00)	ΔH (90-00)
D(r>r*)	-0.186 (3.43)**	-0.145 (2.96)**	-0.128 (2.81)**
(r-r*)	-1.167 (2.22)*	-0.501 (1.32)	-0.120 (0.34)
$(r-r^*)^2$	-0.287 (0.34)	-.401 (0.66)	-0.353 (0.61)
$(r-r^*)^3$	1.788 (1.10)	1.434 (1.12)	1.251 (1.10)
$(r-r^*)^4$	0.222 (0.09)	-0.115 (0.07)	-0.459 (0.29)
Age>30		-0.702 (13.07)**	-0.596 (11.89)**
Unemployment rate			1.140 (2.42)*
Log average household income			0.306 (3.81)**
Poverty rate			-0.401 (1.54)
Percent vacant			-2.097 (3.22)**
Percent white			0.060 (0.94)
Intercept	0.393 (7.71)**	0.684 (16.52)**	-0.677 (1.00)
R^2	0.02	0.04	0.06
N	14,569	14,569	14,569

Notes: The table entries are coefficient estimates and standard deviations for the regression of the change (1990-2000) in tract homeownership percentage as a function of the indicated variables. The independent variables are all dated 1990.

Table 7

Model estimates: 2000s

	ΔH (00-10)	ΔH (00-10)	ΔH (00-10)
D(r>r*)	-0.273 (4.28)**	-0.233 (3.75)**	-0.204 (3.41)**
(r-r*)	-0.557 (1.71)	0.243 (1.10)	0.299 (0.88)
$(r-r^*)^2$	-0.398 (0.97)	-1.026 (2.79)**	-0.776 (1.90)
$(r-r^*)^3$	2.256 (1.67)	1.371 (1.54)	1.562 (1.67)
$(r-r^*)^4$	-1.655 (1.03)	-0.798 (0.71)	-1.415 (1.11)
Age>30		-0.633 (10.77)**	-0.585 (9.36)**
Unemployment rate			0.389 (1.22)
Log average household income			0.153 (2.55)**
Poverty rate			-0.437 (1.90)
Percent vacant			-2.374 (3.06)**
Percent white			0.021 (0.34)
Intercept	0.426 (12.30)**	0.736 (14.26)**	1.288 (1.18)
R^2	0.01	0.02	0.03
N	14,922	14,922	14,922

Notes: The table entries are coefficient estimates and standard deviations for the regression of the change (2000-2010) in tract homeownership percentage as a function of the indicated variables. The independent variables are all dated 2000.

	owner11	
owner09	0	1
0	2,176	460
1	742	18,048