Price and Prejudice: The Interaction between Preferences and Incentives in the Dynamics of Racial Segregation*

David Dorn†

JOB MARKET PAPER
November 10, 2008

Abstract

In the classic Schelling tipping model, white residents flee a neighborhood when the minority resident share exceeds a personal tolerance threshold. Thus, a small movement in minority share beyond a tipping point can cause an integrated neighborhood to segregate rapidly. A key limitation of the Schelling model is that it does not consider the role of expectations and prices in the tipping process. This paper explores an augmented tipping model in which white and minority renters and homeowners interact both spatially (sharing a neighborhood) and financially through rents and house prices. I show that the market mechanism can exacerbate the tipping process: homeowners face a pecuniary incentive to sell their houses prior to neighborhood tipping to avoid a loss in house value, whereas renters are less exposed to tipping because they bear no such asset risk. Hence, high rates of homeownership among white residents make neighborhoods more likely to tip. Building on recent work by Card, Mas, and Rothstein, this study evaluates this prediction by analyzing the interaction between initial homeownership rates and neighborhood tipping between 1970 and 2000 across a large sample of Metropolitan Statistical Areas (MSAs). The results show that when neighborhoods tip, those with high ownership rates experience substantially larger white population loss and a larger decline in house prices. In addition, homeowners are disproportionately likely to exit a neighborhood when tipping occurs, and income and education levels fall, in particular among whites. These findings provide initial evidence that tipping, usually considered a nonmarket interaction, is augmented by market forces.

*I am grateful to David Autor for helpful discussions and advice. I thank Daron Acemoglu, Joshua Angrist, Abhijit Banerjee, David Card, Kerwin Charles, Seda Ertac, Brigham Frandsen, Michael Greenstone, Gordon Hanson, Kevin Lang, Alexandre Mas, Konrad Menzel, Manuel Oechslin, Jesse Rothstein, Albert Saiz, William Wheaton and Maisy Wong for valuable suggestions or assistance with data. I also benefited from comments from participants at MIT Labor Lunches, the MIT Labor and Public Finance Seminar, and the BU Empirical Micro Workshop.

†Economics Department, Boston University, 270 Bay State Road, Boston MA 02215. E-mail: ddorn@bu.edu

1 Introduction

Racial segregation is a salient feature of urban neighborhoods in the United States. A high degree of racial segregation in a city is associated with worse outcomes for young blacks such as lower education, income, and employment (e.g., Cutler and Glaeser, 1997; Ananat, 2007). A frequently suggested cause of segregation is the racial preference of whites for living among white neighbors. In a seminal paper, Schelling (1971) demonstrates that substantial segregation can result even from weak racial prejudice. After the white residents with lowest tolerance for minorities leave a neighborhood, the minority share increases and induces the departure of less prejudiced whites, thereby causing a sequence of white flight.

The dynamic of neighborhood tipping may also be influenced by the interplay of two features absent from the Schelling model: prices and expectations. The tipping process can depress house values in a neighborhood when the willingness of whites to pay for housing falls in response to an increasing minority share. As a result, forward-looking homeowners may not only want to move out of a neighborhood because of an expected increase in minority population but also, and perhaps as important, to avoid an associated decrease in house values.

This paper proposes an augmented tipping model in which white and minority renters and homeowners interact spatially, through the neighborhood minority share, and financially, through house prices and rents. Whites' utility falls when the neighborhood minority share becomes large and the reduced demand of whites for housing translates into lower house prices and rents. When current neighborhood residents can more accurately predict the probability of a shock that will raise the minority share and lower prices, incumbent homeowners, on receiving a signal that the shock probability is high, have a financial incentive to sell their houses to outside buyers. In contrast, white renters face only the risk of an increasing minority share — not the additional asset value risk — and hence may prefer to stay in the neighborhood rather than incurring a moving cost for departing. Accordingly, the model predicts that the decline of the white population in tipping neighborhoods will be more pronounced when neighborhoods have a large homeownership rate.

Such financial incentives for homeowners to depart from tipping neighborhoods can have important consequences for neighborhood socioeconomic composition. In the Schelling model, the order of whites' departure from a tipping neighborhood is determined solely by individual levels of racial prejudice, which several surveys show is most pronounced among whites with low educational attainment and income (Farley, Fielding and Krysan, 1997; Charles and Guryan, 2008). Thus, the departure of whites with the lowest minority tolerance could increase the income and educational levels of tipping neighborhoods.[1] If, however, homeowners leave ahead of renters, average wealth and educational attainment will fall because homeowners tend to be wealthier and better educated than renters.

Building on recent work by Card, Mas and Rothstein (2008a), the empirical analysis tests

[1] Bayer, Fang and McMillan (2005) document the existence of neighborhoods that have mostly black residents together with very high shares of college graduates.

these predictions using 1970-2000 data from a large panel of urban neighborhoods (census tracts) covering over 100 Metropolitan Statistical Areas (MSAs). It uses regression discontinuity models to assess whether the magnitude of discontinuous changes in neighborhood composition at empirically estimated minority share tipping points varies with the neighborhoods' initial homeownership rates. The results confirm that neighborhoods with high ownership rates experience substantially larger discontinuous drops in white population and larger declines in house values. The reduction in white population is primarily due to a fall in white homeownership and tipping neighborhoods experience a decrease in income and education levels. These findings support the proposition that pecuniary incentives for homeowners may exacerbate the tipping process.

The analysis also considers several alternative explanations for strong tipping effects in neighborhoods with high ownership rates. Even when the relatively wealthier homeowners are not more prejudiced than renters, they may be more inclined to leave a tipping neighborhood because they can better afford to relocate. Additionally, owners are more likely to have children and parents may be particularly concerned about changes in neighborhood composition and public goods that could affect their offspring. Finally, white residents who are sensitive to an increase in minority population may be concentrated in certain geographic areas of cities that have larger homeownership rates, such as suburbs. However, robustness tests show that none of these variations in population composition or neighborhood location can explain the larger tipping effects in owner-dominated neighborhoods.

The paper is organized as follows. Section 2 reviews related literature on neighborhood segregation and tipping. Section 3 outlines a theoretical model of neighborhood tipping that shows different moving incentives for homeowners and renters when neighborhood residents anticipate a possible increase of minority population. Section 4 describes the data and econometric approach for the empirical analysis, after which section 5 presents the regression discontinuity estimates for the changes in owner- and renter-occupied housing at empirical tipping points. Sections 6 and 7 then consider changes in white population and in house values, and section 8 presents results for income and education levels. Section 9 concludes the paper.

2 Related Literature

Urban neighborhoods in the United States are characterized by pronounced segregation between whites and blacks, and between natives and recent immigrant groups (Cutler, Glaeser and Vigdor, 1999, 2008). The correlation between such residential segregation and adverse economic outcomes for minorities has been long recognized (Kain, 1968). A large body of literature analyzes the causality of this relationship between neighborhood quality and economic outcomes; examples include work by Cutler and Glaeser (1997) and Ananat (2007) who exploit cross-city variation in segregation, and experimental studies such as Oreopoulos (2003), Jacob (2004) or Kling, Liebman and Katz (2007) which evaluate neighborhood relocation programs. While evidence from this

literature is mixed, the creation of racially and economically diverse urban neighborhoods has nonetheless become an important goal of urban public policy.

A different stream of the literature analyzes the determinants and dynamics of segregation at the neighborhood level. Influential work by Schelling (1969, 1971, 1978) proposes that even weak racial preferences can lead to strong residential segregation. In the Schelling model, all white residents have individual tolerance thresholds for the minority share in their neighborhoods, a preference structure that can lead to rapid segregation of a mixed-race neighborhood when the minority share increases beyond a critical tipping point. That is, once the minority share exceeds the threshold of the most prejudiced white, this person departs. As a consequence, the minority share increases further, and a cascade of white flight from the neighborhood begins that eventually leads to an all-minority equilibrium.

While the Schelling model does not integrate prices, many subsequent models derive tipping behavior in frameworks with explicit housing markets (e.g., Miyao, 1978, 1979; Coulson and Bond, 1990; Benabou, 1993; Becker and Murphy, 2000; Card, Mas and Rothstein, 2008a). For instance, the tipping model proposed by Card et al. (2008a) allows that house prices decline when a neighborhood tips and whites' demand for housing in the neighborhood declines: When a shock increases the minority share of a neighborhood, whites' valuation for houses falls and minority agents who were previously outbid can move into the neighborhood. However, in this and all the aforementioned models, neighborhood residents are myopic and fail to anticipate a possible change in house values. As in the Schelling model, the role of expectations in tipping dynamics is therefore not assessed.

However, a model by Frankel and Pauzner (2002) shows that tipping can occur even when agents have rational expectations. These authors analyze an initially white neighborhood that can tip to an all-black equilibrium when the neighborhood becomes more attractive for blacks because of either a deterministic upward trend in black valuation of the neighborhood or small stochastic shocks to that valuation. When whites expect the neighborhood to tip in the future and moving opportunities for whites occur at random times, white residents will leave before black valuation exceeds their own. Expectations of tipping can therefore be self-fulfilling and anticipate the timing of tipping. However, because their model assumes a large and homogeneous pool of potential neighborhood residents, house prices do not change discontinuously when a neighborhood tips. In contrast, the theoretical model developed here (see section 3) will combine forward-looking behavior of agents and falling house prices in the tipping process.

Only recently has large-scale empirical evidence on neighborhood tipping been available. Card et al. (2008a), who analyze the racial dynamics of neighborhoods based on a large panel of census tracts, show significant discontinuous declines in white neighborhood population at empirically estimated city-specific tipping points.[2] Their study also finds small but mostly insignificant declines

[2] A separate study by the same authors does not find evidence of a reverse tipping where a large number of minorities leave a neighborhood once the minority share falls below a tipping point (Card, Mas and Rothstein, 2008b).

in house values in tipping neighborhoods.[3] Related work by Saiz and Wachter (2006) provides evidence for a relative devaluation of houses in neighborhoods that experience inflows of immigrants. The empirical analysis conducted here will build on the empirical framework of Card et al. (2008a) to study the impact of neighborhood homeownership rates on tipping behavior.

Although, to the best of my knowledge, no previous theoretical or empirical literature examines the role of tenure structure in the dynamics of neighborhood tipping, several papers address the effect of homeownership on social capital or neighborhood amenities (e.g., Sampson, Raudenbush and Earls, 1997; DiPasquale and Glaeser, 1999; Hoff and Sen, 2005). This literature argues that homeownership is beneficial for neighborhoods because homeowners are more likely than renters to engage in community activities and contribute to neighborhood public goods. In contrast to renters, homeowners benefit not only from the consumption value of public goods but also from their capitalization in houses values. However, the same exposure of homeowners to changes in house prices can generate an incentive to leave a neighborhood when incumbent residents anticipate a possible increase in the neighborhood minority share that would depress house prices.

3 Theoretical Framework

The theoretical model proposed here emphasizes that identical expectations about the probability of future neighborhood tipping can translate into different behavior by homeowners and renters. Specifically, it predicts that among otherwise identical neighborhoods, those with a higher homeowner share will experience a larger discontinuous decrease in white population at a critical value of the minority share at which white owners start leaving the neighborhood.

The key observation underlying this theoretical model is that homeowners and home renters face differential incentives to flee a neighborhood at risk of tipping. This prediction is obtained from one period of transactions in a housing market in which neighborhood incumbents have an informational advantage over potential new residents. In particular, incumbents have more precise information about the probability of an exogenous shock that would raise the share of minority residents in the neighborhood. If the minority share exceeds a certain threshold, whites' taste for the neighborhood and house prices decrease. Thus, whereas both white homeowners and renters dislike a high minority share, homeowners are also affected by falling house prices. If neighborhood incumbents anticipate a high likelihood of a shock that would push the minority share over the critical threshold, white homeowners have an additional financial incentive to leave the neighborhood, whereas white renters may decide to stay to avoid a moving cost.

Overall, the model predicts that neighborhoods with high homeownership rates will experience particularly large reductions in white population and house prices once the minority share exceeds a critical tipping point. White owner-occupied housing falls relative to renter-occupied housing,

[3] Another analysis of the same data finds little evidence for tipping effects, partly because it does not allow for city-specific locations of tipping points (Easterly, 2005).

and the share of wealthy residents decreases because of a correlation between homeownership and wealth.

3.1 Neighborhood Structure and Agents

Consider a neighborhood with a fixed supply of N identical houses. There are five types of agents: whites and minorities, who can either have a high or low taste for the neighborhood, and investors. *Whites* and *minorities* can live in the neighborhood as home owners or renters. *Investors* own all rental houses. Investors are profit maximizers who live outside the neighborhood as absentee landlords; they do not affect neighborhood racial composition. All agents are risk-neutral and can own one house at most.

Figure 1 illustrates a possible neighborhood ownership and resident structure. A share r of all houses are owned by investors while the remaining $(1-r)$ houses are owned by white and minority owner-occupiers. The resident structure of the neighborhood is composed of white and minority homeowners and white and minority renters. The model will later allow for separate renter shares r_w and r_m for whites and minorities. The initial minority share of the neighborhood is denoted by m_0.

The model focusses on the moving decisions of agents during one period. If the racial composition of residents who leave the neighborhood differs from the racial makeup of new residents, the neighborhood minority share will change. At the end of the period, all homeowners receive the residual value of their houses. This residual value is equal to the discounted value of an infinite stream of the equilibrium rent that is to be expected from an additional round of housing market transactions in a hypothetical second period.

Two crucial differences between white and minority agents can give rise to neighborhood tipping with falling house prices. Fundamentally, racial segregation occurs because of white agents' preference for white neighbors. Hence, whites' monetary *utility* u_t^w from living in the neighborhood during one period is negative if the neighborhood minority share m_t exceeds the critical threshold $\bar{m} > m_0$.[4] An agent's utility also depends on personal tastes for the neighborhood. Hence, the consumption utility $u_t^{w_H}$ for whites with a high taste for the neighborhood is

$$u_t^{w_H} = \begin{cases} v_H & \text{if } m_t \leq \bar{m} \\ -v_H & \text{if } m_t > \bar{m} \end{cases} \tag{3.1}$$

Minority residents' utility u_t^m from living in the neighborhood also depends on their tastes but not on racial composition. The residential consumption utility $u_t^{w_H}$ for minorities with a high taste for the neighborhood is

$$u_t^{m_H} = v_H \quad \forall m_t \tag{3.2}$$

[4]The homogeneity in white tolerance of minority residents implies that the sequence of white agents' departure from the neighborhood in a case of white flight must be determined by a factor other than differences in prejudice.

The utility of agents with a low taste for the neighborhood (L-types) is smaller by a constant k than the utility of agents of the same race who have a high taste for the neighborhood (H-types):

$$u_t^{i_L} = u_t^{i_H} - k \quad \text{where } i = w, m \tag{3.3}$$

Because L-types have a strictly lower taste and willingness to pay for the neighborhood given the initial minority share $m_0 < \bar{m}$, the initial population consists entirely of white and minority H-types.

This preference structure implies that absent expectations, mixed-race neighborhoods will be stable for minority shares below $\bar{m}$, but whites will have an incentive to leave once the minority share increases beyond $\bar{m}$. However, when agents are forward looking and anticipate that the minority share can be affected by shocks, whites may start to leave a neighborhood at a critical minority share tipping point that is smaller than $\bar{m}$.

The second difference between whites and minorities is a limitation on the number of potential minority residents with a high taste for the neighborhood so that the neighborhood cannot fill with only H-type minorities:

$$n_{m_H} < N \tag{3.4}$$

In contrast, the numbers of H-type whites, L-type whites, L-type minorities, and investors are large and each exceed $2N$.

The distinction between agents with high and low taste for the neighborhood is important when vacancies in the neighborhood fill with new residents. As long as both H-type whites and H-type minorities among potential new residents have equal willingness to pay for housing, there are enough new residents with high taste to fill any number of vacancies in the neighborhood while L-types are outbid. However, when the neighborhood minority share exceeds $\bar{m}$ and whites are no longer willing to live there, the neighborhood can only fill when house prices and rents fall to the level that minority agents with low taste for the neighborhood are willing to pay.

3.2 Resident Turnover and Information

The model covers one period of transactions in the housing market. At the start of each period, a share λ of residents learn that they have to move because of exogenous individual reasons, such as an attractive job offer that makes moving a strictly dominating strategy over staying. The probability of these separations is assumed to be equal across whites, minorities, and investors.

The $(1-\lambda)$ agents that are not forced to leave have the option of moving voluntarily. However, every agent that moves out of a house must leave the neighborhood and incurs a moving cost c that satisfies

$$c < v_H \tag{3.5}$$

Agents are not allowed to change their tenure status within the neighborhood.

When both white and minority H-types have the same willingness to pay for the neighborhood, a proportionate sample of white and minority H-types from outside will fill neighborhood vacancies. However, it is uncertain whether the minority share among these potential new residents will be equal to or larger than that of the neighborhood. The neighborhood's incumbent residents can observe one of two possible signals regarding new residents' racial composition: s_0, which implies that the new resident minority share will be equal to the neighborhood's initial minority share, and s_H, which implies a probability θ of "minority shock," a disproportionate share of minorities among new residents. The probability that incumbents receive the signal s_H is $\gamma < 1$. Based on these signals, the minority share m_1^{new} among new residents will be

$$m_1^{new} \mid s_0 = m_0 \qquad \text{with probability } 1 \tag{3.6a}$$

$$m_1^{new} \mid s_H = \begin{cases} m_0 & \text{with probability } 1-\pi \\ 2m_0 & \text{with probability } \pi \end{cases} \tag{3.6b}$$

The model does not rely on a specific underlying type of signal. One possible example for a signal is neighborhood incumbents' observation that a firm which primarily employs minorities is scouting for a business location in the neighborhood.[5]

Agents living outside the neighborhood, however, have less information than incumbents. Hence, although outsiders know that the incumbents observe a signal s_H with probability γ, they do not themselves receive the signal. Moreover, outsiders have only imprecise information about the initial neighborhood composition: they only observe whether the minority share at the beginning of a period exceeds $\bar{m}$.

Nonetheless, because new residents moving into the neighborhood anticipate the possibility that the neighborhood minority share could increase beyond $\bar{m}$ in the same period, outsiders' expectation for the probability of their new neighborhood having a minority share above $\bar{m}$ is given by

$$E[Prob(m_1 > \bar{m})] \mid no\ signal = \gamma'\pi' \tag{3.7}$$

where γ' is the expected probability that a given vacancy has occurred in a neighborhood where incumbents observed signal s_H, and π' is the expected probability that the minority share will increase beyond $\bar{m}$ given signal s_H (see the theoretical appendix for a discussion of some properties of γ' and π'). Although agents outside the neighborhood take into account the possibility of a rising minority share, they receive no signal about the likelihood of such a change in a particular neighborhood. Therefore, potential new residents will assume that the probability of a minority share above $\bar{m}$ and the associated reduction in whites' consumption utility is equally large across all potential locations in their choice set.

All agents will move simultaneously and agents cannot observe the volume or composition of

[5] Zax and Kain (1996) provide evidence for neighborhood racial change as a consequence of company relocation.

other agents who depart or move in at the same time. Hence, current residents can only observe the neighborhood minority share once all transactions are complete. Moreover, although agents can observe equilibrium prices, the presence of large groups of agents with identical valuations for houses implies that a change in the volume of sales does not need to result in a changing equilibrium price that would give away incumbents' signal (the section on price determination discusses this issue in more detail).

3.3 Game Sequence

The following game sequence covers one period of transactions in the housing market.

1. At the start of the period, a share λ of all agents learns that they must sell their homes or move out of rental houses because of exogenous individual reasons.

2. Incumbent neighborhood residents receive either the signal s_0 or s_H about the racial composition of potential new residents with high valuation who may move into the neighborhood.

3. Nature randomly determines the racial composition of potential new residents with high taste for the neighborhood according to the probabilities indicated by the signal.

4. Nature randomly determines a share $(1 - r)$ of potential new residents who joins investors in bidding for homeownership and a share r who will bid for rental housing.[6] The fact that whites may be disproportionately selected to bid for homeownership implies that their homeownership rate can exceed that of minorities.[7]

5. The market for house ownership clears. When the number of investors and potential owner-occupiers who are willing to pay exactly the equilibrium price exceeds the number of available houses, a share r of all houses sold are bought by investors and the remaining houses are acquired by owner-occupiers. The racial composition of new owner-occupiers is then determined according to the proportion of whites and minorities in the pool of potential owner-occupiers with equal willingness to pay.

6. The market for rental houses clears. When many white and minority agents are willing to pay exactly the equilibrium rent, the racial composition of new renters is determined according to the proportion of whites and minorities in the pool of potential renters with equal willingness to pay.

7. All departures from the neighborhood and all entries into the neighborhood take place simultaneously.

[6]The separate bidding for homeownership and rental housing allows for a sequential clearing of the markets for homeownership and rental units. Although this assumption can readily be relaxed in the basic version of the model, its relevance in a more general setup is discussed in the subsequent section.

[7]Charles and Hurst (2002) provide evidence for racial discrimination in mortgage lending that could result in a lower probability for minorities to be among bidders for homeownership.

8. Neighborhood residents observe the resulting neighborhood minority share, m_1. The consumption values that residents obtain from living in the neighborhood are determined according to equations (3.1) to (3.3). Like all payments for housing, the payoff for the consumption utility accrues at the beginning of the period.

9. At the end of the period, all homeowners are paid the residual value of their houses, which is computed as the discounted value of an infinite stream of the equilibrium rent to be expected from an additional round of housing market transactions.

3.4 Price Determination

The derivation of prices begins with the computation of the residual house value that homeowners obtain at the end of the period. The residual value, as noted above, is based on the equilibrium rent expected from an additional round of housing market transactions. This rent will be equal to the marginal agent's willingness to pay for rental housing after observing the neighborhood minority share m_1.

When all agents inside and outside the neighborhood observe $m_1 \leq \bar{m}$, both white and minority H-types expect a consumption utility of v_H based on this minority share. If the alternative of living outside the neighborhood yields a utility of zero, H-types of both racial groups are willing to pay a rent of up to v_H, and, because of the large number of white H-types, v_H will be the expected equilibrium rent if $m_1 \leq \bar{m}$.

In contrast, when agents observe $m_1 > \bar{m}$, all whites expect a negative utility from living in the neighborhood. Because whites' disutility from staying in the neighborhood during an additional period is smaller than the moving cost, all whites will leave. However, since there are too few potential minority residents with high valuation to occupy all N houses, the neighborhood must fill with L-type minorities whose residential utility is $v_H - k$. Thus, a neighborhood with minority share $m_1 > \bar{m}$ will shift to all-minority equilibrium with a lower rent level of $v_H - k$.

Accordingly, the residual house price P^{end} that agents obtain at the end of the period depends on whether the minority share m_1 exceeds $\bar{m}$:

$$P^{end} = \begin{cases} P_H \equiv \frac{v_H}{1-\beta} & \text{if } m_1 \leq \bar{m} \\ P_L \equiv \frac{v_H - k}{1-\beta} & \text{if } m_1 > \bar{m} \end{cases} \tag{3.8}$$

where β is a discount factor that is equal for all agents.

At the beginning of the period, potential new residents must determine their willingness to pay for rental housing or for homeownership in the neighborhood. The derivation of their willingness to pay invokes two standard nonarbitrage conditions used in many models of location and tenure choice: First, at equilibrium prices, marginal agents are indifferent to whether to locate inside or outside the neighborhood. Second, since homeowners and renters must be indifferent relative to

the same outside option, the expected payoffs from being a renter or a homeowner must equate.[8]

The residential utility from living outside the neighborhood in a location with a minority share below $\bar{m}$ is zero, and the likelihood for a minority share above $\bar{m}$ and the associated reduction in whites' payoff is expected to be equal across all potential locations. New residents are thus indifferent between locating inside or outside the neighborhood when the rent in the neighborhood equals their consumption utility. Hence, given an initial minority share $m_0 < \bar{m}$, both white and minority H-types from outside the neighborhood are willing to pay an equilibrium rent of

$$p = v_H \tag{3.9}$$

Likewise, the price that potential new residents are willing to pay for homeownership makes them indifferent to the alternative of living outside the neighborhood, an option that in turn yields the same expected payoff as being a renter in the neighborhood at the equilibrium rent p. New residents' willingness to pay for houses at the beginning of the period is equal to the equilibrium rent p that they would pay as a renter plus the expected residual value of a house obtained at the end of the period. As noted previously, agents from outside the neighborhood expect a probability $\gamma'\pi'$ that their neighborhood will have a minority share above $\bar{m}$ after transactions in the housing market and therefore, according to equation (3.8), a residual house value of only P_L instead of P_H.

Investors from outside the neighborhood who are potential new owners of rental houses have the same information as potential new owner-occupiers and therefore expect the same probabilities for the two possible residual house values. Hence, investor willingness to pay for houses is the sum of the expected rental income and the expected residual house value, which equates to owner-occupiers' willingness to pay. The equilibrium house price is thus

$$P \equiv p + \beta[(1 - \gamma'\pi')P_H + \gamma'\pi'P_L] \tag{3.10}$$

Note that while the effect of $m_1 > \bar{m}$ on whites' consumption utility is equal for owners and renters, the impact of a high minority share on residual house values only affects homeowners. Therefore, a larger expected probability $\gamma'\pi'$ for a minority share above $\bar{m}$ lowers house prices relative to rents and appropriately compensates home owners for the asset value risk.[9] Absent moving costs, incumbent owner-occupiers will always find it attractive to sell at price P when they obtain the signal s_H and expect that the probability of $m_1 > \bar{m}$ is larger than $\gamma'\pi'$.

It is noteworthy that the equilibrium house price P does not change when a larger fraction of home owners decides to sell upon observing the signal s_H. The presence of groups of agents with equal tastes and equal willingness to pay implies that the demand curve for housing is a step function that is flat over certain intervals of transaction volumes. Given the initial minority share

[8] Glaeser and Gyourko (2007) provide a critical assessment of arbitrage conditions in housing markets.

[9] Sinai and Souleles (2005) make the related observation that the spread between house prices and rents increases in the volatility of rents if agents are risk-averse.

$m_0 < \bar{m}$, there are more than N H-type white and minority agents who are not initial neighborhood residents and who have a high willingness to pay for the neighborhood. The willingness to pay of the marginal new resident is therefore equal irrespective of the share of initial neighborhood residents that chooses to leave. In this setup, the number of departing residents does not affect the equilibrium price and outsiders cannot infer incumbents' signal when they observe that price. Conversely, when agents observe a minority share above $\bar{m}$, the number of agents with a high willingness to pay for housing drops sharply as whites no longer have a positive valuation for living in the neighborhood and H-type minorities cannot fill the neighborhood alone.

It is noteworthy that the sequential clearing of the markets for homeownership and for rental houses can generate a locally flat demand curve for homeownership even if potential residents' tastes for the neighborhood were drawn from a continuum. Idiosyncratic tastes for the neighborhood differentiate the willingness to pay among potential owner-occupiers but not among investors who only have a financial interest in the neighborhood but not an individual taste for living there. Investors' valuation for housing, which is based on expected rental income and expected residual house value, is thus the same for the large number of investors. Hence, unless investors are fully outbid by potential owner-occupiers, the ownership market will always clear at investors' valuation. As a result, there are no price changes that would allow outsiders to infer the signal and eliminate the arbitrage opportunity for incumbent homeowners.[10]

3.5 Moving Decisions

The moving decisions of incumbent residents depend on moving costs, prices and rents, and on the expected minority share m_1, which determines consumption utility and the residual values of houses at the end of the period. Moving decisions are also influenced by agents' beliefs about other residents' moving behavior.

Consider first the case where residents determine their moving decisions without taking into account moving decisions of other residents. If residents observe the signal s_0, agents will anticipate no change in the neighborhood minority share because vacancies will be filled with new residents whose racial composition is equal to the initial minority share m_0. All current residents will therefore expect a consumption utility v_H and an end-of-period house value of P_H, and none will have the incentive to move and voluntarily incur the moving cost c.

However, if neighborhood agents receive the signal s_H, which implies a probability π that the minority share among new residents will be biased toward minorities, the moving pattern will differ. When a minority shock occurs and the λ vacancies created by residents forced to move are filled with a group of new residents that includes a share $2m_0$ of minorities, then the neighborhood

[10] A setup with heterogeneous idiosyncratic tastes and sequential market clearing might however allow the equilibrium rent to fall when a larger number of incumbent residents moves on observing s_H. A falling rent would decrease white renters' incentive to leave.

minority share will increase to

$$m_1 = (1 + \lambda)m_0 \tag{3.11}$$

Proposition 1. *If agents in the neighborhood observe the signal s_H and do not take into account the moving decisions of other residents, there will be a discontinuous change in neighborhood composition at a critical tipping point $m_0^* \equiv \frac{1}{1+\lambda}\bar{m}$. If $m_0 \leq m_0^*$, no residents will move voluntarily. If $m_0 > m_0^*$,*

$$\textit{white owners leave if} \quad c < (\pi - \gamma'\pi')[2v_H + \beta(P_H - P_L)] \tag{3.12a}$$

$$\textit{white renters leave if} \quad c < (\pi - \gamma'\pi')[2v_H + \quad 0 \quad] \tag{3.12b}$$

$$\textit{minority owners leave if} \quad c < (\pi - \gamma'\pi')[\ 0\ + \beta(P_H - P_L)] \tag{3.12c}$$

while minority renters always stay. White home owners have unambiguously the strongest incentive to leave the neighborhood.

Proof. See Appendix. ■

Intuitively, two factors provide incentives for agents to leave the neighborhood on observing the signal s_H. First, all white residents in a neighborhood with minority share $m_0 > m^*$ have an incentive to leave because their residential utility would fall from v_H to $-v_H$ if the racial composition of new residents were biased toward minorities and the minority share increased above $\bar{m}$. Second, all owners have an incentive to sell because the value of their houses would fall if the minority share increased beyond $\bar{m}$. Thus, even though the equilibrium house price P incorporates prospective buyers' expectation that the residual house value will be P_L with probability $\gamma'\pi'$, incumbents who observe the signal s_H expect a higher probability $\pi > \gamma'\pi'$ of a low residual price and therefore have a financial incentive to sell and leave the neighborhood.

White home owners have the unambiguously strongest incentive to move. If the minority share increases above $\bar{m}$, they suffer both a drop in house values and a reduction of residential consumption utility. By contrast, only one of the two moving incentives applies to either white renters or minority owners while none applies to minority renters.

The following analysis will make two assumptions on the structure of moving incentives. First, suppose that the probability of a minority shock is small enough relative to moving costs that equation (3.12a) but not equations (3.12b) and (3.12c) are fulfilled. The probability of a shock is then small enough relative to moving costs that only white owners choose to leave after observing the signal s_H while white renters and minority residents stay. Second, the analysis will assume $2v_H > \beta(P_H - P_L)$ which implies that white renters have a larger moving incentive than minority owners. This assumption yields a clear ranking of moving incentives by resident group which is useful for the analysis of moving decisions of strategically optimizing agents that will be discussed below.

Under these assumptions, proposition 1 implies that a comparison between neighborhoods with minority shares around m^* shows a discontinuity in net white population change: Neighborhoods with a minority share of $m_0 \leq m^*$ have a stable white population unless a minority shock occurs. In contrast, the mere anticipation of a possible shock is sufficient to lower white population in neighborhoods with a minority share above $m_0 > m^*$ where white owners always depart on observing the signal s_H.[11]

The moving choices of proposition 1 thus yield two important testable predictions: At the tipping point m^*, (i) the population of white homeowners should decrease relative to the population of white renters,[12] and (ii) the magnitude of the tipping discontinuity in white population should be larger in neighborhoods having a large initial homeowner share among whites (or equivalently, a low renter share).

Indeed, in a neighborhood with a large share of home owners, white owner departure may be sufficient to raise the minority share above $\bar{m}$ even when no minority shock occurs. The departure of white owners will then have immediate effects on white renters whose consumption utility falls, and on minority owners who experience a drop in residual house values. When residents behave strategically, their moving decisions will take into account these effects of others' moving decisions on their own payoff.

Proposition 2. *If agents expect that no other residents will leave upon observing s_H, unless staying is strictly dominated by another strategy, there will be a discontinuous change in neighborhood composition at a critical tipping point m_0^*. The probability of $m_1 > \bar{m}$ and falling house values will increase in the initial homeowner share among whites $(1 - r_w)$:*

$$Prob(m_1 > \bar{m}) = \begin{cases} 0 & \text{if } m_0 \leq m_0^* \quad (3.13a) \\ \pi & \text{if } m_0 > m_0^* \text{ and } (1 - r_w) \leq (1 - r_w^*) \quad (3.13b) \\ 1 & \text{if } m_0 > m_0^* \text{ and } (1 - r_w) > (1 - r_w^*) \quad (3.13c) \end{cases}$$

where $1 - r_w^* \equiv \frac{\bar{m} - m_0}{(1-\lambda)(1-m_0)m_0}$ and by assumption, $1 - r_w^* < r_m$. If $m_0 > m_0^*$, all white owners will leave in case (3.13b) *whereas all white owners, white renters, and minority owners will leave in case* (3.13c).

Proof. See Appendix. ■

Proposition 2 shows that neighborhood incumbents will never leave a neighborhood with an

[11] It should be noted that the model could readily accommodate heterogeneity in moving costs. The response to the signal s_H could then be limited to the departure of white owners with low moving costs, thus creating smaller population movements that may be empirically more plausible.

[12] This prediction is so far based on the assumption that some of the houses that are vacated by owner-occupiers will be bought by investors and used as rental houses. It can however also result from heterogeneity in wealth (see following section).

initial minority share of $m_0 \leq m_0^*$ because an increase in the minority share above $\bar{m}$ can be averted when all neighborhood incumbents stay.[13] Conversely, when the initial minority share is above m^*, white owners will always depart. In neighborhoods with large white homeownership, the expectation of a possible increase in minority share beyond $\bar{m}$ can become self-fulfilling: As white owners leave a neighborhood with an owner share above $(1 - r_w^*)$, the minority share rises beyond $\bar{m}$. White renters anticipate this increase in minority share and therefore leave as well to avoid a negative consumption utility. Furthermore, minority owners have an incentive to depart in order to avoid a reduction in house values: Since a large ownership rate weakly increases the probability that the minority share will exceed $\bar{m}$, it by consequence also raises the likelihood that the (residual) price of houses will fall at the tipping point m^*.

An additional third testable prediction of the model is therefore that around the tipping point m^*, (iii) neighborhoods with a large owner share (or small renter share) should be more likely to experience a drop in house prices. The empirical analysis will test this prediction along with the earlier predictions that white owners should be particularly likely to depart at the tipping discontinuity and that neighborhoods with high owner shares and low renter shares should hence experience larger decreases in white population.

3.6 Extension: Heterogeneity in Wealth

The model provides a richer set of predictions when it allows for heterogeneity in agents' wealth. This extension of the model assumes the presence of rich and poor agents who have identical tastes for the neighborhood. Rich agents can afford to either buy or rent a house while poor agents are credit constrained and can only rent. The indifference of the rich agents to either owning or renting at equilibrium prices implies that the same share of rich agents can be consistent with different values of the renter share.

Suppose that the share of rich agents among new potential residents equals the proportion of incumbent residents that are wealthy. Thus, if a proportionate sample of incumbents were replaced with new residents, the share of wealthy agents would not change. However, proposition 2 suggests that among both racial groups, owners are more likely than renters to depart when the initial neighborhood minority share exceeds the tipping point m^*. Consequently, the composition of departing residents is biased toward wealthy agents, and the average income level in both racial groups falls when a proportionate sample of rich and poor new residents moves in. Moreover, a reduction in the homeownership rate is necessary when there are fewer new wealthy residents than owner-occupiers who depart. The model thus provides a fourth prediction that (iv) there will be a discontinuous fall in neighborhood income level at the tipping point m^* when home owners are more likely than renters to depart on observing the signal s_H. Importantly, such a reduction in

[13] While the expectation structure of proposition 2 is attractive in that it avoids excessive movement of residents, it is theoretically conceivable that incumbents instead expect that other residents will always panic and leave when observing the signal s_H unless leaving is a dominated strategy. This alternative expectation structure is discussed in the theoretical appendix. Its main property is that the moving behavior of whites owners and renters does not differ.

wealthy population will not be driven by greater racial prejudice of wealthy whites but by a financial incentive for home owners to leave the neighborhood ahead of a possible decrease in house values.

4 Empirical Framework

The theoretical model emphasizes that identical expectations about the probability of future neighborhood tipping can translate into different behavior by homeowners and renters. Specifically, it predicts that when the minority share of a neighborhood exceeds a critical tipping point, white homeowners are more likely to depart than white renters. The objective of the empirical analysis is therefore to test whether tipping neighborhoods lose more homeowners than renters, and whether the magnitude of discontinuous changes in neighborhood racial composition and house prices at empirically estimated tipping points varies according to neighborhoods' initial proportions of homeowners and renters. In addition, the analysis tests the predictions that neighborhoods with higher homeownership rates and lower renter shares experience a reduction in house values, and that income levels fall discontinuously at the tipping point. Based on the well-known correlation between income and education, it also tests for a decrease in education levels in tipping neighborhoods. The analysis builds on an empirical identification of tipping points in recent work by Card et al. (2008a).

4.1 Data

The neighborhood data is taken from the Neighborhood Change Database (NCDB), which includes census tract data from the 1970, 1980, 1990, and 2000 decennial censuses. These tracts are areas with a population of about 3,000-4,000 individuals and represent neighborhoods with a relatively homogeneous demography and housing stock. The NCDB provides a panel of tracts based on Census 2000 tract boundaries onto which earlier data have been mapped.[14] This analysis focuses on changes in tract characteristics over the three 10-year periods 1970-1980, 1980-1990, and 1990-2000.

The "cities" included in the sample are metropolitan statistical areas (MSAs) that encompass both central city and suburban neighborhoods. The sampling process, which follows Card et al. (2008a), creates separate samples for each 10-year period and excludes tracts having very few residents at the beginning of a decade and MSAs with less than 100 developed tracts (see the data appendix for details of the sample selection). Panel A of Table 1 presents summary statistics for the tract samples from each 10-year period. The sample size grows with each decade from about 36,000 tracts in 104 MSAs for 1970-1980 to about 40,000 tracts in 114 MSAs for 1990-2000.

Throughout the analysis, the term "white population" refers to non-Hispanic whites, while "minority population" refers predominantly to black or Hispanic residents but also includes Na-

[14]The mapping to boundaries at the end of the sample period is not optimal because of the possible endogeneity of later boundaries. Results for a subsample of tracts without boundary changes in the 1990-2000 period are, however, similar to those reported for the full sample.

tive Americans, Asians, Pacific Islanders, and other nonwhite races. The tract tabulations of the decennial censuses, which are integrated into the NCDB data, only separate population counts for non-Hispanic whites as of 1980. Following Card et al. (2008a), non-Hispanic white shares for 1970 have been imputed by first regressing the non-Hispanic white tract population share in 1980 on the share of whites, blacks, and Hispanics in the same period, and then multiplying the resulting coefficients with the tract share of whites, blacks, and Hispanics in 1970. As Panel A, table 1 shows, the minority share in the sample tracts increased considerably over time, from 16% in 1970 to 29% in 1990.

The NCDB data is most comprehensive for 1990 and 2000 when homeownership, income, and education variables were tabulated separately by race. Prior to 1990, the census either did not report these cross-tabulations, or values were suppressed for many tracts in the sample; the analysis of these outcomes by race therefore focuses on the 1990-2000 period. Likewise, education and income variables for non-Hispanic whites had to be imputed from separate counts for whites and Hispanics (again, the data appendix provides a detailed description of variable definitions and imputations).

4.2 Identification of Candidate Tipping Points

The empirical analysis uses regression discontinuity models to identify decadal changes in population composition and housing variables at city-level tipping points. A tipping point is a critical value of the minority share above which the growth rate of the white population falls discontinuously and neighborhoods begin to converge to an all-minority equilibrium. As a prerequisite for the regression discontinuity analysis, the location of these tipping points must be empirically estimated from the data; this analysis uses the candidate tipping points identified and generously shared by David Card, Alexandre Mas, and Jesse Rothstein.

Card et al. (2008a) report two methods for identifying tipping points which both yield similar tipping point estimates. This present study focuses on the simpler technique, which builds on the methodology for identifying structural breaks. The structural break approach regresses decadal changes in white tract population expressed as a share of a tract's initial population on a constant and a dummy for an initial minority share above m^*, where $m^* \in (0, 50)$. The regression is run separately for each city in each decade using only tracts with initial minority shares of up to 60 percent. The candidate tipping point for each city-decade cell is the value of m^* that maximizes the R^2 of the regression.

While the structural break approach identifies a possible tipping value for every city, it is not a priori clear that white population indeed significantly declines around this value. Instead, it is possible that there is a significant increase in white population or a change that is not significantly different from zero. Moreover, the identification of tipping points based on changes in white population is not immediately related to various outcome variables of this study such as house price, income levels, or education levels. Nevertheless, if the same data were used to identify tipping points

and estimate the magnitude of discontinuities, standard hypothesis tests would too often reject the null hypothesis of zero discontinuity in white population growth. Card et al. (2008a) address this problem with a split-sample technique that identifies tipping points using only a randomly selected subsample of 2/3 of all tracts and then estimates the magnitude of tipping discontinuities based on the remaining 1/3. The independent selection of the two subsamples allows the use of conventional hypothesis tests to evaluate the magnitude and statistical significance of discontinuous changes at the tipping point.

Based on the subsample of 2/3 of all tracts, the resulting average estimates for tipping points across all cities are minority shares of 9 percent in 1970, 12 percent in 1980, and 14 percent in 1990. These rising tipping point values are consistent with an increasing white tolerance for living with minority neighbors. Card et al. (2008a) also show that cities whose white residents report more favorable attitudes toward minorities in the General Social Survey tend to have higher tipping points.

Panel B of Table 1 reports descriptive statistics for tracts with a minority share within two percentage points of the estimated tipping points. Tracts near the tipping point have slightly higher income and education levels and a smaller renter share than average tracts in the sample. The population of tracts near the tipping point also differs notably from the average population in terms of education levels by race which are reported in the 1990 data. Whereas the share of residents with college degrees is equal for whites and minorities in neighborhoods near the tipping point, in the overall sample, minorities have considerably lower educational attainment. A similar observation applies for income levels. While average family income by race is not reported in the NCDB, bracketed income data allows to compute the share of families with an income above 45,000 US dollars in 1999 value. That share is similar for white and minority families in neighborhoods near the tipping point (54 vs. 51 percent) while there is a considerably larger racial income gap in the overall sample (54 vs. 38 percent). This observation is noteworthy because it implies that the departure of a random sample of whites from a neighborhood near the tipping point would hardly change the overall income and education levels of the neighborhood.[15] Despite relatively similar education and income levels, minority residents in neighborhoods near the tipping point are more likely than white residents to be renters. These relatively lower homeownership rates for minorities or immigrants are well-documented in the literature (e.g., Collins and Margo, 2001; Coulson, 1999) and may partly result from racial discrimination in the mortgage application process (Charles and Hurst, 2002).

[15] An analysis of census house values by Bayer, Ferreira and McMillan (2007) suggests that homeowners not only value own-race neighbors but also neighbors with similar educational attainment and income levels. If whites had considerably more education than minorities, such preferences would exacerbate the departure of educated whites from a neighborhood once a random group of whites have left. However, because the educational attainment of whites and minorities is similar, it is unclear a priori whether such a dynamic will unfold.

4.3 Distribution and Correlates of the Renter Share

The empirical analysis tests the model's prediction that neighborhoods with a large proportion of homeowners and hence a small share of renters will experience larger discontinuous decreases in white population at the tipping point. The renter share is defined as the share of renter-occupied houses among all occupied housing units. It is by construction equal to one minus the owner share.

Panel A of Table 2 shows percentiles of the distribution of the renter share for neighborhoods with minority shares within two percentage points of the city-level tipping point. There is considerable variation in the neighborhood renter structure, which should facilitate the identification of heterogeneous treatment effects. In each year, the 10th percentile of the renter share falls at about 9 percent renter-occupied housing, while the 90th percentile of the distribution falls near 60 percent.

Panel B of table 2 shows correlates of the renter share. It reports the coefficients from separate regressions of the tract renter share on the indicated tract characteristic, controlling for MSA fixed effects. Tracts with a higher renter share tend to be populated by families with lower average income and fewer children and are more frequently located in central cities than in suburbs. They also have more neighboring tracts with a minority share that exceeds the city-level tipping point.[16] The correlation of renter share with family income and share of families with children raises the possibility that heterogeneity of tipping effects by renter share may be driven by the differential tastes and behavior of rich and poor agents or of families with and without children. The variation in renter share by location within a city could also lead to spurious results if tastes of residents differ by location. The empirical analysis will explicitly account for these factors.

A further noteworthy characteristic of renter share is its extremely strong correlation with renter share among white residents which is not surprising given that neighborhoods near the tipping point are predominantly white. Hence, the identifying variation in renter share used throughout the analysis is plausibly driven primarily by variation in white ownership configurations. Unfortunately, these are not available for the full sample period.

4.4 Estimation of Tipping Effects

The magnitude of discontinuities in population and housing outcomes at the candidate tipping points is estimated using regression discontinuity models (Angrist and Lavy, 1999; Imbens and Lemieux, 2007). All estimations use the randomly selected 1/3 of tracts not previously used to identify the locations of the candidate tipping points.

The basic regression analysis uses a model of the form

$$\Delta y_{ic\tau} = \alpha + p(d_{ict})\beta_1 + \beta_2 1[d_{ict} > 0] + \beta_4 r_{ict} + X_{ict}\beta_5 + \gamma_c + \epsilon_{ic\tau} \tag{4.1}$$

[16] Tract neighbors are defined as tracts whose central point falls within a 3-mile buffer zone around a given tract's boundary.

where τ stands for the decades 1970-1980, 1980-1990, and 1990-2000, and t is the year at the start of the respective decades (i.e., 1970, 1980, and 1990). The decadal change of an outcome variable, $\Delta y_{ic\tau}$, is regressed on a quartic polynomial $p(d_{ict})$ in the deviation of a tract's minority share from the city-level tipping point, a dummy variable $1[d_{ict} > 0]$ for a tract minority share above the tipping point, a set of city fixed effects γ_c, the renter share r_{ict}, and a vector X_{ict} of neighborhood-level control variables, all measured at the beginning of a decade. Inclusion of city fixed effects implies that all models analyze within-city variation. Reported standard errors are clustered by MSA.

A second regression setup of the form

$$\Delta y_{ic\tau} = \alpha + p(d_{ict})\beta_1 + \beta_2 1[d_{ict} > 0] + \beta_3 1[d_{ict} > 0] * r_{ict} + \beta_4 r_{ict} + X_{ict}\beta_5 + \gamma_c + \epsilon_{ic\tau} \qquad (4.2)$$

interacts the dummy variable for the tipping discontinuity with the renter share and thus allows for heterogeneity of the treatment effect according to a tract's initial share of renters. The coefficient β_2 for the tipping dummy provides the predicted tipping effect for an all-homeownership neighborhood while the coefficient β_3 for the interaction term yields the predicted difference in tipping effects for neighborhoods with higher renter shares and lower homeownership rates.

5 Tipping Discontinuity for Homeowners and Renters

The key prediction of the theoretical model is that homeowners have a stronger incentive than renters to leave a neighborhood in anticipation of immanent racial tipping and falling house prices. The model predicts that the selective departure of homeowners will result in a reduction of owner-occupied housing relative to renter-occupied housing when part of the previously owner-occupied housing units fill with renters. Alternatively, when the assumption of a constant number of occupied houses in the neighborhood is relaxed, a neighborhood may experience a relative reduction in population growth as homeowners depart.

Panel A of Table 3 presents decade-specific estimates of equation (4.1) for the change in the number of owner-occupied and renter-occupied housing units at the candidate tipping points. All models include a quartic polynomial in the deviation of tract minority share from the city-specific tipping point, as well as MSA fixed effects. The regressions also control for a tract's renter share at the beginning of a decade, and for five additional tract characteristics in the base year: the log of the mean family income, the share of families with children under 18, the unemployment rate, and the fraction of vacant and single-unit housing units in a tract.

In each of the three decades, owner-occupied housing decreases significantly by 6-8 log points at the tipping discontinuity. In contrast, the change in renter-occupied housing does not display a discontinuous change. These results for owner- and renter-occupied housing imply a reduction in the growth rate of the housing stock around the tipping point. The table also reports the results of Wald tests for the equality of the coefficients for owning and renting derived from fully interacted

regressions that combine the separate regressions for owner- and renter-occupied housing. For all three decades, the null hypothesis of an equally large decrease in owner- and renter-occupied houses can be rejected at least marginally.

The lower panel of table 3 reports separate estimates of the change in owner- and renter-occupied housing for whites and minorities which can be computed based on the race-specific data for 1990-2000. The results for whites indicate a significant drop in white homeownership while there is no apparent decrease in the number of houses occupied by white renters. The point estimates for minorities suggest a modest decrease in owner-occupied relative to renter-occupied housing, but the imprecise estimate for the decrease in minority homeownership is not significantly different either from zero or from the change in minority-occupied rental units.

These results are consistent with the prediction that neighborhoods primarily lose white homeowners at the tipping point. While white owner-occupied housing discontinuously falls, there is no evidence for a reduction in white renter-occupied housing.

6 Discontinuity in Racial Composition

The magnitude of racial tipping — the rapid reduction in white relative to minority population in neighborhoods whose minority share exceeds a critical tipping point — should depend on a neighborhood's tenure structure. If the departure of white residents from tipping neighborhoods is mostly confined to white homeowners, then neighborhoods with higher homeownership rates and smaller renter shares should experience larger outflows in white population. This section presents estimates for the change of white, minority, and overall population at empirical tipping points, allowing for heterogeneity of tipping effects by initial renter share of a neighborhood. The analysis also evaluates a series of alternative hypotheses that provide potential explanations for a relationship between neighborhood tenure structure and the magnitude of the reduction in white population at the tipping discontinuity.

6.1 Baseline Results and Robustness Tests

The first four columns of Table 4 present estimates for the decadal change in white population as a fraction of initial tract population, alternatively excluding and including a vector of tract-level demography and housing controls. The estimated coefficients in columns (1) and (3) corroborate that the growth rate of the white population is discontinuous around the estimated tipping points; a finding documented by Card et al. (2008a). The regressions that include demographic and housing controls, reported in column (3), show statistically significant discontinuous declines in the growth rate of white population by -10, -11, and -9 percentage points for the three decades 1970-1980, 1980-1990, and 1990-2000.

While the models reported in column (1) and (3) show mean tipping effects across all tracts, those shown in columns (2) and (4) are based on the regression equation (4.2) that allows for

variation in the magnitude of the tipping discontinuity by including an interaction term between the tipping dummy and the renter share of a tract in the base year. The positive and highly significant coefficients of these interaction terms confirm that the discontinuous decrease in white population at the candidate tipping points is smaller for neighborhoods with a high renter share. Conversely, neighborhoods with a large proportion of homeowners experience a larger decline in white population.[17]

The coefficient of the tipping dummy in the interacted specification reports the predicted tipping effect for neighborhoods with a homeowner share of 100%. In each decade, the coefficient estimates imply that this predicted discontinuity in white population growth for pure-ownership neighborhoods is roughly twice as large as the main effect for the whole sample. To facilitate the interpretation of the results in column (4), Table 5 reports the predicted tipping effects for tracts at different percentiles of the renter share distribution. The white population is predicted to fall by about 15-18 percentage points in the owner-dominated neighborhoods at the 10th percentile of the renter share distribution. There is only a modest decrease of 0-4 percentage points for tracts at the 90th percentile of the renter share. These results confirm that the magnitude of the tipping discontinuity varies strongly with the initial renter share: neighborhoods with high homeownership rates experience substantially larger drops in white population around candidate tipping points.

The remainder of table 4 estimates discontinuities in the growth rate of the minority and the overall population. Columns (5) and (6) show that the discontinuous increase in the growth rate of the minority population is quite small and only statistically significant in 1990-2000. The growth in minority population is somewhat larger in neighborhoods with large ownership rates that lose more white residents. The strong decrease in white population and the modest increase in minority population combine to produce a discontinuous decrease in overall population around candidate tipping points. This decline in population growth is larger in neighborhoods with more homeownership and a smaller renter share. One possible explanation for such a decrease is a drop in the supply of new houses once a neighborhood tips.[18]

The results in Table 6 provide further evidence for the robustness of the discontinuity in white population growth at candidate tipping points. These models control more flexibly for the initial renter share of a tract using a fourth order polynomial. The resulting model is then augmented with controls for 10-year lags in the renter and minority share (lags that can only be determined for the later two decades). A final set of models also controls for 10-year lags in the demographic and housing control variables. Although the addition of this rich set of control variables attenuates the estimated coefficients, all models continue to find a significant decrease in the growth rate of white population at candidate tipping points, one that is larger for neighborhoods with high

[17] All models in table 4 control for a fourth-order polynomial in the difference between a tract's initial minority share and the city-level tipping point. Appendix Table A1 shows that the estimated discontinuities in white population are very similar for models that include polynomials of lower or higher order. A model with separate polynomials on both sides of the tipping point estimates a larger mean tipping effect in the 1970s.

[18] Card et al. (2008a) show that outflows of white population are approximately offset by inflows of minority population in tracts where a scarcity of undeveloped land restricts potential growth in the housing stock.

homeownership rates and small renter shares.

6.2 Alternative Hypotheses

The results of Tables 4 to 6 provide robust evidence that neighborhoods with large homeownership rates experience larger drops in white population at the tipping discontinuity. While homeowners may be particularly inclined to depart from a tipping neighborhood in order to avoid a potential decrease in house values, it is also conceivable that the differential behavior of owners and renters is driven by differences in tastes. Notably, the departure of owners may be driven by Tiebout (1956) sorting if a change in neighborhood racial composition affects public goods of a neighborhood that are primarily consumed by owners. These concerns are particularly justified in view of the systematic relationship between renter share and various measures of population composition and tract location, as previously reported in table 2. This section will therefore address a variety of alternative explanations for the selective departure of homeowners from tipping neighborhoods.

Consider first the hypothesis that home owners are more likely to leave a tipping neighborhood because of their superior ability to afford housing in an alternative location. Indeed, in a study of suburbanization during 1960-1980, Boustan (2007a) identifies a price premium for houses in largely white suburban neighborhoods compared to houses of similar quality in racially mixed inner-city neighborhoods. Even if rich whites are not more racially prejudiced than poorer whites, they may nevertheless be more likely to leave a tipping neighborhood when living in a predominantly white neighborhood is a normal good. It is therefore conceivable that the observed stronger tipping effects in owner-dominated neighborhoods are driven by the higher income levels of such neighborhoods rather than homeownership.

As a first test to evaluate this alternative hypothesis, Table 7 explores whether the discontinuity in white population growth at candidate tipping points remains larger for neighborhoods with high homeownership rates when the sample is stratified into subsamples of tracts that are relatively homogeneous in income levels. Specifically, it groups all neighborhoods into five subsamples of equal size according to their average family income. Columns (1) and (2) report estimated coefficients for neighborhoods whose mean family income puts them into the top 20% of the sample, while each subsequent pair of columns refers to subsamples with lower incomes. Strikingly, the results in table 7 show the point estimates for mean tipping effects to be negative in all 15 subsamples, whereas the interaction term of the tipping point dummy and the renter share is positive in all subsamples with the exception of the second income quintile in 1970-1980. The majority of the estimated coefficients, including all estimates for 1990-2000, are also statistically significant despite the smaller sample size in these regressions. Conversely, there is no evidence for particularly strong tipping effects among the tracts in the top income quintile which together with the second and third quintile accounts for a disproportionate share of neighborhoods near the tipping point. These results provide evidence against the hypothesis that the larger tipping effects in ownership-dominated neighborhoods are

due to higher income levels of such neighborhoods.

Another possible explanation for larger tipping effects in neighborhoods with high homeownership rates is that residents with greater sensitivity to racial change might be particularly concentrated among homeowners. These residents' aversion to racial change may stem not only from racial prejudice but also from a preference for public goods and neighborhood amenities that may be affected by a higher minority share. In particular, it is conceivable that parents worry about their children's heightened exposure to changes in the neighborhood: School-age children may be be affected by a rising minority share both through a change in the composition of their classmates and possibly through changes in the quality of neighborhood amenities such as schools or public parks.[19] As a consequence, families with children may be particularly inclined to leave a tipping neighborhood.

The hypotheses that the large tipping discontinuities for white population in owner-dominated neighborhoods are due to higher income levels or a larger share of families with children is assessed in columns (2), (5), and (8) of Table 8 where the baseline model specifications are augmented with interaction terms between the tipping dummy and (i) the tract log average family income and (ii) the share of families in a tract with children under 18, both measured as a deviation from MSA means. The estimates show that the result for the renter share interaction term is robust to the inclusion of these additional variables.

While the discontinuous drop in white population is larger in neighborhoods with higher homeownership rates, it is actually somewhat smaller in neighborhoods with higher income levels. The latter result seems consistent with survey evidence that wealthier whites express a greater willingness to live in racially mixed neighborhoods (Farley et al., 1997). The positive correlation of wealth and homeownership, however, implies that despite higher tolerance for minorities, wealthy whites might still be the first to leave a tipping neighborhood to avoid decreasing house values.

Neighborhoods with a larger share of families with children indeed show larger tipping discontinuities in white population. This finding is consistent with the notion that families with children might react more sensitively to an increase in minority share. The results are also in line with recent work by Baum-Snow and Lutz (2008) who find evidence for an outflow of white population from central city school districts after court-ordered desegregation in the 1970s. The effect of the share of families with children on the magnitude of the predicted tipping discontinuity is sizable. Based on the coefficients for 1990-2000, a one standard deviation increase in the share of families with children, measured for tracts near the tipping point, predicts an additional decrease in white population of 7 percentage points at the tipping point. An equally large drop in white population results from a one standard deviation decrease in the renter share. In contrast, a one standard deviation increase in log average family income mitigates the drop in white population by 3 percentage points.

[19] A large body of research examines the effects of racial segregation across schools and of racial composition of peers on student achievement. See, for example, Guryan (2004), Angrist and Lang (2004), Card and Rothstein (2007), and Vigdor and Ludwig (2007).

A third alternative explanation for the relationship between tenure structure and tipping effects is based on the observation that neighborhoods with a higher renter share differ from owner-dominated neighborhoods not only with regard to resident composition but also in terms of spatial location within a city. In particular, as table 2 shows, central city neighborhoods and neighborhoods in the proximity of tracts with a minority share above the tipping point tend to have larger renter shares. If whites in different areas of a city vary in terms of their racial preferences or their taste for public goods that are affected by the racial composition of a neighborhood, then spatial variation in homeownership can proxy for variation in tastes. Specifically, the suburbs and areas far from previously tipped neighborhoods might attract white residents who are more sensitive to racial composition and who locate away from central cities and areas close to tipped neighborhoods because these areas may be more likely to attract minority residents.[20] Such a spatial sorting by tastes could then predict stronger tipping effects in suburbs and areas far from tipped neighborhoods which both tend to have relatively high homeownership rates.

To evaluate this hypothesis, columns (3), (6), and (9) of table 8 again report the estimations for the baseline model for change in white population augmented with interaction terms between the tipping point dummy and (i) central city location and (ii) share of tract neighbors with minority shares above the tipping point, measured in deviations from MSA means. Tract neighbors are defined as tracts whose central point is within a three-mile buffer zone around a given tract's boundary. Consistent with earlier findings (Card et al., 2008a), the results indicate no systematic difference in the magnitude of the tipping discontinuity between central-city and suburban neighborhoods. For the first two decades, the decrease in white population at the estimated tipping point is larger in neighborhoods with few tipped neighbors. This relationship no longer appears, however, in the 1990-2000 decade. Conversely, the magnitude of the tipping discontinuity continues to be larger in neighborhoods with large homeownership in all three decades.

In summary, the results in tables 7 and 8 suggest that the larger tipping discontinuities in neighborhoods with high homeownership rates cannot be explained by a number of apparent correlates of the renter share. While the possibility that tastes differ between homeowners and renters cannot be conclusively ruled out, the evidence suggests that variation in neighborhood income level, the share of families with children, and neighborhood location are not responsible for the strong tipping effects in owner-dominated neighborhoods.

7 Discontinuity in House Prices and Rents

The results so far establish that tipping neighborhoods tend to lose white homeowners rather than renters, and that tipping effects are larger in magnitude in owner-dominated neighborhoods even when controlling for various measures of neighborhood composition and location that are

[20]The rapid suburbanization in the post-war era has been extensively analyzed; see, for example, Margo (1992), Bajari and Kahn (2005), Baum-Snow (2007), and Boustan (2007b). A process of circular ghetto expansion in which an existing ghetto spreads to adjacent neighborhoods is described by Moebius and Rosenblat (2001).

related to owner and renter shares. The theory outlined in section 3 predicts that the selective departure of homeowners may be driven by the risk of a drop in house prices when the neighborhood minority share exceeds the tipping point. Although the data does not allow to directly assess whether departing homeowners expected house prices to fall, the analysis is able to test the model prediction that declines in house prices should be more pronounced in the neighborhoods with large homeownership that experience stronger declines in white population.

Table 9 presents the results for the change in the log average house values and log average rents at the tipping discontinuity.[21] Columns (1) and (3) of table 10 present the estimates from the regression discontinuity models that use the same specification as columns (1) and (3) in table 4. In line with results by Card et al. (2008a), the estimated discontinuous declines in house values of 1-2 log points are small and mostly insignificant. Columns (2) and (4) show the results from augmented models that include an interaction term between the tipping dummy and the renter share. The outcomes for 1980-1990 and 1990-2000 indicate that the magnitude of price drops at candidate tipping points varies significantly with neighborhood renter share. Neighborhoods with high ownership rates do not only experience a greater decline in white population, as previously shown, but also a significantly larger reduction in house values. According to the coefficients in column (2), ownership-dominated neighborhoods at the 10th percentile of the renter share distribution experienced a decrease in house value of -4.9 and -3.2 log points in 1980-1990 and 1990-2000, respectively. Conversely, the expected price change in renter-dominated neighborhoods at the 90th percentile of the renter share is zero for both decades. The coefficients for 1970-1980 show a qualitatively similar pattern, but they are smaller and less precisely estimated than those for later decades.

The theoretical model predicts that once whites' taste for the neighborhood declines, rents should fall along with house prices. Indeed, the results for rents in columns (5) and (6) show a discontinuous decline of rents for the period 1980-1990, one that is equal in magnitude to the fall in house values. However, the estimates for 1990-2000 provide no such evidence for a significant discontinuity in the average rent. The data for 1970-1980 can unfortunately provide little further evidence for rental change at the tipping discontinuity because rents in 1970 are only reported for a small subsample of tracts.

In summary, although the responses of house prices and rents to neighborhood tipping tend to be relatively modest and imprecisely measured, the results provide support for the hypothesis that the magnitude of price declines increases with the neighborhood homeownership rate. Most particularly, a higher ownership rate and lower renter share predict both larger discontinuous declines in white and overall population at candidate tipping points and larger decreases in house values.

[21] House values and rents in the census are self-reported and may be affected by misreporting and long adjustment lags (Bayer et al., 2007), as well as by noisy measurement due to tabulation at intervals. These characteristics may make it more difficult to observe substantial price changes as neighborhoods tip.

8 Discontinuities in Income and Education

The results of the previous sections are consistent with the theoretical model's prediction that tipping neighborhoods primarily lose homeowners who might decide to leave in order to avoid falling house prices. Due to the correlation of homeownership and wealth, whites with higher incomes might be particularly likely to depart from a neighborhood that is beyond the tipping point even though survey evidence firmly suggests that wealthier whites are less racially prejudiced than their poorer peers.[22] An extension of the model that allows heterogeneity in wealth therefore predicts that the income level of a neighborhood should fall at the tipping discontinuity. Moreover, the positive correlation between education and income implies that the reduction in average income might be associated with a decrease in average educational attainment. The following two subsections consider the change in income and education levels at the tipping discontinuity.

8.1 Income

The first panel of Table 10 provides estimates for the change in the log average family income of a tract at the tipping discontinuity. The figures reported in columns (1), (3), and (5) indicate that the mean tipping effect is a -2.2, -2.8, and -1.3 log point decrease in average family income in 1970-1980, 1980-1990, and 1990-2000, respectively. The change in population composition required to generate such decreases in average income can be illustrated using the mean tipping discontinuity in population of -11, -11, and -7 percentage points given for the three decades in column (5), table 4. If the only population change at the tipping point were the departure of the indicated proportions of residents, the departing residents would need an income about 20 to 25 percent above the income of the remaining residents to generate the observed decreases in average income levels.

The results reported in columns (2), (4), and (6) of table 10 further indicate that the drop in income level is larger for neighborhoods with large homeownership. For instance, the predicted reduction in average income for neighborhoods at the 10th percentile of the renter share is between -3 and -5 log points for each of the three decades. It should also be noted that the estimated decreases in average income are commensurate to the declines in house values.

Even though the NCDB does not report the variable for average family income separately by race, it does provide the number of families in broad income brackets for 1990 and 2000. Because transforming these interval data into a continuous variable is challenging given the sensitivity of assumptions about family distribution within income brackets, the analysis of income change by race focuses on the change in the share of white and minority families with an income above 45,000 dollars. Specifically, it exploits the fact that the real value of 45,000 dollars in 1999 is almost precisely equal to the value of 35,000 dollars in 1989.[23] Since these two numbers form borders of reported income intervals in the respective years, the data allows to consistently observe the share

[22] There is both theoretical and empirical work that identifies income and wealth as critical determinants of homeownership; see, for example, Henderson and Ioannides (1983), Jones (1990), and Fu (1991).

[23] Census income data refers to the year preceding the survey.

of white and minority families with incomes over 45,000 dollars. The lower panel of table 10 shows a significant decrease in the share of white residents with an income above 45,000 dollars at the tipping discontinuity. The point estimates for minorities also suggest an income reduction, but they are less precisely estimated and not statistically significant.

Overall, these results provide evidence that tipping decreases the average income of a neighborhood. Importantly, the reduction in income is not only due to a change in racial composition but it can separately be observed among white residents, and to a weaker degree among minorities. Moreover, it is worth noting that this finding of a decline in income levels at the tipping discontinuity need not be at odds with the smaller discontinuities in white population for wealthier neighborhoods (see table 8). Whereas wealthier whites may be more tolerant of minority neighbors than less affluent whites, the wealthy are also more likely to be homeowners and may therefore have a greater financial incentive to leave a neighborhood.

8.2 Education

To add to the evidence for a discontinuous reduction in neighborhood quality at the tipping point, Table 11 provides results for the change in the share of neighborhood residents age 25 or higher who have a college degree.[24] The columns (1), (3), and (5) in the first panel of the table indicate a significant tipping discontinuity in the share of college graduates in both 1980-1990 and 1990-2000 but not in 1970-1980. In each of the three decades, neighborhoods with smaller initial renter shares and more homeowners experience a larger reduction in the share of residents with college degrees; in neighborhoods without renters, the predicted reduction in the share of college graduates is about one percentage point.

The similarity of education levels for the white and minority populations in neighborhoods near the tipping point that was shown in table 1 implies that a discontinuity in education would not result if the tipping effect were limited to the departure of a random sample of white residents. Indeed, the second panel of table 11 shows a discontinuous reduction in the share of college graduates within racial groups that is particularly pronounced for whites and again weaker for minorities.

Taken together, the results for income and education levels indicate a decline in neighborhood quality along both these dimensions when neighborhoods tip. The reduction in income and education is particularly apparent among whites and it is thus consistent with the notion that tipping neighborhoods primarily lose white homeowners, a group of residents that tends to be wealthier and better educated that renters.

[24] Benabou (1993) shows that the local concentration of residents with high educational attainment can strongly affect the residents of a neighborhood when there are local complementarities in human capital investments.

9 Conclusions

White preferences for neighborhoods with small minority shares can give rise to a tipping dynamic of racial segregation by which whites begin leaving a neighborhood once its minority share exceeds a critical tipping point. This paper proposes that if a neighborhood tips and white demand for housing falls in response to a growing minority population, homeowners may fear devaluation of their houses. Even though white owners and white renters both want to avoid an increase in the neighborhood minority share, homeowners have the additional financial incentive to leave a neighborhood ahead of immanent tipping to avoid a decrease in wealth. To illustrate that this market mechanism can exacerbate the tipping process, this paper develops a tipping model with asymmetric information and flexible prices which predicts that discontinuous population changes in tipping neighborhoods will be larger for neighborhoods with higher homeownership rates.

Financial incentives in the tipping process can also have important implications for the sequence of white residents' departure from segregating neighborhoods. In the classic model by Schelling (1971), a tipping neighborhood first loses the white residents with lowest racial tolerance, the most prejudiced of whom, survey evidence suggests, are typically persons of low education and income levels. Nonetheless, homeowners' financial incentives may contribute to a reversal of this sequence of white resident departure; that is, homeowners who on average are relatively wealthy and highly educated may leave the neighborhood ahead of poorer and less educated renters due not to greater racial prejudice but to avoid a loss in asset value.

This prediction of stronger tipping effects in neighborhoods with high homeownership rates is tested empirically using tipping values estimated by Card et al. (2008a). The results confirm that in every decade from 1970 to 2000, once the minority share exceeds the tipping point, neighborhoods with a high homeownership share experience considerably larger drops in white neighborhood population than those with more renters. Neighborhoods with a large homeownership rate also experience larger decreases in home values at the tipping discontinuity.

The effects of neighborhood tipping go beyond a change in racial composition: when a neighborhood tips, both income and education levels fall in the overall population, among white residents, and possibly among minority residents. Moreover, despite no evidence that higher incomes in a neighborhood exacerbate tipping, these results are consistent with the model's prediction that tipping neighborhoods will lose relatively wealthy and well-educated homeowners, who are more likely to leave than renters due not to greater racial prejudice but because of owners' financial incentive to avoid falling house prices. Indeed, tipping neighborhoods experience a sharp drop in white owner-occupied housing only, with no change observable in white renter-occupied housing.

This analysis thus provides evidence that tipping, usually considered a nonmarket interaction, may be augmented by market forces. The relative magnitude of these market and nonmarket channels and the complementarities between them warrants further study.

References

Ananat, Elisabeth Oltmans (2007), "The Wrong Side(s) of the Tracks: Estimating the Causal Effects of Segregation on City Outcomes.". National Bureau of Economic Research Working Paper No. 13343.

Angrist, Joshua D. and Kevin Lang (2004), "Does School Integration Generate Peer Effects? Evidence from Boston's Metco Program." *American Economic Review*, 94 (December), 1613–1634.

Angrist, Joshua D. and Victor C. Lavy (1999), "Using Maimonides' Rule to Estimate the Effect of Class Size on Scholastic Achievement." *Quarterly Journal of Economics*, 114 (May), 533–575.

Bajari, Patrick and Mathew E. Kahn (2005), "Estimating Housing Demand with an Application to Explaining Racial Segregation in Cities." *Journal of Business and Economics Statistics*, 23 (January), 20–33.

Baum-Snow, Nathaniel (2007), "Did Highways Cause Suburbanization?" *Quarterly Journal of Economics*, 115 (May), 775–805.

Baum-Snow, Nathaniel and Byron Lutz (2008), "School Segregation, School Choice and Changes in Residential Location Patterns by Race.". Mimeograph, August 2008.

Bayer, Patrick, Hanming Fang, and Robert McMillan (2005), "Separate when Equal? Racial Inequality and Residential Segregation.". National Bureau of Economic Research Working Paper No. 11507, October 2005.

Bayer, Patrick, Fernando Ferreira, and Robert McMillan (2007), "A Unified Framework for Measuring Preferences for Schools and Neighborhoods." *Journal of Political Economy*, 115 (August), 588–638.

Becker, Gary S. and Kevin M. Murphy (2000), *Social Economics: Market Behavior in a Social Environment*, Cambridge MA: Harvard University Press.

Benabou, Roland (1993), "Workings of a City: Location, Education, and Production." *Quarterly Journal of Economics*, 108 (August), 619–652.

Boustan, Leah Platt (2007a), "Escape from the City? The Role of Race, Income, and Local Public Goods in Post-War Suburbanization.". National Bureau of Economic Research Working Paper No. 13311, August 2007.

——— (2007b), "Was Postwar Suburbanization 'White Flight'? Evidence from the Black Migration.". National Bureau of Economic Research Working Paper No. 13543, October 2007.

Card, David and Jesse Rothstein (2007), "Racial Segregation and the Black-White Test Score Gap." *Journal of Public Economics*, 91 (December), 2158–2184.

Card, David, Alexandre Mas, and Jesse Rothstein (2008a), "Tipping and the Dynamics of Segregation." *Quarterly Journal of Economics*, 123 (February), 177–218.

——— (2008b), "Are Mixed Neighborhoods Always Unstable? Two-Sided and One-Sided Tipping.". Mimeograph, March 2008.

Charles, Kerwin Kofi and Jonathan Guryan (2008), "Prejudice and Wages: An Empirical Assessment of Becker's *The Economics of Discrimination*." *Journal of Political Economy*, 116 (October), 773–809.

Charles, Kerwin Kofi and Erik Hurst (2002), "The Transition to Home Ownership and the Black-White Wealth Gap." *Review of Economics and Statistics*, 84 (May), 281–297.

Collins, William J. and Robert A. Margo (2001), "Race and Home Ownership: A Century-Long View." *Explorations in Economic History*, 38 (May), 68–92.

Coulson, N. Edward (1999), "Why are Hispanic- and Asian-American Homeownership Rates so Low? Immigration and Other Factors." *Journal of Urban Economics*, 45 (March), 209–227.

Coulson, N. Edward and Eric W. Bond (1990), "A Hedonic Approach to Residential Succession." *Review of Economics and Statistics*, 72 (August), 433–444.

Cutler, David M. and Edward L. Glaeser (1997), "Are Ghettos Good or Bad?" *Quarterly Journal of Economics*, 112 (August), 827–872.

Cutler, David M., Edward L. Glaeser, and Jacob L. Vigdor (1999), "The Rise and Decline of the American Ghetto." *Journal of Political Economy*, 107 (June), 455–506.

——— (2008), "Is the Melting Pot Still Hot? Explaining the Resurgence of Immigrant Segregation." *Review of Economics and Statistics*, 90 (August), 478–497.

DiPasquale, Denise and Edward L. Glaeser (1999), "Incentives and Social Capital: Are Homeowners Better Citizens." *Journal of Urban Economics*, 45 (March), 354–384.

Easterly, William (2005), "Empirics of Strategic Interdependence: The Case of the Racial Tipping Point.". New York University DRI Working Paper No. 5.

Farley, Reynolds, Elaine L. Fielding, and Maria Krysan (1997), "The Residential Preferences of Blacks and Whites: A Four-Metropolis Analysis." *Housing Policy Debate*, 8 (4), 763–800.

Frankel, David M. and Ady Pauzner (2002), "Expectations and the Timing of Neighborhood Change." *Journal of Urban Economics*, 51 (June), 295–314.

Fu, Yuming (1991), "A Model of Housing Tenure Choice: Comment." *American Economic Review*, 81 (June), 381–383.

Glaeser, Edward L. and Joseph Gyourko (2007), "Arbitrage in Housing Markets.". National Bureau of Economic Research Working Paper No. 13704.

Guryan, Jonathan (2004), "Desegregation and Black Dropout Rates." *American Economic Review*, 94 (September), 919–943.

Henderson, J. Vernon and Yannis M. Ioannides (1983), "A Model of Housing Tenure Choice." *American Economic Review*, 73 (March), 98–113.

Hoff, Karla and Arijit Sen (2005), "Homeownership, Community Interactions, and Segregation." *American Economic Review*, 95 (September), 1167–1189.

Imbens, Guido and Thomas Lemieux (2007), "Regression Discontinuity Designs: A Guide to Practice.". National Bureau of Economic Research Working Paper No. 13039.

Jacob, Brian A. (2004), "Public Housing, Housing Vouchers, and Student Achievement: Evidence from Public Housing." *American Economic Review*, 94 (March), 233–258.

Jones, Lawrence D. (1990), "Current Wealth Constraints on the Housing Demand of Young Owners." *Review of Economics and Statistics*, 72 (August), 424–432.

Kain, John F. (1968), "Housing Segregation, Negro Employment, and Metropolitan Decentralization." *Quarterly Journal of Economics*, 82 (May), 175–197.

Kling, Jeffrey R., Jeffrey B. Liebman, and Lawrence F. Katz (2007), "Experimental Analysis of Neighborhood Effects." *Econometrica*, 75 (January), 83–119.

Margo, Robert A. (1992), "Explaining the Postwar Suburbanization of Population in the United States: The Role of Income." *Journal of Urban Economics*, 31 (May), 301–310.

Miyao, Takahiro (1978), "Dynamic Stability of a Mixed City in the Presence of Neighborhood Externalities." *American Economic Review*, 68 (June), 454–463.

——— (1979), "Dynamic Stability of an Open City with Many Household Classes." *Journal of Urban Economics*, 6 (July), 292–298.

Moebius, Markus and Tanya Rosenblat (2001), "The Process of Ghetto Formation: Evidence from Chicago.". Mimeograph, Harvard University 2001.

Oreopoulos, Philip (2003), "The Long-Run Consequences of Living in a Poor Neighborhood." *Quarterly Journal of Economics*, 118 (November), 1533–1575.

Ruggles, Steven, Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander (2004), *Integrated Public Use Microdata Series: Version 3.0 [Machine-readable database]*, Minneapolis: Minnesota Population Center [producer and distributor].

Saiz, Albert and Susan Wachter (2006), "Immigration and the Neighborhood.". Institute for the Study of Labor (IZA) Discussion Paper No. 2503.

Sampson, Robert J., Stephen W. Raudenbush, and Felton Earls (1997), "Neighborhoods and Violent Crime: A Multilevel Study of Collective Efficacy." *Science*, 277 (August), 918–924.

Schelling, Thomas C. (1969), "Models of Segregation." *American Economic Review*, 2 (May), 488–493.

——— (1971), "Dynamic Models of Segregation." *Journal of Mathematical Sociology*, 1 (July), 143–186.

——— (1978), *Micromotives and Macrobehavior*, New York: Norton.

Sinai, Todd and Nicholas S. Souleles (2005), "Owner-Occupied Housing as a Hedge Against Rent Risk." *Quarterly Journal of Economics*, 120 (May), 763–789.

Tiebout, Charles (1956), "A Pure Theory of Local Expenditures." *Journal of Political Economy*, 64 (October), 416–424.

Vigdor, Jacob and Jens Ludwig (2007), "Segregation and the Black-White Test Score Gap.". National Bureau of Economic Research Working Paper No. 12988.

Zax, Jeffrey S. and John F. Kain (1996), "Moving to the Suburbs: Do Relocating Companies Leave Their Black Employees behind." *Journal of Labor Economics*, 14 (July), 472–504.

Data Appendix

The empirical analysis is based on tract-level tabulations of decennial census data mapped onto Census 2000 tract boundaries in the Neighborhood Change Database (NCDB). The sample includes tracts from every Metropolitan Statistical Area (MSA, based on 1999 definition) containing at least 100 tracts with two exclusions: tracts whose decadal population growth rate exceeds the MSA mean by more than five standard deviations and tracts whose decadal growth in white population exceedes 500 percent of the baseline population.

The analysis of tipping discontinuities uses the estimated structural break tipping points identified by Card et al. (2008a). I thank David Card, Alexandre Mas, and Jesse Rothstein for generously sharing these data. All regressions include only the randomly selected 1/3 of the tract sample not used for the estimation of tipping points.

Throughout the analysis, the term "white population" refers to white non-Hispanics, while "minority population" comprises all blacks, Hispanics, native Americans, Asians, Pacific Islanders, and members of other nonwhite races. However, because census tabulations do not report separate population counts for white and nonwhite Hispanics in 1970, in accordance with Card et al. (2008a),

this study draws on the 1980 data to estimate a regression of the white non-Hispanic population share in a tract on the white, black, and Hispanic shares, and then employs the coefficient estimates from this regression to predict the white non-Hispanic share of tract populations in 1970. To identify population changes between 1970 and 1980, it performs an analogous imputation for the non-Hispanic white share in 1980.

The best available data on homeowner status, income, and education by race and ethnicity are those for 1990 and 2000. In earlier years, these variables were either not reported or the Census Bureau suppressed values for a large number of tracts. Nonetheless, although homeowner status is reported separately for non-Hispanic whites in 1990 and 2000, income and education data is only tabulated for either all whites or all Hispanics (not for non-Hispanic whites). Hence, the number of white Hispanics in a given income or education cell (e.g., white Hispanic college graduates) is imputed by multiplying the reported share of a tract's white Hispanics by the number of Hispanics that fall into the income or education cell (e.g., share of whites among Hispanics x Hispanics that are college graduates). The imputed number of Hispanic whites in a cell is then subtracted from the number of all whites in that cell to obtain the number of non-Hispanic whites with a given income or education level.[25] The reported results for income and education of non-Hispanic whites are very similar to the results for all whites.

All regressions control for the renter share, which is defined as the share of renter-occupied housing units among all occupied housing units. An additional vector of tract population and housing characteristics includes the natural logarithm of mean family income, the share of persons aged 16+ who are in the civilian labor force and are unemployed, the share of families with children under age 18, the fraction of homes that are vacant, and the fraction of homes that are single unit.

Data on family income by race is only reported in broad intervals. Rather than converting these interval data to a continuous measure, this analysis exploits the fact that the real value of $35,000 in 1989 almost coincides with the real value of $45,000 in 1999 (income data in the census is based on the year that precedes the census). Because both values are available as interval borders in the respective years, the data thus allow consistent measurement of the share of white or minority families with an income above $45,000 by 1999 value. All real dollar amounts are inflated using the Personal Consumption Expenditure price index.

[25] In the 2000 census, individuals were allowed to indicate multiple races. Whenever tabulations for every possible combination of races are available, the NCDB counts persons who choose combinations of white, Native American, and "other race" as white and all other multiple-race persons as minorities. The income and education data, however, only report a summary count of all multiple-race persons for each income or education cell. To compute the share of whites among multiple race persons for each MSA, this analysis uses microdata from the 5 percent extract of the 2000 census (Ruggles, Sobek, Alexander, Fitch, Goeken, Hall, King and Ronnander, 2004). Income and education counts for multiple-race persons are then assigned to whites and minorities according to these proportions.

Theory Appendix

Ad Section 3.2. Expectations of Outsiders. According to equation (3.7), outsiders expect a probability of $\gamma'\pi'$ that their new neighborhood has a minority share above $\bar{m}$ where γ' is the expected probability that incumbents of the neighborhood observed signal s_H and π' is the expected probability that the minority share increases beyond $\bar{m}$ given signal s_H. In the formation of these expectations, outsiders may take into account that neighborhood incumbents may choose to move upon observing s_H. Consider the standard case where only white home owners leave. A share r of all houses that change ownership are bought by investors and used as rental houses, and the departure of white owners will thus both increase the number of new owner-occupiers and new renters that move into the neighborhood. Suppose the share of new residents who move in given signal s_H is $\lambda' > \lambda$. The expected probability that a vacancy arises in a neighborhood whose incumbents obtained the signal s_H is then

$$\gamma' \equiv \frac{\gamma\lambda'}{(1-\gamma)\lambda + \gamma\lambda'} > \gamma \tag{A.1}$$

where γ is the probability that incumbents observe the signal s_H. Whether or not a neighborhood with signal s_H will exceed $\bar{m}$ depends on the exact composition of the neighborhood which is not observed by outside agents. Let π' be outsiders' expectation of the probability that the neighborhood minority share will exceed $\bar{m}$ in case of the signal s_H. The expected probability of moving into a neighborhood whose minority share rises above $\bar{m}$ is then equal to

$$E[Prob(m_1 > \bar{m})] \mid no\ signal = \gamma'\pi' \tag{A.2}$$

Without making further assumptions on outsiders' expectations, it is clear that for a small likelihood of the signal s_H, $\gamma'\pi' \to 0$ as $\gamma \to 0$. In the rare case that incumbent residents do observe the signal s_H, they may anticipate a much larger probability of a minority share above $\bar{m}$ than outsiders who consider such a change very unlikely.

Proof of Proposition 1. If $m_0 = m_0^* \equiv \frac{1}{1+\lambda}\bar{m}$ and λ vacancies are filled with new residents of whom a share $2m_0$ are minorities, then $m_1 = (1+\lambda)m_0 = \bar{m}$. Without taking into account moving decisions of other neighborhood incumbents, residents will expect that $m_1 > \bar{m}$ with probability 0 if $m_0 \leq m_0^*$ and no agent has an incentive to move voluntarily. If however $m_0 > m_0^*$, agents expect that $m_1 > \bar{m}$ with probability π. Whites' consumption utility falls by $2v_H$, from v_H to $-v_H$, if $m_1 > \bar{m}$ instead of $m_1 \leq \bar{m}$. Incumbents do not obtain signals about alternative locations and therefore expect that $m_1 \leq \bar{m}$ occurs with a probability $\gamma'\pi'$ when locating outside the neighborhood. White renters will move if the sum of the expected utility outside the neighborhood (net of housing costs) and the moving cost exceeds the sum of the expected utility inside the neighborhood and the rental

payment,

$$\gamma'\pi'2v_H - c = (1-\pi)v_H - \pi v_H - v_H \tag{A.3}$$

which solves to (3.12b). Minority owners will move if the payoff from selling at the equilibrium price P, moving at a cost c and obtaining a utility of zero outside the neighborhood exceeds the expected payoff from staying inside the neighborhood,

$$P - c = v_H + \beta[(1-\gamma'\pi')P_H + \gamma'\pi' P_L] - c > v_H + \beta[(1-\pi)P_H + \pi P_L] \tag{A.4}$$

which solves to (3.12c). The moving condition for white owners results from a combination of the arguments for minority owners and white renters. ■

Proof of Proposition 2. If $m_0 \leq m_0^*$, no group of current residents has an incentive to deviate from the strategy of staying because $m_1 \leq \bar{m}$ even when a minority shock occurs. If $m_0 > m_0^*$ and equation (3.12a) is fulfilled, moving is a strictly dominating strategy for white owners and all neighborhood incumbents will anticipate their departure. If no minority shock takes place, the voluntary departure of the $(1-\lambda)(1-m_0)(1-r_w)$ white owners who were not forced to leave raises the minority share to

$$m_1 = m_0 + (1-\lambda)(1-m_0)(1-r_w)m_0 \tag{A.5}$$

The resulting minority share is equal to $\bar{m}$ if the home owner share among whites is

$$1 - r_w = 1 - r_w^* \equiv \frac{\bar{m} - m_0}{(1-\lambda)(1-m_0)m_0} \tag{A.6}$$

Thus, if the neighborhood has a white owner share $(1-r_w) \leq (1-r_w^*)$, the departure of white owners will not increase m_1 above $\bar{m}$ and therefore $Prob(m_1 > \bar{m}) = \pi$. Neither minority owners nor white renters will deviate from the strategy of staying if equations (3.12b) and (3.12c) do not hold.

If the neighborhood has a white owner share $(1-r_w) > (1-r_w^*)$, the minority share will always rise beyond $\bar{m}$ if only white owners depart, even when no shock occurs. White renters will therefore also chose leave in order to avoid a disutility from the increased minority share, thus exacerbating the decrease in white population and increase in m_1. Since P^{end} is lower when $m_1 > \bar{m}$, minority home owners will depart. Their departure will partly mitigate the increase in m_1 that is caused by the departure of white residents; however, the condition

$$1 - r_w^* < r_m \tag{A.7}$$

implies that the departure of minority homeowners cannot push m_1 back below $\bar{m}$. It can then readily be verified that $m_1 > \bar{m}$ when only minority renters stay and the neighborhood fills with new residents of whom a share m_0 are minorities. If condition (A.7) were not fulfilled, then $m_1 \leq \bar{m}$

when all minority owners left along with all white residents. Minority owners would then prefer a mixed strategy where their moving decision is randomized so that $\pi < Prob(m_1 > \bar{m}) < 1$ when $1 - r_w > 1 - r_w^*$. Even in that case, however, the probability of exceeding $\bar{m}$ is weakly increasing in $1 - r_w$. ■

Ad Section 3.5. Alternative Expectations of Residents. Suppose agents expect that on observing s_H, all residents leave unless leaving is a dominated strategy. For minority renters, the strategy of leaving is always strictly dominated by staying because the payoff of minority renters does not fall when $m_1 > \bar{m}$. All agents will therefore expect that minority renters stay. However, if no minority shock takes place and the renter share satisfies condition (A.7), then the voluntary departure of all residents but minority renters always raises the minority share to

$$m_1 > \bar{m} \tag{A.8}$$

The combination of minority renters who stay in the neighborhood and a minority share m_0 among new residents adds to a minority share $m_1 > \bar{m}$. Based on the expectation that others depart as well, it is therefore rational for all neighborhood incumbents but minority renters to leave. As a consequence, it is possible that agents choose to leave the neighborhood even in case of an initial minority share $m_0 \leq m^*$ where an increase in the minority share above $\bar{m}$ could have been avoided if all residents stayed. Importantly, this alternative expectation structure does not predict a differential moving behavior for white owners and white renters. ■

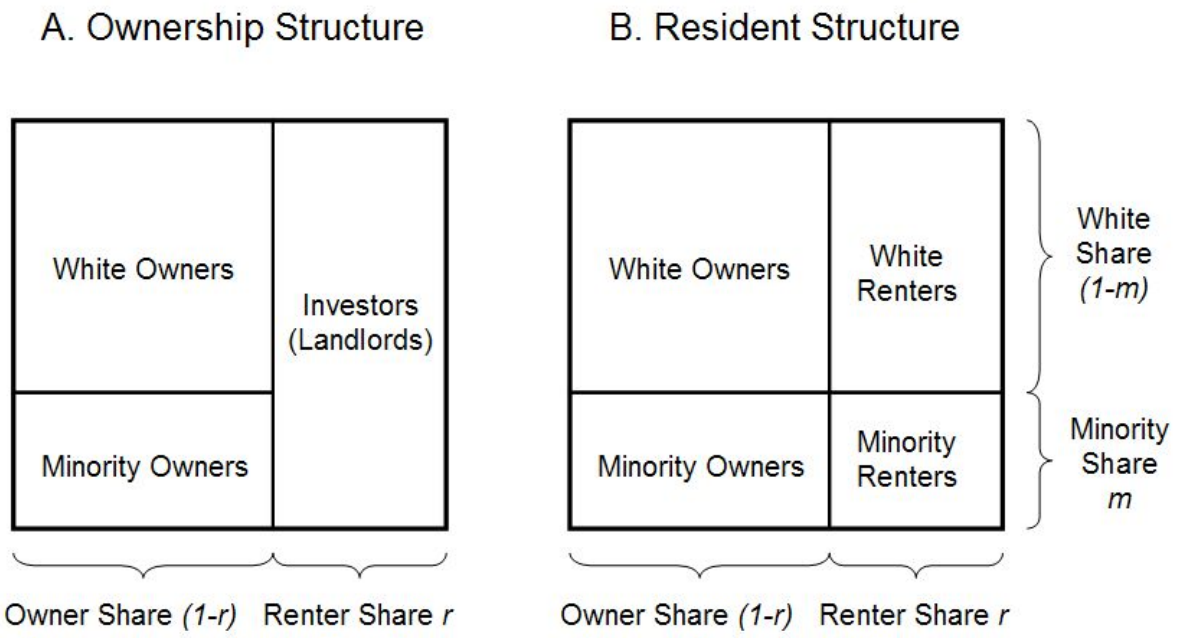

Figure 1: Example for neighborhood ownership and resident composition.

Table 1. Average Characteristics of All Tracts and Tracts +/-2% Around Tipping Point, 1970-1990

	A. All Tracts			B. Tracts +/-2% Around Tipping Point		
	1970 (1)	1980 (2)	1990 (3)	1970 (1)	1980 (2)	1990 (3)
No. of MSAs in Sample	104	113	114	104	113	114
No. of Tracts in Sample	35,725	39,283	40,187	9,306	5,502	5,047
No. of Tracts in 1/3 Sample	11,906	13,091	13,402	3,087	1,834	1,684
Total Population	3333.7	3507.8	3940.8	3233.2	3507.8	3940.8
	(2052.8)	(1763.2)	(1805.2)	(2010.0)	(1763.2)	(1805.2)
Minority Share	0.163	0.235	0.291	0.049	0.082	0.107
	(0.245)	(0.293)	(0.310)	(0.048)	(0.065)	(0.080)
Renter Share	0.347	0.364	0.383	0.295	0.313	0.307
	(0.242)	(0.250)	(0.246)	(0.200)	(0.212)	(0.188)
Renter Share, Whites			0.309			0.293
			(0.207)			(0.177)
Renter Share, Minorities			0.567			0.467
			(0.261)			(0.269)
Log Avg Family Income	10.727	10.804	10.923	10.794	10.880	11.054
	(0.323)	(0.355)	(0.443)	(0.271)	(0.276)	(0.346)
Sh. Families with Income >45'000$, Whites			0.535			0.544
			(0.443)			(0.174)
Sh. Families with Income >45'000$, Minorities			0.380			0.511
			(0.206)			(0.234)
Share of College Graduates	0.123	0.179	0.223	0.140	0.202	0.260
	(0.108)	(0.134)	(0.161)	(0.114)	(0.129)	(0.153)
Share of College Graduates, Whites			0.259			0.262
			(0.166)			(0.156)
Share of College Graduates, Minorities			0.150			0.259
			(0.141)			(0.182)

See data appendix for sample selection. The descriptive statistics include only the 1/3 of the tract sample that has not been used for the estimation of tipping point locations. Data on renter share, income, and education by race is only available for 1990. The race-specific statistics for whites or minorities are weighted by the number of white or minority residents in a tract.

Table 2. Distribution and Correlates of Renter Share for Tracts with a Minority Share within +/-2% of Tipping Point

	1970 (1)		1980 (2)		1990 (3)	
A. Distribution of Renter Share						
10th Percentile	0.092		0.091		0.092	
20th Percentile	0.135		0.133		0.141	
50th Percentile	0.236		0.264		0.276	
80th Percentile	0.440		0.487		0.462	
90th Percentile	0.605		0.618		0.571	
B. Correlates of Renter Share						
Log Avg. Family Income	-0.240	***	-0.176	***	-0.324	***
	(0.032)		(0.021)		(0.010)	
Share of Families with Children under Age 18	-0.835	***	-0.464	***	0.326	***
	(0.062)		(0.061)		(0.055)	
Central City Location	0.129	***	0.109	***	0.215	***
	(0.014)		(0.013)		(0.012)	
Share of Neighboring Tracts beyond Tipping Point	0.165	***	0.06	***	0.215	***
	(0.023)		(0.016)		(0.012)	
Renter Share Whites					1.009	***
					(0.003)	
Renter Share Minorities					0.502	***
					(0.022)	

Each data point in panel B reports the coefficient of a separate regression of renter share on the specified variable and MSA fixed effects. Tract neighbors are defined to have their central point within a 3 mile buffer zone around a given tract's boundary. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 3. Change in Owner-Occupied and Renter-Occupied Housing Units. Dependent Variables: Log Change in Owner-Occ or Renter-Occ Housing Units

I. All Races, 1970-2000

	A. 1970-1980		B. 1980-1990		C. 1990-2000	
	Own	Rent	Own	Rent	Own	Rent
Beyond Tipping Point	-0.073 ***	-0.019	-0.080 ***	-0.026	-0.056 ***	0.015
	(0.025)	(0.024)	(0.023)	(0.025)	(0.013)	(0.017)
Wald Test Own=Rent	F(1,103)=3.19 * p=0.08		F(1,112)=4.07 ** p=0.05		F(1,113)=15.35 *** p=0.00	
n	11,806	11,581	12,931	13,042	13,229	13,333
R^2	0.34	0.29	0.23	0.34	0.14	0.07

II. By Race, 1990-2000

	A. Whites		B. Minorities	
	Own	Rent	Own	Rent
Beyond Tipping Point	-0.056 ***	-0.005	-0.038	-0.021
	(0.016)	(0.022)	(0.027)	(0.032)
Wald Test Own=Rent	F(1,113)=5.74 ** p=0.02		F(1,113)=0.20 p=0.66	
n	12,622	12,687	12,580	11,568
R^2	0.29	0.13	0.20	0.18

All models control for MSA fixed effects, a quartic polynomial for the difference between a tract's minority share and the estimated MSA tipping point at the beginning of a decade. They also control for renter share, log average family income, share of families with children under age 18, unemployment rate, share of vacancies, and share of single-unit homes in a tract at the beginning of a decade. Robust standard errors in parentheses are clustered by MSA. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 4. Decadal Change in Overall, White, and Minority Population. Dependent Variable: Change of Indicated Population in Percentage Points of Initial Total Tract Population

	White Non-Hispanics				Minorities		Total Population	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				A. 1970-1980				
Beyond Tipping Point	-12.28 ***	-24.72 ***	-9.92 ***	-17.51 ***	-0.53	1.17	-10.45 ***	-16.34 ***
	(3.79)	(5.69)	(3.47)	(5.35)	(1.37)	(2.54)	(3.72)	(5.93)
Beyond TP x Renter Share		39.12 ***		23.58 **		-5.28		18.30 *
		(8.92)		(9.64)		(4.94)		(10.97)
R^2	0.20	0.21	0.27	0.27	0.23	0.23	0.25	0.25
				B. 1980-1990				
Beyond Tipping Point	-12.45 ***	-25.76 ***	-11.25 ***	-19.92 ***	0.60	2.34	-10.65 ***	-17.58 ***
	(3.85)	(5.98)	(3.44)	(5.54)	(1.06)	(1.93)	(3.94)	(6.29)
Beyond TP x Renter Share		40.78 ***		26.48 ***		-5.29		21.19 **
		(8.06)		(7.72)		(3.77)		(8.83)
R^2	0.23	0.24	0.32	0.32	0.27	0.27	0.32	0.32
				C. 1990-2000				
Beyond Tipping Point	-9.81 ***	-21.86 ***	-8.52 ***	-19.37 ***	1.70 **	5.72 ***	-6.83 ***	-13.64 ***
	(1.83)	(2.70)	(1.76)	(2.61)	(0.79)	(1.22)	(2.18)	(3.18)
Beyond TP x Renter Share		38.64 ***		34.55 ***		-12.84 ***		21.71 ***
		(4.55)		(4.57)		(2.41)		(5.36)
R^2	0.12	0.13	0.16	0.17	0.19	0.19	0.15	0.15
4th Polynomial Minority Sh	y	y	y	y	y	y	y	y
Renter Share	y	y	y	y	y	y	y	y
MSA Fixed Effects	y	y	y	y	y	y	y	y
Demogr/Housing Controls	n	n	y	y	y	y	y	y

N=11,886 in 1970-1980; N=13,077 in 1980-1990; N=13,378 in 1990-2000. Regressions include only tracts that have not been used to compute candidate tipping points. All models control for initial renter share, MSA fixed effects, and a quartic polynomial for the difference between a tract's minority share and the estimated MSA tipping point at the beginning of a decade. Models in columns 3-8 also control for log average family income, share of families with children under age 18, unemployment rate, share of vacancies, and share of single-unit homes in a tract at the beginning of a decade. Robust standard errors in parentheses are clustered by MSA. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 5. Predicted Change in White Population at Different Percentiles of the Renter Share Distribution.

	I. 1970-80	II. 1980-90	III. 1990-00
	(1)	(2)	(3)
Percentile of Renter Share			
10th Percentile	-15.34	-17.50	-16.20
Median	-11.95	-12.92	-9.82
90th Percentile	-3.25	-3.56	0.37

Predicted values are obtained by evaluating the regression coefficients from column 4 of table 4 at the 10th, 50th, and 90th percentiles of the renter share distribution, which are reported in table 2.

Table 6. Decadal Change in White Population - Robustness Tests. Dependent Variable: Change of White Population in Percentage Points of Initial Total Tract Population

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)	
							A. 1970-1980									
Beyond Tipping Point	-9.92	***	-17.51	***	-9.72	***	-14.54	***								
	(3.47)		(5.35)		(3.44)		(5.27)				n/a				n/a	
Beyond TP x Renter Share			23.58	**			15.08									
			(9.64)				(9.49)									
							B. 1980-1990									
Beyond Tipping Point	-11.25	***	-19.92	***	-10.62	***	-16.45	***	-10.32	***	-16.12	***	-6.88	***	-11.17	**
	(3.44)		(5.54)		(3.44)		(5.78)		(3.63)		(6.12)		(2.58)		(4.31)	
Beyond TP x Renter Share			26.48	***			17.71	**			17.42	**			12.50	*
			(7.72)				(8.57)				(8.78)				(6.69)	
							C. 1990-2000									
Beyond Tipping Point	-8.52	***	-19.37	***	-7.93	***	-15.96	***	-8.12	***	-15.45	***	-7.42	***	-13.64	***
	(1.76)		(2.61)		(1.73)		(2.77)		(1.72)		(2.65)		(1.34)		(2.18)	
Beyond TP x Renter Share			34.55	***			25.35	***			23.15	***			19.68	***
			(4.57)				(5.63)				(4.94)				(3.93)	
4th Polynomial Renter Sh	n		n		y		y		y		y		y		y	
Lagged Minority, Renter Sh -10y	n		n		n		n		y		y		y		y	
Lagged Controls -10y	n		n		n		n		n		n		y		y	

All models control for initial renter share, MSA fixed effects, a quartic polynomial for the difference between tract minority share and the estimated MSA tipping point, as well as the control variables log average family income, share of families with children under age 18, unemployment rate, share of vacancies, and share of single-unit homes, all measured at the beginning of a decade. Models in columns 3-8 also control for a quartic polynomial in the difference between tract renter share and MSA mean. Models in column 5-8 sequentially add ten-year lags of tract minority share and renter share, and ten-year lags of log average family income, share of families with children under age 18, unemployment rate, share of vacancies, and share of single-unit homes. Robust standard errors in parentheses are clustered by MSA. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 7. Decadal Change in White Population by City-Level Quintiles of Tract Mean Average Family Income. Dependent Variable: Decadal Change of White Population in Percentage Points of Initial Total Tract Population

	Tracts sorted by Mean Average Family Income (Rich to Poor)									
	1st Quintile of MSA		2nd Quint. of MSA		3rd Quintile of MSA		4th Quintile of MSA		5th Quintile of MSA	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
					A. 1970-1980					
Beyond Tipping Point	-1.5	-5.6	-12.5	-7.6	-13.2 **	-27.6 ***	-5.2	-13.0	-4.8	-34.2 ***
	(7.4)	(9.4)	(8.7)	(8.9)	(6.2)	(9.9)	(5.8)	(10.0)	(4.6)	(10.6)
Beyond TP x Renter Share		15.0		-18.2		44.6 **		20.4		64.5 ***
		(19.0)		(17.7)		(21.0)		(15.5)		(18.7)
					B. 1980-1990					
Beyond Tipping Point	-2.3	-7.5	-16.5 **	-22.8 **	-14.0 ***	-20.2 ***	-4.0	-7.9	-6.9	-24.2 ***
	(9.6)	(13.2)	(6.8)	(9.7)	(4.1)	(5.3)	(4.1)	(7.0)	(4.3)	(7.9)
Beyond TP x Renter Share		20.5		22.2 *		18.5		9.7		36.0 ***
		(20.0)		(13.1)		(12.5)		(10.6)		(11.4)
					C. 1990-2000					
Beyond Tipping Point	-10.5 **	-21.4 ***	-9.0 **	-16.7 ***	-5.4 **	-13.1 ***	-6.4 **	-17.6 ***	-1.2	-17.4 ***
	(4.2)	(6.3)	(4.0)	(5.4)	(2.7)	(3.2)	(2.5)	(4.4)	(3.3)	(5.5)
Beyond TP x Renter Share		41.4 ***		25.3 **		23.4 ***		29.3 ***		34.6 ***
		(13.1)		(12.4)		(6.0)		(7.9)		(10.4)

All models use the baseline specification with demographic and housing controls as described in the table notes of table 4. Robust standard errors in parentheses are clustered by MSA. * p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Table 8. Decadal Change in White Population - Alternative Hypotheses. Dependent Variable: Decadal Change of White Population in Percentage Points of Initial Total Tract Population

	A. 1970-1980			B. 1980-1990			C. 1990-2000		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Beyond Tipping Point	-17.5 ***	-20.6 ***	-11.8 **	-19.9 ***	-20.6 ***	-15.0 ***	-19.4 ***	-22.2 ***	-14.2 ***
	(5.3)	(5.7)	(4.7)	(5.5)	(5.8)	(5.2)	(2.6)	(2.6)	(2.6)
Beyond TP x Renter Share	23.6 **	27.3 **	21.1 **	26.5 ***	21.0 **	27.9 ***	34.5 ***	35.9 ***	31.6 ***
	(9.6)	(12.1)	(9.6)	(7.7)	(9.2)	(8.5)	(4.6)	(4.4)	(4.8)
Beyond TP x Ln Avg. Family Income		34.0 ***			10.4 **			9.0 ***	
		(6.5)			(4.1)			(2.6)	
Beyond TP x Share Families with Children		-29.0			-70.0 ***			-66.1 ***	
		(17.6)			(14.0)			(12.1)	
Beyond TP x Central City Location			-3.7			-6.4			1.7
			(4.2)			(4.0)			(2.4)
Beyond TP x Share of Tipped Neighbor Tracts			44.9 ***			15.4 **			-3.0
			(6.7)			(6.3)			(2.8)

All models use the baseline specification with demographic and housing controls as described in the table notes of table 4. Models in columns 2-3, 5-6, and 8-9 include interaction terms between estimated MSA tipping points and log average family income, share of families with childeren below age 18, central city location, and share of neighboring tracts with a minority share above the tipping point, all measured in deviations from MSA means; as well as main effects for the interacted variables. Tract neighbors are defined to have their central point within a 3 mile buffer zone around a given tract's boundary. Robust standard errors in parentheses are clustered by MSA. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 9. Decadal Change in Average House Values and Rents. Dependent Variable: Change of Log Average House Value or Rent

	I. House Values				II. Rents	
	(1)	(2)	(3)	(4)	(5)	(6)
			A. 1970-1980			
Beyond Tipping Point	-0.008	-0.027	-0.004	-0.015		
	(0.013)	(0.022)	(0.013)	(0.019)	n/a	
Beyond TP x Renter Share		0.059		0.034		
		(0.053)		(0.045)		
n	9,752	9,752	9,752	9,752		
R^2	0.39	0.39	0.40	0.40		
			B. 1980-1990			
Beyond Tipping Point	-0.024 **	-0.059 ***	-0.023 **	-0.065 ***	-0.023 **	-0.054 ***
	(0.010)	(0.015)	(0.010)	(0.015)	(0.011)	(0.014)
Beyond TP x Renter Share		0.111 ***		0.130 ***		0.092 ***
		(0.032)		(0.033)		(0.026)
n	12,221	12,221	12,220	12,220	12,273	12,273
R^2	0.63	0.63	0.63	0.64	0.20	0.20
			C. 1990-2000			
Beyond Tipping Point	-0.016	-0.039 **	-0.012	-0.031 *	-0.008	-0.005
	(0.010)	(0.017)	(0.009)	(0.016)	(0.007)	(0.011)
Beyond TP x Renter Share		0.074 **		0.060 *		-0.012
		(0.036)		(0.035)		(0.019)
n	13,024	13,024	13,024	13,024	13,309	13,309
R^2	0.49	0.49	0.50	0.50	0.15	0.15
Renter Share	y	y	y	y	y	y
Demogr/Housing Controls	n	n	y	y	y	y

All models control for initial renter share, MSA fixed effects, and a quartic polynomial for the difference between a tract's minority share and the estimated MSA tipping point at the beginning of a decade. Models in columns 3-6 also control for log average family income, share of families with children under age 18, unemployment rate, share of vacancies, and share of single-unit homes in a tract at the beginning of a decade. Robust standard errors in parentheses are clustered by MSA. Data on average rents is missing for most tracts in 1970. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 10. Change in Income Levels. Dependent Variables: Change Log Avg Family Income; Change Share of Families Above Income Threshold

	I. Change Log Avg. Family Income, All Races					
	A. 1970-1980		B. 1980-1990		C. 1990-2000	
	(1)	(2)	(3)	(4)	(5)	(6)
Beyond Tipping Point	-0.022	-0.058 ***	-0.028 ***	-0.040 ***	-0.013 **	-0.032 ***
	(0.016)	(0.015)	(0.007)	(0.011)	(0.006)	(0.012)
Beyond TP x Renter Share		0.113 ***		0.036		0.061 *
		(0.038)		(0.030)		(0.031)
n	11,863	11,863	13,052	13,052	13,357	13,357
R^2	0.16	0.16	0.32	0.32	0.15	0.15
	II. Share of Families with Annual Income >45K$					
	A. Whites, 1990-2000			B. Minorities, 1990-2000		
Beyond Tipping Point		-0.009 **	-0.010 *	-0.003	-0.008	
		(0.004)	(0.005)	(0.007)	(0.011)	
Beyond TP x Renter Share			0.005		0.016	
			(0.010)		(0.023)	
n		13,155	13,155	13,109	13,109	
R^2		0.07	0.07	0.04	0.04	

All models use the baseline specification with demographic and housing controls as described in the table notes of table 4. Robust standard errors in parentheses are clustered by MSA. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.

Table 11. Change in Educational Levels. Dependent Variable: Change Share of College Graduates among Residents Age 25+

I. All Races, 1970-2000

	A. 1970-1980		B. 1980-1990		C. 1990-2000	
	(1)	(2)	(3)	(4)	(5)	(6)
Beyond Tipping Point	0.002	-0.006	-0.006 **	-0.015 ***	-0.006 **	-0.012 ***
	(0.003)	(0.004)	(0.003)	(0.004)	(0.002)	(0.004)
Beyond TP x Renter Share		0.026 **		0.027 ***		0.018 *
		(0.010)		(0.010)		(0.009)
n	11,886	11,886	13,066	13,066	13,371	13,371
R^2	0.14	0.14	0.15	0.15	0.14	0.14

II. By Race, 1990-2000

	A. Whites		B. Minorities	
Beyond Tipping Point	-0.009 ***	-0.014 ***	0.000	-0.004
	(0.003)	(0.004)	(0.007)	(0.009)
Beyond TP x Renter Share		0.016		0.014
		(0.012)		(0.016)
n	13,246	13,246	13,274	13,274
R^2	0.04	0.04	0.03	0.03

All models use the baseline specification with demographic and housing controls as described in the table notes of table 4. Robust standard errors in parentheses are clustered by MSA. * p ≤ 0.10, ** p ≤ 0.05, *** p ≤ 0.01.

Appendix Table 1. Decadal Change in White Population - Alternative Specification of Minority Share Polynomial. Dependent Variable: Change of White Population in Percentage Points of Initial Total Tract Population

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)		(10)	
A. 1970-1980																				
Beyond Tipping Point	-17.8	***	-22.4	***	-10.1	***	-15.9	***	-9.9	***	-17.5	***	-11.8	***	-18.8	***	-19.5	***	-25.8	***
	(2.5)		(4.8)		(3.3)		(5.1)		(3.5)		(5.3)		(3.5)		(5.2)		(4.4)		(6.0)	
Beyond TP x Renter Share			13.1				17.7	*			23.6	**			21.7	**			20.7	**
			(9.3)				(9.3)				(9.6)				(9.7)				(10.0)	
B. 1980-1990																				
Beyond Tipping Point	-15.0	***	-22.5	***	-11.2	***	-18.5	***	-11.3	***	-19.9	***	-12.2	***	-21.1	***	-16.2	***	-25.3	***
	(2.0)		(4.1)		(3.1)		(5.2)		(3.4)		(5.5)		(3.9)		(6.0)		(5.1)		(6.8)	
Beyond TP x Renter Share			22.2	***			22.4	***			26.5	***			27.0	***			29.0	***
			(7.8)				(7.7)				(7.7)				(7.8)				(7.7)	
C. 1990-2000																				
Beyond Tipping Point	-12.2	***	-23.0	***	-9.9	***	-20.0	***	-8.5	***	-19.4	***	-8.1	***	-19.3	***	-7.8	***	-19.0	***
	(1.3)		(2.3)		(1.7)		(2.6)		(1.8)		(2.6)		(1.8)		(2.6)		(2.7)		(3.1)	
Beyond TP x Renter Share			33.5	***			32.8	***			34.5	***			35.0	***			36.2	***
			(4.6)				(4.7)				(4.6)				(4.5)				(4.5)	
Minority Share Polynomial (Difference from TP)																				
none	x		x																	
2nd order					x		x													
4th order									x		x						x		x	
6th order													x		x					
separate polyn on both sides of TP																	x		x	

All models use the baseline specification with demographic and housing controls as described in the table notes of table 4 but vary the order of the polynomial for the difference between a tract's minority share and the estimated MSA tipping point. The models of columns (9) and (10) include separate 4th order polynomials on both sides of the tipping point. * $p \leq 0.10$, ** $p \leq 0.05$, *** $p \leq 0.01$.